

LIVSFORMEN
HOS
PLANTER PAA NY JORD
AF
C. RAUNKIÆR

D. KGL. DANSKE VIDENSK. SELSK. SKRIFTER, 7. RÆKKE, NATURVIDENSK. OG MATHEM. AFD. VIII. 1

KØBENHAVN
BIANCO LUNOS BOGTRYKKERI
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INDLEDNING.

Hovedopgaven for min Rejse til Vestindien i 1905—1906 var den: at faa Lejlighed til at bestemme Livsformen hos de enkelte Arter af Blomsterplanter indenfor et begrænset Omraade i et tropisk Klima, i foreliggende Tilfælde paa de danske vestindiske Øer, for derved at faa Materiale til Fremstillingen af det biologiske Spektrum for et forholdsvis regnfattigt tropisk Lands Vedkommende. Selv om jeg haaber senere at faa Lejlighed til at give mere detaillerede Oplysninger om biologiske Forhold hos en Del af Dansk Vestindiens og St. Domingos Blomsterplanter, har jeg dog allerede paa en vis Maade givet Hovedresultatet af mine Undersøgelser, der ganske vist kun fylder en Linie, nemlig det paa Livsformernes Statistik grundede biologiske Spektrum for St.Thomas og St. Jan, som jeg har meddelt Side 129 i min Bog „Planterigets Livsformer og deres Betydning for Geografien“; der er her givet et Udgangspunkt for en sammenlignende Undersøgelse af de forskellige Tropelandes Planteklima o: Klimaet som Betingelse for en bestemt Vegetation og udtrykt ved det statistiske Forhold mellem samtlige Arters Livsform bestemt ved Tilpasningen til at overleve den ugunstige Aarstid.

Foruden dette mit Hovedformaal, saa vidt muligt at bestemme Livsformen hos de enkelte Arter, havde jeg stillet mig forskellige mindre Opgaver, som jeg agtede at give mig af med, hvis Tid og Lejlighed gaves; saaledes blandt andre en Undersøgelse af Naturforholdene og Vegetationen paa de Alluvialdannelser, som hist og her findes ved de danske vestindiske Øers Kyster; min Hensigt hermed var navnlig den, at faa et Grundlag for en sammenlignende Undersøgelse af den Vegetation, som findes paa væsentlig samme Bund men i forskellige Klimater, f. Eks. i Dansk Vestindien og i Danmark, især for derigennem at se, i hvilken Grad Klimaet, ogsaa indenfor et saa specielt Omraade som de alluviale Stranddannelsers Formationer, giver sig Udslag i Vegetationens biologiske Spektrum.

Alluviale Stranddannelser findes jo i alle Klimater og kan være af forskellig Beskaffenhed. Der er ganske vist ikke altid skarpe Grænser mellem de forskellige Stranddannelser, men i Almindelighed kan man dog skelne mellem de af grovere uorganiske Bestanddele (Sand, Grus) sammensatte Aflejringer og de Aflejringer, som bestaar af finere Bestanddele (Ler, Slam, osv.); de første findes som bekendt især paa ubeskyttet Kyst, de sidste paa beskyttet Kyst; de to Lokaliteters Vegetation er

derfor ikke alene betinget af Jordbundens forskellige Beskaffenhed men ogsaa delvis af Læforholdene. Til disse to Stranddannelser, Sand- og Lerstrand, kan der føjes en tredie, for en væsentlig Del af organisk Materiale dannet Bund, der imidlertid kun i ringe Grad er repræsenteret i Dansk Vestindien.

Hvor der er en, selv kun smal, lav Strand mellem det højere Lands Fod og Havet, findes langs Kysterne af vore vestindiske Øer i Regelen mere eller mindre udstrakte Sanddannelser, navnlig i Bunden af de aabne Bugter; overalt bestaar Sandet væsentlig af „Koralsand“, som dog langt fra alene hidrører fra Koraller, men tillige stammer fra andre Dyr Skaller og fra Kalkalger; paa nogle Steder er Koralsandet mere eller mindre blandet med Sand, der er dannet ved Smuldring af Klipernes Bjærgarter, og som dels dannes paa Stranden selv, hvor der er Klippe-kyst, dels i Bæklejerne, „Gut“erne, hvorfra det af Regntidens stride Bjærgbække føres ud i Havet. Paa nogle Steder, hvor der kun er en smal, faa Meter bred Strand mellem Havet og Klippens Fod, har man Lejlighed til at se alle Overgange mellem det endelige Produkt, det mere eller mindre fine Sand, og det Materiale, fra hvilket Sandet stammer; saaledes f. Eks. i den lille Popilleaus Bay paa St. Jan.

Paa andre Steder er den inderste, af hidført Materiale mere eller mindre opfyldte Del af en Bugt bleven delvis adskilt fra Havet, idet Havet har dannet en Sandvold tværs over Bugten, hvorved der indenfor er fremkommet en større eller mindre Lagune med roligere Vand, i Regelen med en frodig Mangrove-Vegetation i Randen. Paa andre Steder igen er en saadan Lagune bleven helt adskilt fra Havet som en lavvandet Sø, der i Dansk Vestindien i Regelen bliver kaldt „Salt Pond“ eller „Salt Panne“; ogsaa blot „Pond“ eller „Panne“; en saadan „Pond“ kan endelig blive helt opfyldt dels af nedskyllet Materiale dels af ved Højvande indskyllet Materiale og derved tørlagt, saa at den kun undtagelsesvis, i Regntider og Stormflods-tider, sættes under Vand.

Denne Udviklingsgang er i det væsentlige allerede skildret af ØRSTED¹ og EGGER²; men da jeg har haft Lejlighed til at studere disse Forhold paa en Række Punkter, vil jeg som Indledning til Skildringen af Sandy Point og Krauses Lagune give en kort Beskrivelse af de forskellige Udviklingstrin paa den Maade, at jeg beskriver Forholdene som de nu er paa bestemte, navngivne Lokaliteter; jeg mener, at dette kan have Betydning som Udgangspunkt og Støttepunkt for fremtidige Undersøgelser over Arten og Hurtigheden af de Forandringer, som foregaar og i Fremtiden vil foregaa ved de danske vestindiske Øers Kyster; ved mine Undersøgelser over Forholdene ved Krauses Lagune og de store Forandringer, som her er foregaaet i nyeste Tid, har jeg selv stærkt følt Savnet af en mere detailleret Skildring af, hvorledes Forholdene her var, før disse Forandringer fandt Sted.

Nogen indgaaende Skildring af Vegetationsformationerne skal jeg ikke her

¹ ØRSTED, A. S., Dansk Vestindien i physisk-geographisk og naturhistorisk Henseende. BERGSØE, Den danske Stats Statistik. 4. Bd. Kjøbenhavn 1849.

² EGGER, H. F. A., Naturen paa de dansk-vestindiske Øer. Tidsskrift for populære Fremstillinger af Naturvidenskaben. 5^{te} Række, 5^{te} Bind. Kjøbenhavn 1878.

komme ind paa, men kun nævne de Formationer, som findes paa de enkelte Lokaliteter. Paa de alluviale Stranddannelser i Dansk Vestindien findes fire HovedFormationer, nemlig paa udsat Kyst, yderst: *Pescaprae*-Formationen, og indenfor denne: *Coccoloba*-Formationen, og, paa beskyttet Kyst, yderst: *Mangrove*-Formationen og, indenfor denne og paa højere Bund, *Conocarpus*-Formationen; de tre først nævnte Formationer er allerede omtalte af WARMING¹ og BØRGESEN²; ved den fjerde, *Conocarpus*-Formationen³, forstaar jeg den Bevoksning, som findes paa den højere og mere tørre Lagunebund indenfor *Mangrove*-Formationen og af hvilken *Conocarpus erectus* idetmindste ofte danner en meget væsentlig Bestanddel navnlig i Formationens yderste, laveste Facies nærmest ved *Mangrove*formationen.

Kun paa faa fremspringende Punkter af Kysten gaar Havet umiddelbart ind mod den faststaaende Klippe; derimod dannes Stranden paa mange Steder alene af store, nedstyrtede Klippemasser; her kan man enten slet ikke komme frem langs Stranden, idet Bølgerne med Voldsomhed kastes ind i Mellemrummene mellem Klippeblokkene (Fig. 3), eller man kan kun komme frem med stort Besvær, idet man maa springe fra den ene Klippeblok til den anden, idelig besværet af det tætte, ofte tornede Krat, som fra Klippeskraaningen breder sig

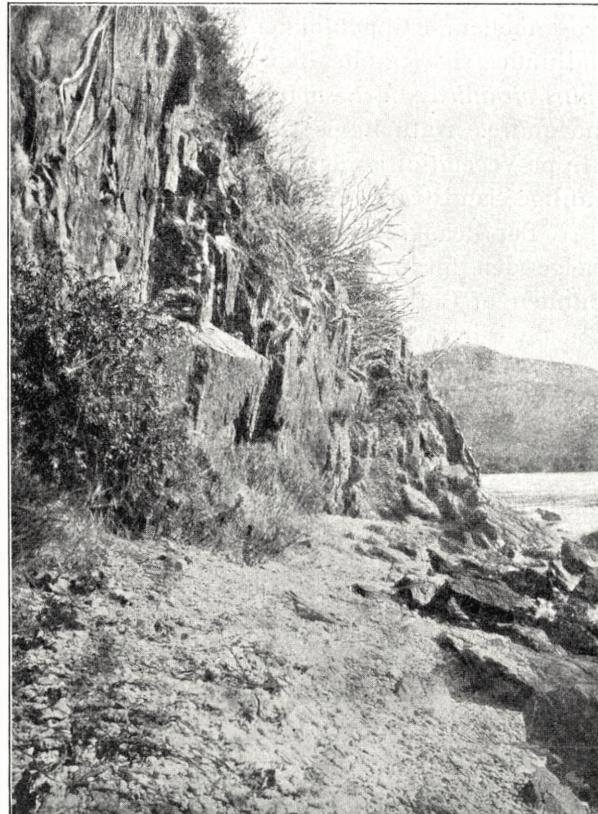


Fig. 1.

Fra Coral Bay paa St. Jan (24. 2. 06). Nordsiden af Popilleaus Bay set mod Øst; i Baggrunden „Orkanhullet“ og Østenden af St. Jan. Billedet viser det yderste fremspringende Hjørne ved Indgangen til Popilleaus Bay, som ligger bagved og tilhøje for Tilskueren. Fra den stejle Klippekysts Fod gaar der et Rev af store Klippeblokke ud i Havet; langs Klippens Fod er Bunden dækket af lost Materiale — Sten, Grus og Sand — med en mager Vegetation af *Croton flavens*, *Capparis frondosa*, *C. cynophallophora*, *Randia aculeata*, *Comocladia ilicifolia* (delvis bladløs), *Pictetia aculeata* (bladløs), *Pisonia fragrans*, *Elaeodendron xylocarpum*, *Caesalpinia crista*, *Canavalia obtusifolia* og *Ipomoea pescaprae*. I Spalter paa Klippevæggen vokser: *Melocactus communis*, *Opuntia tuna*, *O. curassavica*, *Pilocereus Royenii*, *Pitcairnia angustifolia*, *Euphorbia petiolaris*, *Plumeria alba* (bladløs) og *Pisonia subcordata* (bladløs). Hele Vegetationen stærkt præget af Tørhed.

¹ WARMING, E., Plantesamfund. Kjøbenhavn 1895.

² BØRGESEN, F. og OVE PAULSEN, Om Vegetationen paa de dansk-vestindiske Øer. Kjøbenhavn 1898.

³ RAUNKJÆR, C., Vegetationsbilleder fra dansk Vestindien; Krauses Lagune. Bot. Tidsskrift. Bd. 28. 1907—08. Beretning om Foreningens Virksomhed. Side III.

ud over Stranden (Fig. 4). Allerede paa en saadan Kyst, f. Eks. paa Vestsiden af Løvenlund Bay (Fig. 3) paa Nordsiden af St. Thomas, træffes svage Spor af en Sandstrand, idet Havet i Stormfloodstider hist og her har ført Sandmasser saa højt op, at de under sædvanlige Forhold ikke naaes af Bølgerne; herved er Fordybninger i og mellem Klippeblokkene blevet delvis udfyldte med Sand, hvor der saa har indfundet sig enkelte Repræsentanter for Pescaprae-Formationen, især *Sporobolus virginicus* og *Sesuvium portulacastrum*; hist og her ogsaa *Ipomaea pescaprae* og faa andre. Naturligvis kan der ogsaa forekomme Arter fra den omgivende Strandklippe-Vegetation; men de vedkommer os ikke her, da de ikke findes paa den sædvanlige Sandstrand, hvor Bunden i større Dybde bestaar alene af Strandsand.

Popilleaus Bay. Som Eksempel paa det sidste Stadium i Udviklingen vil jeg vælge den forannævnte lille Popilleaus Bay paa Østsiden af Batteri-Halvøen i Bunden af Coral Bay paa St. Jan. Paa begge Sider af denne Bugt, men navnlig paa Sydsiden, gaar Bølgerne umiddelbart ind mod den faststaaende Klippekyst, hvis Nedbrydning er i fuld Gang og hvor Havets Paavirkning har frembragt fantastiske Former; nogle Steder staar endnu enkelte isolerede, ofte ret høje Klippepartier i Vandkanten, i Regelen med en forblæst *Coccoloba uvifera*, et Par Kaktus og enkelte andre Planter paa Toppen (*Pilocereus Royenii*, *Opuntia tuna*, *Melocactus communis*, *Sporobolus virginicus*, *Capparis cynophallophora* og *Pictetia aculeata*). Skønt jeg ikke her skal behandle Strandklippe-Vegetationen, mener jeg dog, at det kan have nogen Interesse at se, hvilke Arter der paa en bestemt og saa begrænset Lokalitet som Popilleaus Bay findes paa den nederste Del af de stejle, af Havet til Tider direkte paavirkede Strandklipper og paa og mellem de nedstyrtede Klippemasser; foruden Arterne paa den flade af Sand og rullede Sten dannede Strand var her følgende:

<i>Sporobolus virginicus</i>	<i>Elaeodendron xylocarpum</i>
<i>Scleria lithosperma</i>	<i>Pictetia aculeata</i>
<i>Hymenocallis caribaea</i>	<i>Pithecellobium unguis-cati</i>
<i>Pitcairnia angustifolia</i>	<i>Conocarpus erectus</i>
<i>Agave Morrisii</i>	<i>Laguncularia racemosa</i>
<i>Coccoloba uvifera</i>	<i>Antherylium Rohrii</i>
<i>Pisonia subcordata</i>	<i>Bumelia cuneata</i>
<i>Melocactus communis</i>	<i>Tecoma leucoxylon</i>
<i>Opuntia curassavica</i>	<i>Anthacanthus spinosus</i>
" <i>tuna</i>	<i>Bontia daphnoides</i>
<i>Pilocereus Royenii</i>	<i>Plumieria alba</i>
<i>Capparis cynophallophora</i>	<i>Erithalis fruticosa</i>
" <i>frondosa</i>	<i>Randia aculeata</i>
<i>Melochia tomentosa</i>	<i>Vernonia arborescens</i>
<i>Croton flavens</i>	

Da det her kun drejer sig om et ganske lille Omraade, nemlig den korte Syd-side af Popilleaus Bay, er det let at forstaa, at Listen kun omfatter en Brøkdel af

de Arter, som kan træffes paa lignende Lokaliteter. Det er værd at lægge Mærke til, at mange af de opførte Arter er saadanne, som udgør en væsentlig Bestanddel af Floraen paa de alluviale Stranddannelser.

Ved det yderste, udsatte Hjørne paa Bugtens Nordside ligger der en Mængde Sten og Klippeblokke ud i Vandet ved Strandklippens Fod (Fig. 1); lidt til Siden herfor bestaar Stranden af større og mindre, mere eller mindre rundslidte Sten, Brudstykker af Koralblokke, Skaller af Muslinger, Snegle og Søpindsvin, som i stor Mængde lever langs Kysten. Naar Bølgerne ruller tilbage fra Strandens, rasler Stenene mod hverandre under øredøvende Larm. Efterhaanden som man kommer længere og længere hen mod det inderste, roligere, fladstrandede Hjørne af Bugten, bliver Strandens Materiale mindre og mindre, idet Materialeet sorteres i Overensstemmelse med Vandbevægelsens Styrke; man passerer alle Stadier fra store Sten, nævere store Sten, Sten som Hønseæg, som Dueæg osv. til grovere og finere Grus, indtil man i det inderste Hjørne af Bugten har en almindelig Sandstrand.

Paa det Sted, hvor Stenene var fra en Hasselnøds til en Valnøds Størrelse, bestemte jeg Talforholdet mellem de Sten, som stammede fra Kystens Klipper, og dem der hidrørte fra Dyrskaller eller Kalkskelet; jeg talte 10 Hundrede Sten og hvert Hundrede udtoget som fire i Blinde tagne Prøver; Resultatet ses i omstaaende Oversigt, S. 8.

Koralsandet og de rundslidte Fragmenter af Koraller og Skaller paa Strandens stammer idetmindste for en væsentlig Del fra den lille Bugs eget Dyreliv; dette er her, som paa de fleste andre Steder i Coral Bay, meget rigt. I en Afstand af



Fig. 2.

Fra Østenden af St. Jan (3. 06). Nordvestsiden af Overhale-Bugten i Coral Bay, set mod Nordøst. Mindre stejl Klippekystr med forholdsvis rig, men sterkt torhedspræget Vegetation. Nederst i Forgrunden en Roset af *Agave Morrisii*; derpaa *Pilocereus Rogenii* og, ovenfor denne, *Plumiera alba* (bladløs); længere tilbage en blomstrende Agave. Den øvrige Vegetation bestod af: *Citharexylum cinereum*, *Bursera simaruba* (næsten bladløs), *Erihalia fruticosa*, *Randia aculeata*, *Ibatia maritima*, *Ipomoea pes-caprae*, *Lantana involucrata*, *Anthacanthus spinosus*, *Canavalia obtusifolia*, *Rhynchosia minima*, *Pithecellobium unguis*, *Serjania polyphylla*, *Comocladia ilicifolia*, *Elaeodendron xylocarpum*, *Melochia tomentosa*, *Euphorbia linearis*, *Croton flavens*, *C. betulinus*, *Melocactus communis*, *Opuntia tuna*, *O. curassavica*, *Cissampelos Pareira*, *Callisia repens* og nogle Græsser.

Bjærgarter	Koraller	Snegle	Muslinger
79	16	4	1
75	19	5	1
69	30	1	0
75	23	1	1
73	25	0	2
72	26	1	1
72	20	5	3
65	32	3	0
81	17	2	0
73	25	0	2
<hr/>			
% 73,4	23,3	2,2	1,1

10—15 Meter fra Stranden begynder en tæt Bevoksning af store Koraller, navnlig en kredsformet, indtil over 1 Meter bred Art, som i Form og Udseende meget minder om en *Polyporus giganteus*; fra en enkelt Stamme udgaar i forskellig Højde brede, flade, lappede Flige, som er graagule, medens de ældre Partier er mere eller mindre mørkt brune. Endvidere store, brune, *Clavaria*-lignende Arter, pude- eller kageformede Mæandriner og flere andre. I og indenfor dette Koralbælte lever en Hærskare af andre Dyr: Snegle, Muslinger, Søpølser, Svampe og Sværme af flere Arter Søpindsvin; at disse sidstes Skaller ikke er repræsenterede i den foran givne Prøve af Strandens Smaasten, hidrører fra, at Søpindsvinenes paa Stranden opkastede tomme Skaller hurtigt føres saa langt op, at de ikke naas af Bølgerne og derfor i Regelen ikke bliver slaaede itu; saa snart en saadan Skal er blevet kastet ind paa Stranden og Bølgen gaar tilbage, løber Vandet ud af Skallen, som derved bliver saa let, at en følgende Bølle, som maatte naa højere op, fører Skallen foran sig tilligemed andet let Materiale, f. Eks. opskyllede Alger og Blade af Havgræsformationens Arter; Søpindsvinenes Skaller findes derfor ofte i Mængde i „Tang“-Striben, hvor de efterhaanden dækkes af opskyllet eller tilblæst Sand.

Paa de store Sten paa Siderne af Bugten findes en tæt Vegetation af forskellige Alger, mellem hvilke der lever en Mængde mindre Dyr; især findes her smukt farvede Albuskæl og Chitonter, og pragtfulde Aktinier; og i den lune Tropenat glimter i Vandet selvlysende Dyr omkap med Genskin af Himlens Stjerner.

Paa Stranden i den inderste Del af Bugten fandtes yderst en svagt udviklet *Pescaprae*-Formation af *Ipomaea pescaprae*, *Sesuvium portulacastrum*, *Sporobolus virginicus* og *Canavalia obtusifolia*, med enkelte *Tournefortia gnaphalodes*, og indenfor denne en smal *Coccoloba*-Formation blandet med Arter fra de tilgrænsende Skraaningers Kratvegetation.

Væsentlig de samme Forhold som i den inderste Del af Popilleaus Bay, nemlig en forholdsvis smal Sandstrand mellem Havet og det højere Land, findes paa mange andre Steder paa vore vestindiske Øer; dog er Sandstranden ofte bredere og dens *Pescaprae*- og *Coccoloba*-Formation rigere udviklet; saaledes f. Eks. i John

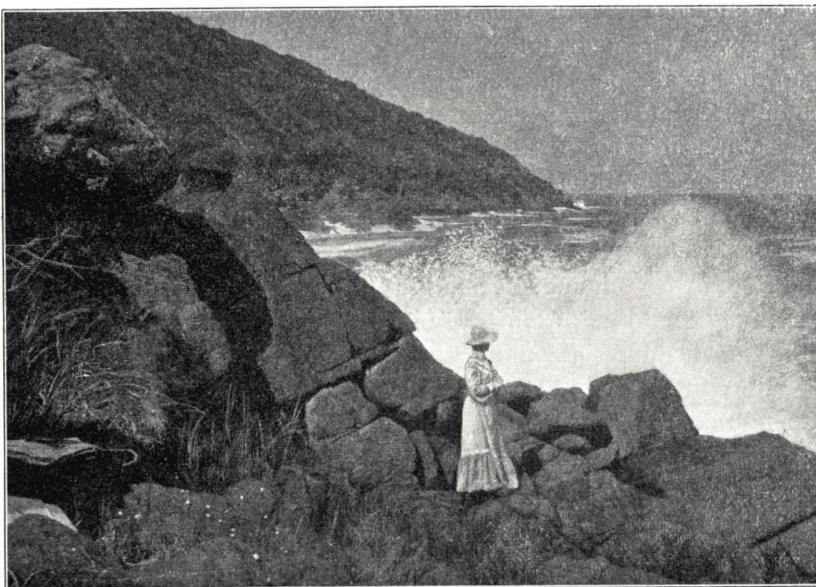


Fig. 3.

Vestkysten af Løvenlund Bay paa Nordkysten af St. Thomas (12. 12. 05). Klippekyst; langs Strandkanten ligger større og mindre Klippeblokke, mod hvilke Bolgerne til Tider brydes saa voldsomt, at det nederste Bælte af Skraaningsens Vegetation vædes af Skumsprojt. Vandet presses ofte højt op mellem Klippeblokkene og medfører Sand, hvorfra Revner og Fordybninger efterhaanden udfyldes; her indfinder sig saa nogle af Sandstrandens Planter, f. Eks. *Sporobolus virginicus*, som ses nederst til venstre paa Billedet.

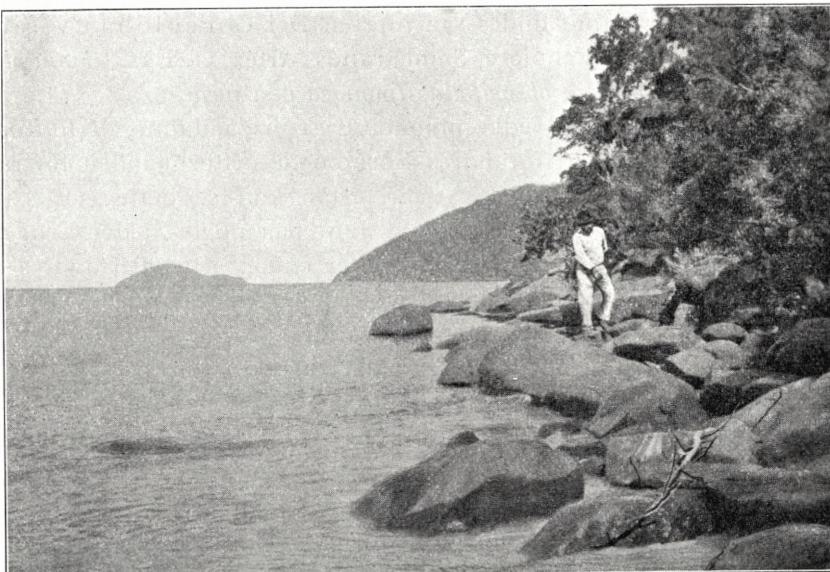


Fig. 4.

Østkysten af Magens Bay (Great Nordside Bay) paa Nordkysten af St. Thomas (8. 12. 05). Klippekyst med Sten og Klippeblokke i Strandkanten.

Bruce Bay og andre Punkter paa Sydsiden af St. Thomas, og paa Vestenden af St. Croix. Fig. 7 viser Sandstranden med *Pescaprae*- og *Coccoloba*-Formationerne som de ser ud paa det sidste Sted i Nærheden af Plantagen „the William“; de mørke Linier i Strandkanten er Randen af en Kalksten af ung Alder, dannet af Sandstrandens Materiale, der er kittet sammen til en fast Stenart; en saadan Kalksten findes paa mange Punkter af Kysten paa St. Croix.

I roligere Bugter, mindre udsatte end den foran skildrede Popilleaus Bay, er der i Regelen opstaaet en Mangrove-Formation (Fig. 8—11) paa den alluviale Bund i Vandkanten, og denne Vegetation bidrager saa yderligere til, at der i Tidens Løb dannes en bredere, lav Strand, idet saa vel Slam som nedskyllet organisk og uorganisk Materiale holdes tilbage og ophobes mellem Mangrovens System af Støtterødder. Men Mangrove-Formationen er heller ikke her den af Strandens Formationer, som først er blevet til; visse af *Coccoloba*-, *Conocarpus*- og *Pescaprae*-Formationens Planter kommer først, navnlig *Conocarpus erectus* og *Coccoloba uvifera*, der i Forvejen er en Bestanddel af den Vegetation, som findes paa de Klipper, ved hvis Fod Stranden er dannet; saa snart der er fremkommet en selv kun ganske smal Strand af nedskyllet Materiale og opskyllet Sand og Sten, tager disse to Arter den straks i Besiddelse. *Conocarpus erectus* har en Fordel frem for *Coccoloba uvifera* deri, at den kan gaa nærmere til Havet, lige til Vandkanten, og den kan derfor gaa ned paa den allerførste, lave Stranddannelse. Paa de Steder paa den beskyttede Kyst, hvor Mangroven endnu ikke har indfundet sig, danner *Conocarpus erectus* derfor i Regelen Vegetationens yderste Bræmme langs Havet. Paa den noget højere og mere tørre Bund indenfor denne Bræmme findes saa ofte en Del *Coccoloba uvifera* og hist og her tillige andre af den højere Sandstrands Arter, f. Eks. *Caesalpinia crista*, *Sporobolus virginicus*, *Canavalia obtusifolia*, *Ipomoea pescaprae* o. a.

Hvis nu Betingelserne paa vedkommende Kyst er saadanne, at *Rhizophora* kan trives og den indfinder sig der, forandres Forholdene; efterhaanden fortrænges den udsatte, solaabne Sandstrands typiske Arter. Man kan se dette f. Eks. i Otters Creek og Water Creek i Coral Bay paa St. Jan; paa nogle Steder hvor Mangrove-Bæltet, af Grunde jeg ikke kender, var lavt eller endog afbrudt, fandtes enkelte af Sandstrandens Arter paa Stranden; men hvor Mangroven dannede en høj og tæt Bevoksning, var Sandstrandens Planter forsvundne fra det sandede eller stenede Terræn langs Klipernes Fod og Pladsen optaget af *Conocarpus*-Formationens Arter; højere oppe paa Klipperne voksede *Coccoloba*. Den solaabne Sandstrands Planter er Lysplanter, og det er vel nok især den Skygge, som Mangrove- og *Conocarpus*-Formationens Fanerofyter giver, der her fordriver *Coccoloba*- og *Pescaprae*-Formationens typiske Repræsentanter.

Paa de fleste Steder er Terrænforholdene jo saadanne, at Bugterne fortsættes som mere eller mindre udprægede Dalstrøg eller Lavninger op mellem de omgivende lave Bjerge; i Dalenes Bund findes et stenet Bækleje, „Gut“, der, bortset

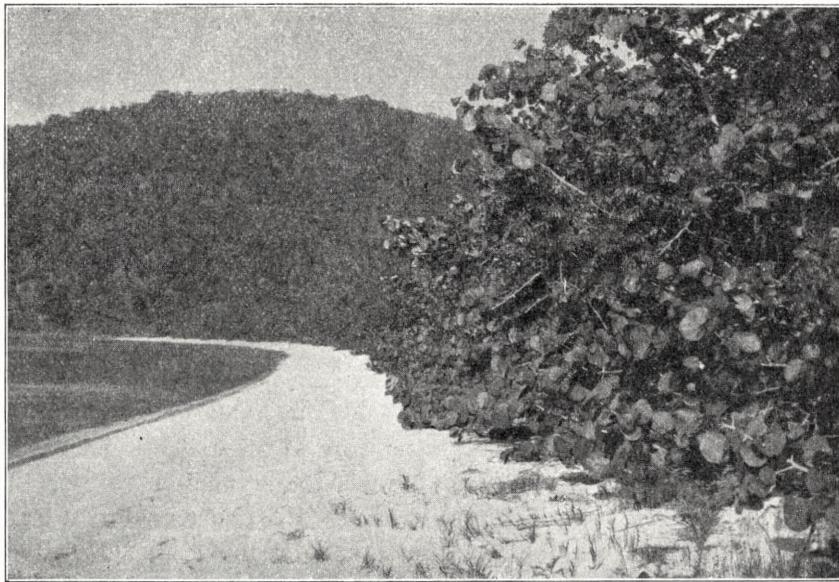


Fig. 5.

Sandstrand i Bunden af Magens Bay (Great Nordside Bay) paa Nordkysten af St. Thomas, set mod Øst (12. 05). Længst tilhøjre ses Coccoloba-Formationen, her næsten alene dannet af *Coccoloba uvifera*, kun hist og her med lidt *Caesalpinia cristata* (i Forgrunden tilhøjre) og enkelte andre Arter. Coccolobaens nederste Grenे hviler paa Sandet og er ofte rodslaende. Sandstranden udenfor Coccoloba-Formationen er ganske smal, 4–7 M. bred, og paa sine Steder naar Bølgerne ofte op lige til Coccoloba-Formationen. I denne findes hist og her nogle af Pescaprae-Formationens Arter (*Sporobolus virginicus*, *Ipomaea pescaprae*, *Canavalia obtusifolia*), men en selvstaendig Pescaprae-Formation er ikke udviklet her; kun lige i Forgrunden begynder Pescaprae-Formationen at vise sig, her alene repræsenteret af *Sporobolus virginicus* med vidt krybende underjordiske Udløbere, hvorfra der med bestemte Mellemrum skyder Løvbladskud op over Sandet; længere mod Vest faar vi efterhaanden en normal Pescaprae-Formation (se Fig. 6). Tilhøjre for Coccoloba-Formationen findes et ret stort, mere eller mindre fugtigt, af en *Conocarpus*-Formation dækket Terræn, dannet af den inderste Del af Bugten, som ved den Sandrevle, som Coccoloba-Formationen staar paa, i sin Tid er blevet adskilt fra Havet og efterhaanden udfyldt af Sand og andet Materiale dels indskyllet fra Havet dels nedskyllet fra de omgivende Højder. I Baggrunden, hvor den hvide Sandstrand bojer tilvenstre og holder op, begynder Østkystens Klippekyst, og fra dette Sted stammer Fig. 4.

fra enkelte Bække paa St. Croix, er ganske tørt den meste Tid af Aaret eller kun med enkelte Vandpytter i Fordybninger i Klippebunden; men i Regntiden bruser der ned gennem disse „Gut“er rivende Bjærgbække, der fører Materiel af forskellig Art ud i Bugterne; derved og ved opskyllet Sand fra Havet bliver Stranden i Bunden af Bugterne efterhaanden langt bredere end langs Bugternes Sider. Hvor denne Tilvækst foregaar jevnt, idet de nye Sandmasser aflejres i Sammenhæng med de ældre, er Vegetationsforholdene væsentlig som de foran skildrede; paa utsat Kyst, hvor Havet kan føre Sandet højere op, og hvor den nydannede Bund derfor er løs og tør, faar vi en *Pescaprae*- og en *Coccoloba*-Formation; i de roligere Bugter, derimod, hvor den nydannede Bund er lavere og fugtigere og oftest tillige dannet af finere Materiale, faar vi, foruden en *Mangrove*-Formation eller dog en *Laguncularia-Conocarpus*-Bræmme, en *Conocarpus*-Formation, der indefter grænser op til Bakkeskraaningerne Kratvegetation.

Paa de mest beskyttede Steder bliver den ny Jord i større eller mindre Grad, undertiden næsten udelukkende, dannet af Ler og fine Kalkpartikler, idet Havet til Tider gaar op over disse lave Strækninger medførende Ler- og Kalkslam, hvorved Bunden langsomt højnes; men paa Grund af, at Regnvandet tillige ofte skyller grovere Materiale ud over disse Sletter og der i uroligt Vejr desuden kan skyldes Sand ind fra Havet, kan Bunden her ofte være ret vekslende baade i Højde og Beskaffenhed, og det forstaaes, at der ofte bliver Betingelser for en Blanding af *Conocarpus*-Formationens og *Coccoloba* + *Pescaprae*-Formationernes Arter. Ved en af de smaa Bugter, nær Bovoni, i det Indre af Jersey Bay (Fig. 11) paa St. Thomas, var Forholdet følgende:

- 1) ud i Havet en frodig *Mangrove*-Bevoksning;
- 2) i Strandkantens Slambund et 4—5 Meter højt *Avicennia*-Bælte med *Laguncularia*; Bunden næsten ganske dækket af *Avicennia*'s Aanderødder;
- 3) temmelig fugtig, ganske jevn Lerslette, dels helt bar, dels med *Batis maritima*;
- 4) lidt højere, sandet Bund med *Sporobolus virginicus* og enkelte Individer af *Heliotropium curassavicum*, *Acacia Farnesiana*, *Antherygium Rohrii* og *Rhacoma cossopetalum*;
- 5) derpaa xerophil Mikrofanerofyt-Vegetation paa de omgivende lave Højder.

De tre første Facies hører til *Mangrove*-Formationen. No. 4 er *Conocarpus*-Formationen, men paa dette meget begrænsede Omraade uden *Conocarpus*, der iøvrigt fandtes i Mængde paa lignende Terræn i Nærheden.

Andre Steder foregaar Tilvæksten ikke stedse i Sammenhæng med det allerede dannede, idet det tilførte Materiale ikke altid aflejres paa eller langs med Kysten. Ofte har Havet opkastet en Sandvold tværs over en Bugt enten ved dens Munding, f. Eks. Krauses Lagune paa St. Croix, eller længere inde, f. Eks. i Magens Bay

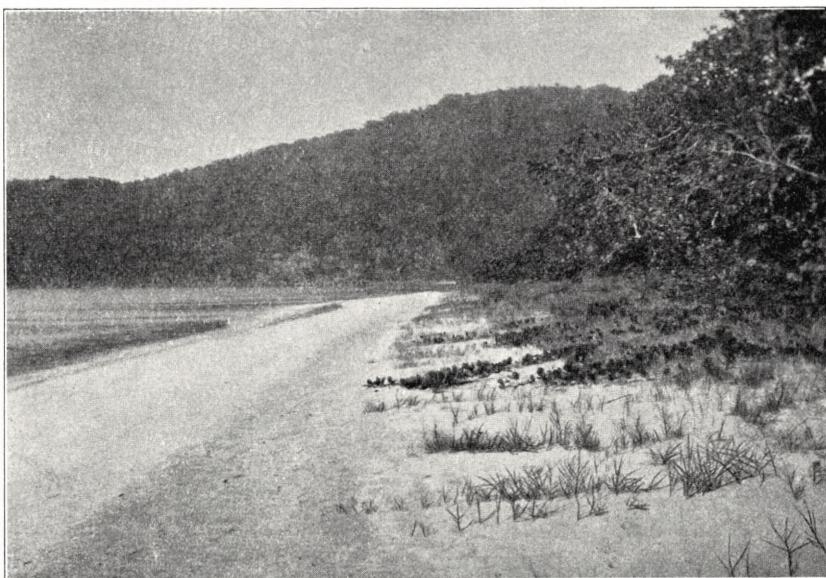


Fig. 6.

Sandstrand i Bunden af Magens Bay (Great Nordside Bay) paa Nordkysten af St. Thomas, længere mod Vest end Billedet i Fig. 5 men ligesom dette set mod Øst (12. 05). Stranden er her noget bredere end i Fig. 5, og udenfor Coccloba-Formationen (tilhøjre) findes en udpræget Pescaprae-Formation dannet især af *Sporobolus virginicus*, hvori ses *Ipomoea pescaprae*, *Canavalia obtusifolia* og, ind mod Coccloba-Formationen, *Euphorbia buxifolia*. Mellem Pescaprae-Formationen og Flodlinien (nederste Hjørne tilvenstre) et ganske smalt vegetationsløst Bælte med tunnelgravende Staphyliner.

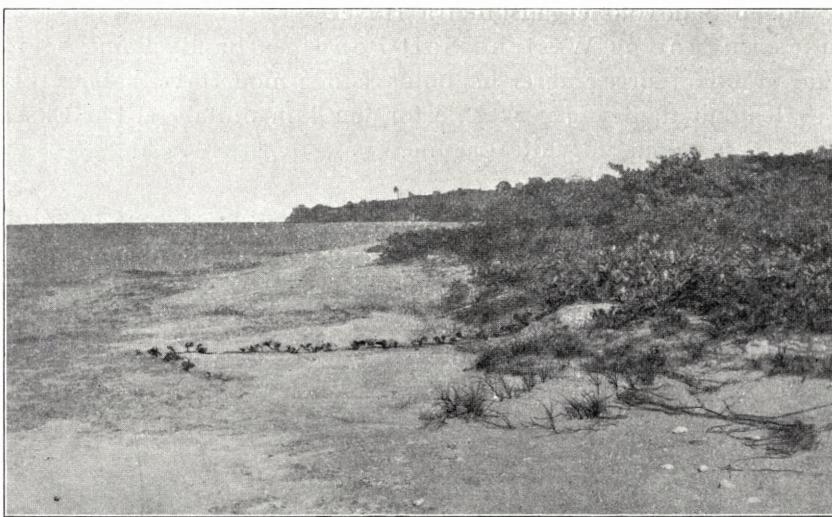


Fig. 7.

Vestkysten af St. Croix ud for Plantagen „the William“, set mod Nord (1. 06). Længst tilhøjre: Coccloba-Formationen navnlig dannet af *Coccloba uvifera*, *Hippomane mancinilla* og *Caesalpinia crista*; derefter Pescaprae-Formationen, hvori ses *Sporobolus virginicus* og *Ipomoea pescaprae*, af hvilken sidste et Skud ses at næsten lige til Havet. Den mørkere Linie i Strandkanten længere tilbage er Randen af en Kalksandsten af nyere Oprindelse.

paa St. Thomas og i Great Cruz Bay paa St. Jan. Selv om en saadan Sandvold til en Tid har været sammenhængende og har helt aflukket Bugten, vil den i visse Tilfælde senere blive gennembrudt, nemlig hvor der i Regntiden tilføres den af Sandvorden inddæmmede Del af Bugten saa meget Vand, at det gennembryder Sandvorden paa et eller flere Steder; der bliver paa denne Maade dannet en Lagune med roligt Vand; ved nedskyllet Materiale og ved Ler og Kalkslam, som Havet fører ind i Lagunen, udfyldes denne lidt efter lidt, saa at Bunden tilsidst, først langs Bredderne senere overalt, højnes saa meget, at den kun paa visse Tider staar under Vand; man ser i Dansk Vestindien saadanne Laguner paa alle mulige Trin af Udfyldning og Tørlægning; om denne sidste skyldes Udfyldning alene eller om den tillige hidrører fra en langsom Hævning af Øerne, ved jeg ikke, men den relativt betydelige Højde af idetmindste tilsyneladende gammel Lagunebund ved Krauses Lagune tyder paa en Hævning.

I en stor Mængde Tilfælde, endelig, er den fra Havet ved en Sandvold afgrænsede Del af en Bugt ganske uden Forbindelse med Havet, fordi der, paa Grund af Terrænforholdene, ikke i Regntiden tilføres den saa meget Vand, at dette kan gennembryde Sandvorden; derimod kan, idetmindste for nogle Vedkommende, Havet til Tider skylle over Sandvorden. De paa denne Maade dannede Strandsøer, Salt Ponds, udfyldes efterhaanden af nedskyllet Materiale. Nogle af dem er nu saa lavvandede, at de i Tørtiden er fuldstændig tørlagte, saa at man kan gaa hen over den flade, lerede, vegetationsløse Bund; saaledes f. Eks. en Salt Pond ved Smiths Bay paa St. Thomas. Da jeg kun har undersøgt Forholdene ved en Brøkdel af de mange Strandsøer i Dansk Vestindien, ved jeg ikke, hvor vidt det gælder dem alle, at de kun ved en Sandvold er adskilt fra Havet.

Krauses Lagune og Westend Salt Pond paa Sandy Point, som jeg straks nærmere skal omtale, repræsenterer henholdsvis den mod Havet aabne, ikke udfyldte Lagune og Salt Pond-Stadiet; jeg skal derfor her kun omtale et Par Eksempler paa den helt eller næsten helt udfyldte Lagune.

Great Cruz Bay paa St. Jan.

Denne Bugt fortsættes indefter i et lavt Terræn, som sikkert nok tidligere har været en Lagune, men som nu er udfyldt saa meget, at Bunden ligger højere end Havet og er uden Spor af Vand paa nær den laveste Del af et Løb, gennem hvilket Regnbækken har Udløb til Havet; saaledes var Forholdet i alt Fald, da jeg i Februar 1906 besøgte Stedet. Den opfyldte Lagune er adskilt fra Havet ved en 30—50 Meter bred Sandvold med et Bælte af rullede Sten i Strandkanten. Kun et enkelt Sted, ved det omtalte Løb, fandtes lidt *Ipomaea pescaprae*; bortset herfra bestod den yderste Vegetation af et tæt Bælte af *Coccoloba uvifera*; desuden var Sandvorden bevokset med *Acacia Farnesiana*, *Caesalpinia crista*, *Canella alba*, *Colubrina ferruginea*, *Pithecellobium unguis-cati*, *Erihalis fruticosa*, *Argythamnia candicans*, *Stigmatophyllum periplocifolium*, *Solanum racemosum*, og, især ned mod Løbet, *Laguncularia racemosa*.

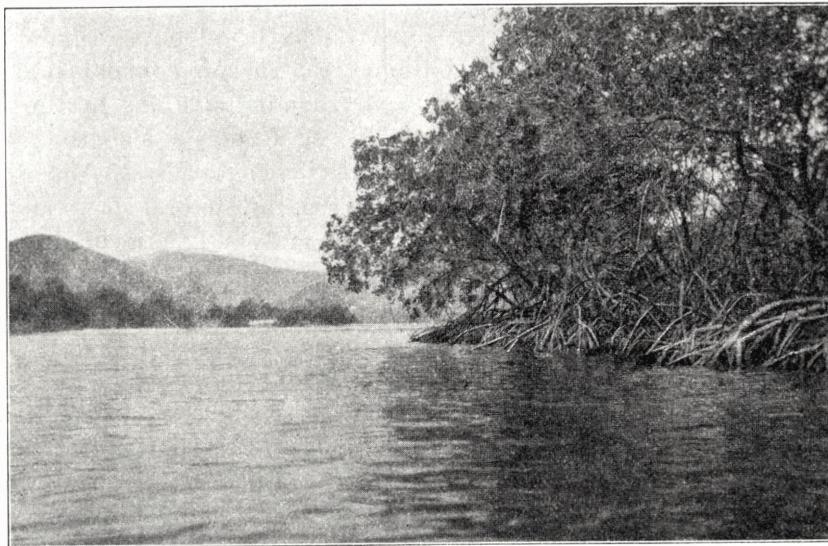


Fig. 8.

Fra Østenden af St. Jan (2. 06). Mangrove-Formation langs Østsiden af Kølhale-Bugten i Water Creek.

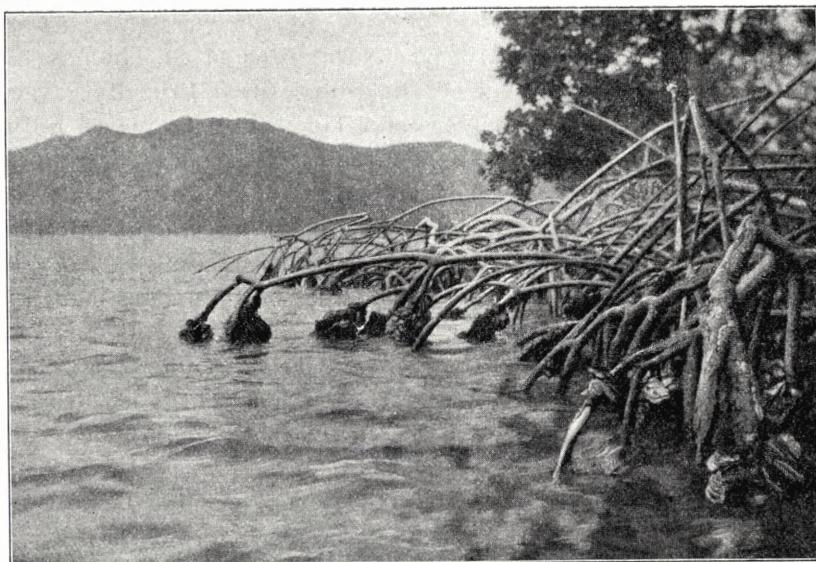


Fig. 9.

Fra Østenden af St. Jan (2. 06). Den yderste Rand af Mangrove-Formationen paa Nordsiden af Otters Creek.
I Vandskorpen ses Knipper af Muslinger paa Mangrove-Rødderne. Bordeaux Hill i Baggrund.

Af det indenfor Sandvolden liggende Terræn er den Del, som ligger umiddelbart indenfor Sandvolden, lavest, og Bunden er her for en meget væsentlig Del dannet af organisk Materiale, Blade og Kviste, dels fra den paa Stedet voksende, meget frodige Vegetation dels fra Vegetationen paa de omgivende Højder. Skønt Bundens Overflade laa en Del over Grundvandet, fandtes der dog her en meget tæt Bevoksning af *Rhizophora mangle*, den højeste og frodigste Mangrove-Vegetation, som jeg overhovedet har set i Dansk Vestindien; den var 9—15 Meter høj, med overordentlige talrige og kraftige Støtterødder (Fig. 10), hvoraf de øverste udgik i en Højde af c. 9 Meter. Bunden var dækket af et tykt Lag nedfaldne Blade, de øverste tørre, de nederste mere eller mindre fugtige; mellem disse lidt fugtige Blade fandtes et rigt Dyreliv; blandt andet fandtes her en Amphipod-Art og tillige en indtil c. 4 Ctm. lang, til Tandkarpernes Familie hørende Fisk, som Prof. H. JUNGERSEN har bestemt som *Haplochilus Hartii* Boulenger. Naar man rodede op i Løvet, saa man det sprællende Dyr bevæge sig meget hurtigt, og det var vanskeligt at fange det, især fordi det hurtigt skjulte sig under Bladene. Da der ikke mellem Løvet her fandtes Spor af draabeflydende Vand, maa denne Fisk ligesom Amphipoden antages at være indrettet paa at kunne aande og leve i fugtig Luft.

Indenfor *Rhizophora*-Bevoksningen, hvor Bunden var lidt højere og mindre rig paa organiske Bestanddele, fulgte et Bælte af indtil 10 Meter høje *Avicennia nitida*, med særdeles talrige, 15—30 ctm. lange, undertiden indtil $\frac{1}{2}$ Meter lange Aanderødder. Paa den højere, mere tørre og mere sandede Bund indenfor *Avicennia*-Bevoksningen fandtes en ret aaben, men høj og frodig Vegetation af *Bucida buceras* (indtil c. 18 M. høj), *Antheryllum Rohrii*, *Acacia Farnesiana*, *Andira jamaicensis*, *Melicocca bijuga*, *Ficus populnea* o. fl. a.

Magens Bay (Great Nordside Bay) paa Nordkysten af St. Thomas.

Den inderste Del af denne Bugt er, ligesom i Great Cruz Bay, ved Sandvold bleven adskilt fra Havet som en Lagune, der i Tidens Løb er bleven udfyldt, saa at der nu kun findes lidt Vand paa et lille Omraade, hvorigennem Regntids-Bækkene har Udløb til Havet. Sandvolden er dækket af en tæt *Coccoloba*-Formation; nogle Steder gik denne lige ud til Havet, saa at der kun var 1—1,5 Meter mellem *Coccoloba*-Bevoksningen og den Linie, som naaedes af Bølgerne, der her rullede opad en jevn Skraaning paa 3—5 Meters Bredde; paa dette Sted fandtes ikke Spor af *Pescaprae*-Formationen (Fig. 5). Paa de fleste Steder, derimod, var Afstanden mellem *Coccoloba*-Formationen og Havet større, dog kun nogle faa Meter, og her fandtes en smal *Pescaprae*-Formation (Fig. 6) dannet af de overjordiske udlobende Skud af *Ipomaea pescaprae* og af de underjordisk vandrende Skud af *Sporobolus virginicus*; desuden *Euphorbia buxifolia*, *Canavalia obtusifolia* og *Cenchrus echinatus*. Umiddelbart ved den Linie, hvortil Bølgerne naaede, fandtes flere Steder ganske lave, indtil et Par Mm. høje, af tørt og løst Sand dannede Forhøjninger, frembragte af smaa *Staphyliner*, som fandtes i Sandet; altsaa det samme Fænomen som paa danske Sandstrande, f. Eks. paa Vestkysten af Fanø, hvor gang-

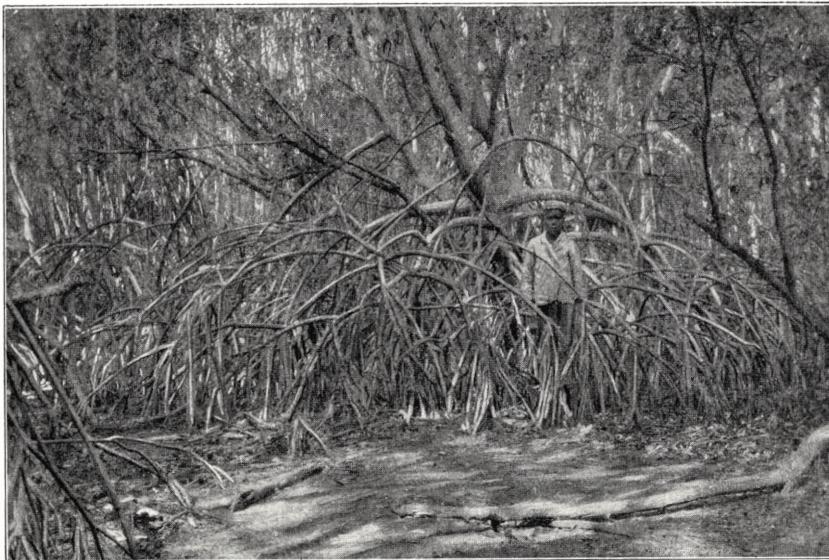


Fig. 10.

Fra Great Cruz Bay paa Vestenden af St. Jan²(2. 06). Fra det Indre af en meget frodig Rhizophora mangle-Bevoksning, som stod paa fugtig, men ikke vanddækket Bund.

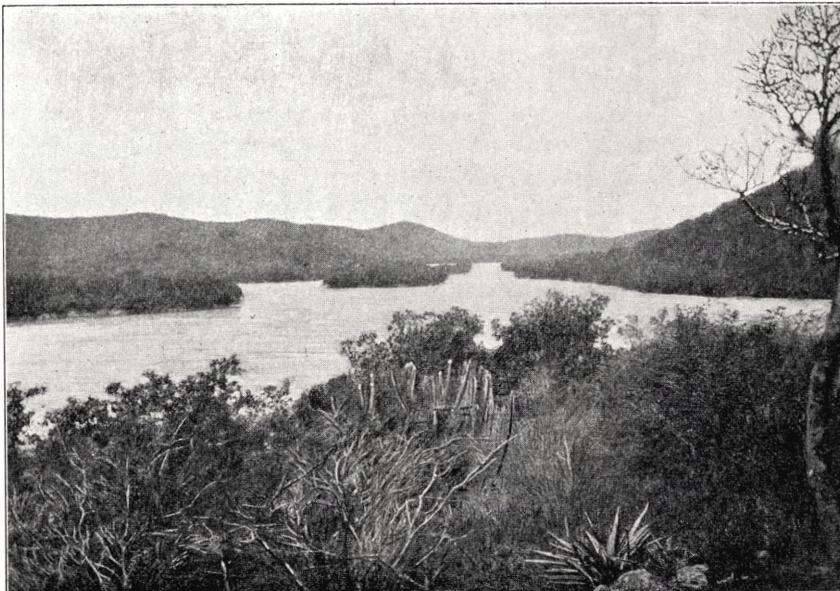


Fig. 11.

Fra Østenden af St. Thomas (5. 06). Udsigt over Yersey Bay fra et Punkt i Nærheden af Nadir. Holmene og den mørkere Bræmme langs Kysterne er Mangrove-Formationen. Det højere Terræn i Forgrunden er dækket af Croton Krat, hvori ses *Pilocereus Royenii* og *Agave*.

gravende smaa Biller spiller en stor Rolle ved Kltdannelsen, idet de af Billerne frembragte Smaahøjes Sand tørre meget hurtigere end Sandet i den omgivende forholdsvis faste Bund, og hvor det derfor først og fremmest er disse smaa Højes Sand, som føres bort af Vinden og tjener til de nye Klitters Vækst.

I Coccoloba-Formationen fandtes foruden *Coccoloba uvifera* især *Caesalpinia crista*, *Dalbergia hecastophyllum* og klattrende *Canavalia obtusifolia*. Paa Terrænet indenfor Sandvolden findes jevn Overgang fra vanddækket Bund til høj og ret tør, mere eller mindre sandet Bund, med en frodig Bevoksning af *Conocarpus*-Formationens Arter.

KRAUSES LAGUNE.

Krauses Lagune (eller Anguilla Lagune, som den ogsaa kaldes) ligger paa Sydsiden af St. Croix og er den største Lagune i Dansk Vestindien; den er dannet af en c. 3 Kilometer bred Bugt adskilt fra Havet ved en Sandrevle, der er gennembrudt paa et Par Steder, hvor Lagunen saaledes staar i Forbindelse med Havet. Denne Lagune har ikke alene særlig Interesse paa Grund af sin Størrelse men tillige derved, at der her i nyeste Tid er foregaaet store Forandringer, idet

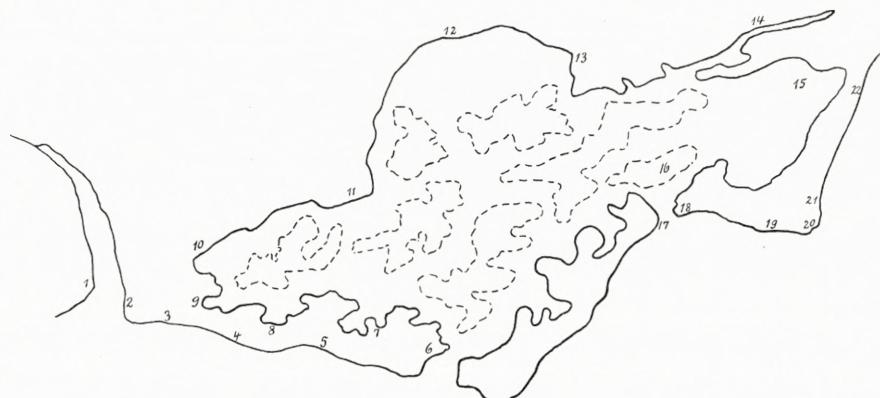


Fig. 12.

Krauses Lagune; efter Oxholms Kort over St. Croix, 1828. De med punkteret Linie begrænsede Pletter i Lagunen er paa Oxholms Kort betegnede som Skov-(Mangrove-)Holme, der nu alle er dræbte og enten fjernede, saaledes i den vestlige Del af Lagunen (se Fig. 14), eller, som i Lagunens østlige Del, endnu tilstede som døde Stammer (se Fig. 15). Angaaende Tallene se Teksten.

den tidligere frodige Mangrove-Vegetation er blevet ganske tilintetgjort som Følge af en Orkan i 1899. For at man kan have et Holdepunkt ved Undersøgelser over Forholdenes Udvikling i Fremtiden, vil jeg her, saa vidt mine Iagttagelser rækker, give en Skildring af Forholdene som de var, da jeg i Januar og Februar 1906 besøgte Stedet. Ved denne Skildring har jeg stærkt følt Savnet af et helt tilforladeligt Kort, idet Fremstillingen paa Oxholms Kort over St. Croix paa flere Punkter er i Uoverensstemmelse med de nuværende Forhold og vel aldrig har været fuldt korrekt, f. Eks. med Hensyn til Udstrækningen af de Mangrove-Holme, der tidligere laa spredt i Lagunen. Men i Mangel af noget bedre har jeg maattet benytte dette

Kort ved den følgende Fremstilling, og hvad Hovedtrækkene angaaer lader dette sig ogsaa gøre. Saa vel efter dette Kort som efter de korte Beskrivelser, som Eggars og senere Børgesen har givet, har Lagunen været omkranset af en Mangrove-Vegetation, og tillige har der ligget en Del Mangrove-Holme ude i Lagunen. EGGERs siger (l. c. S. 20), at Lagunen „er tæt overgroet med Mangrovekrat og er i Færd med at udfyldes“; og BØRGESEN skriver (l. c. S. 28): „Her har jeg ogsaa set de mest udstrakte Mangrovebevoxninger. Ved en lille Bæk i den vestlige Del af Lagunen besøgtes saaledes en udelukkende af Rhizophora dannet Skov . . . ret høj, aldeles skyggefuld Skov, under hvis Løvtag man, saa langt ses kunde, kun saa Luftrod ved Luftrod“. Børgesen giver tillige et Fotografi af Lagunen, set fra det højere Land; man ser her ikke alene Mangrovebevoksningen langs Bredden men tillige Mangrove-Holmene ude i Lagunen. Alt dette er nu ganske forandret.

Ude ved Mundingen af den smalle Bugt, hvori Kinghill Gut løber ud, er der paa Vestsiden (ved 1 paa hosføjede Kort) en Mangrove-Vegetation, og ovenfor denne, paa det tørre Terræn, en lav mikrofanerofyt Vegetation. Paa det aldeles tilsvarende Sted paa Østsiden af Bugten (2 i Fig. 12) skæres der bort af den løse, sandede Bund, og der findes her en stejl, c. $1\frac{1}{2}$ Meter høj Brink; Terrænet øst herfor, mellem 2, 3 og 9 og nordefter, er dækket af en mikrofanerofyt-nanofanerofyt Formation, hvis væsentligste Bestanddel bestaar af Arter af Kaktus, *Croton* og *Acacia*; desuden en Mængde andre Arter, f. Eks. *Haematoxylon campechianum*.

Paa den lave, smalle, af Sand dannede Halvø, som skiller den vestlige Del af Krauses Lagune fra Havet, er Vegetationens Sammensætning meget vekslende efter Bundens Højde. Bunden falder jevnt til begge Sider, navnlig mod Lagunen, desuden er Sandrevlens Midtparti af forskellig Højde paa forskellige Steder. Paa tilsvarende Lokaliteter ved vore danske Kyster findes under saadanne Forhold en Række udprægede Vegetations-Facies, idet Arterne her ordne sig næsten alene efter Jordbundens af Højden betingede forskellige Fugtighedsgrad; her er nemlig Lysforholdene væsentlig de samme overalt, idet Planterne er omtrent af ens Højde, idetmindste er der ingen, som i fremtrædende Grad skygger over de andre. Anderledes paa den nævnte Lokalitet i Vestindien ved Krauses Lagune. Naturligvis bestemmes Arternes Plads ogsaa her af deres Fordringer til Jordbundens Fugtighed; men da en stor Mængde af Arterne her er træagtige og forholdsvis høje, saa at de kommer til at skygge over andre, kommer ved Arternes Fordeling Lysforholdene til at spille en langt større Rolle end paa vore Strande. Hvor Jordbundens Højde frembyder mange Forskelligheder indenfor korte Strækninger, kommer de større Arter til idetmindste delvis at fortrænge de mindre fra de Pladser, hvor de ellers hører hjemme; Fordelingen i Facies bliver følgelig her ikke saa i Øjne faldende og ikke nær saa fint nuanceret som hos os, hvor Materialet er finere, ø: Arternes Individer mindre og ikke saa forskellige i Størrelse.

Langs Havsiden af Sandrevlen er der saa meget Læ for Passaten, at en Mangrove-Vegetation kan trives paa den lavvandede Bund langs Kysten endog et godt Stykke ud i Havet, medens der ikke findes en saadan Mangrove-Vegetation udenfor

den for Passaten udsatte Kyst langs Sandrevlen, der adskiller den østlige Del af Lagunen fra Havet.

Allerede ved 3 (se Kortet Fig. 12) ses enkelte smaa Mangrove-Holme og enkelte ganske unge Mangrove-Planter udenfor Kysten; langs denne findes her en 1—2 Meter bred Strandkant af Koralsand, hist og her med *Sporobolus virginicus* og *Sesuvium portulacastrum*, og paa nogle Steder fandtes her i Vandkanten tillige smaa Individer af *Laguncularia racemosa* og *Avicennia nitida*, Begyndelsen til den *Laguncularia-Avicennia*-Facies, som findes langs Strandkanten længere ude. Derefter følger, paa et noget højere Terræn, en faa Meter bred *Sporobolus virginicus*-Facies med spredte *Heliotropium currassavicum*, *Batis maritima*, *Borrichia arborescens*, *Ipomaea pescaprae* og *Canavalia obtusifolia*; derpaa en lav Fanerofyt-Vegetation, som paa

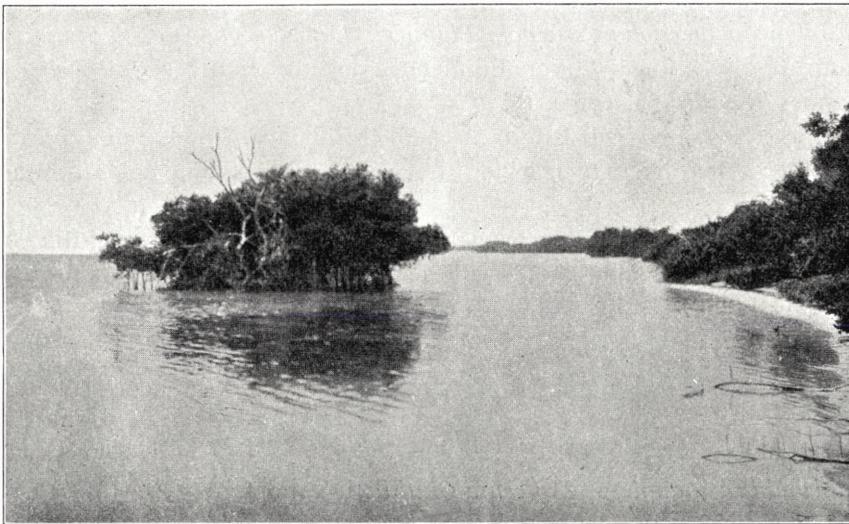


Fig. 13.

Havssiden af den Sandrevle, som begrænsrer Krauses Lagune mod Sydvest, set fra 5 (se Kortet Fig. 12) mod Nordvest. Langs Kysten *Laguncularia racemosa* og *Avicennia nitida* med Aanderødder; ude i Havet en Mangrove-Holm, delvis udgaaet. (4. 2. 06).

dette Sted for en væsentlig Del var dannet af Mancinil (*Hippomane macinilla*). Indenfor dette højere Sandterræn følger en Lavning, hvis Bund dels er lerblandet Sand dels sandblandet Ler og dækket af en tæt *Sporobolus virginicus*-Bevoksning; paa de laveste Steder staar lidt Vand med *Ruppia rostellata*; langs Bredden et Bælte af *Philoxyrus vermicularis*. Denne Lavning synes at være en tidligere Fortsættelse af den med 9 (se Kortet) betegnede Bugt fra Lagunen, og man faar den Tanke, at Kingshill Gut maaske her engang har haft Udløb i Lagunen; dog har jeg ikke haft Lejlighed til nærmere at følge Terrænforholdene; det tornede, tildels uigennemtrængelige Krat lægger i høj Grad Hindringer i Vejen for en saadan Undersøgelse.

Ved 4 (se Kortet) findes langs Kysten et bredt Bælte væsentlig dannet af *Conocarpus erectus*; hist og her er Bundnen saa lav, at der staar lidt Vand over den;

andre Steder er den lidt højere og her med en aaben Vegetation af *Batis maritima*, *Sesuvium portulacastrum*, *Salicornia ambigua*, *Heliotropium curassavicum* og *Sporobolus virginicus*; paa Lagune-Siden (ved 8) findes store Strækninger af fugtig Bund, dannet af Koralsand og Kalkslam og bevokset med *Salicornia* og *Batis* eller ganske vegetationsløs.

Ved 5 og 7, i Retning fra Havet og ind mod Lagunen, var Forholdet følgende:

1. Udenfor Kysten, i det lave Vand, en *Rhizophora mangle*-Facies, dannet af smaa Mangrove-Holme (Fig. 13) og mange Kimplanter af *Rhizophora*.
2. Langs Strandkanten en Bræmme af *Rhizophora mangle*, *Avicennia nitida*, *Laguncularia racemosa* og *Conocarpus erectus*, den sidste inderst.
3. Den noget højere Sandvold med *Hippomane mancinilla*, *Dalbergia hecastophyllum*, *Borrichia arborescens* (i stor Mængde), *Sporobolus virginicus*, *Euphorbia buxifolia*, *Scaevola Plumieri*, *Lantana odorata* og *Batis maritima*.
4. Ind mod Lagunen bliver Bunden lavere og fugtigere med en *Avicennia*-Facies med *Batis*.
5. *Batis*-Facies, paa en Bund af vaad Kalkslam, med *Salicornia*, som paa nogle Steder har Overvægten over *Batis*; desuden enkelte *Avicennia* og *Sesuvium*.
6. Store Strækninger uden Vegetation; Bunden, som væsentlig bestaar af Kalkslam, er ved at slaa Revner paa Grund af Tørken; enkelte Kimplanter af *Rhizophora*.
7. Den lavvandede Lagune. Et Sted skyder et lidt højere Terræn sig ud i Lagunen med større Buske af *Avicennia* og *Laguncularia*.

Ude ved Udløbet ved 6 (se Kortet), endelig, var Forholdet følgende, fra Havet ind mod Lagunen:

1. *Rhizophora mangle* og *Avicennia nitida* i Vandet.
2. Lav Strand med *Laguncularia* og *Batis*.
3. Lidt højere Bund med *Borrichia arborescens*, *Conocarpus erectus* og *Sporobolus virginicus*.
4. *Sporobolus* med *Batis maritima*, *Sesuvium portulacastrum*, *Philoxyerus vermicularis*, *Capraria biflora* og *Canavalia obtusifolia*.

Derpaa, ud mod Lagunen:

5. *Conocarpus erectus*-Facies.
6. *Laguncularia* + *Avicennia*-Facies.
7. *Rhizophora*-Facies i Vandet.

Bortset fra Kimplanter og fra den svage Mangrove-Bevoksning paa Indersiden af Sandrevlen, der begrænser Lagunen mod Sydvest, findes i den vestlige Del af Lagunen hverken levende Mangrove-Bevoksning eller Rester af den gamle, som Følge af Orkanen 1899 dræbte Mangrove, der tidligere dels omkransede Lagunen dels laa som Øer ude i denne; den dræbte Mangrove var, efter sigende, blevet hugget om og benyttet som Brændsel. Langs Nordsiden af Lagunen saas endnu

enkelte Stubbe i Vandet; hist og her saas forøvrigt enkelte ganske unge Kimplanter af *Rhizophora mangle* som en første Ansydning af en fremtidig Mangrove-Bevoksning.

Indenfor 10—11—12 (se Kortet) har Orkan-Søen ædt sig ind i det noget højere Land, der omgiver Lagunen; Grænsen er derfor her skarp, dannet af en ved 10 indtil meterhøj men mod Øst langt lavere Brink. Mellem denne og Vandet i Lagunen ligger lave, flade, indtil flere Hundrede Meter brede Strækninger, hvis Bund bestaar af Ler og Sand af vekslende Blanding og som, idetmindste mod Vest, er ganske vegetationsløse; mod Øst bliver Brinken lavere og lavere og forsvinder ved 12 næsten ganske; samtidig begynder der at vise sig en lav Vegetation hist og her paa Strandsletten.



Fig. 14.

Nordsiden af Krauses Lagune, mellem Punkterne 11 og 12 paa Kortet Fig. 12, set mod Øst over den nordlige Del af Lagunen. I Randen af Lagunen ses Stubbe af den i Orkanen 1899 dræbte, nu borthuggede Mangrove-Bevoksning og desuden ganske unge, levende Individer af *Avicennia nitida* og *Rhizophora mangle*. Indenfor Lagunen ses en vidstrakt, flad, i Tørken revnet Lerslette med Grupper af *Batis maritima* og *Salicornia ambigua*. (2. 06).

Mellem Punkterne 11 og 12 (se Kortet Fig. 12) var Forholdet, fra Lagunen og indefter, følgende (Fig. 14):

1. Lagunen med enkelte Træstubbe i Vandet og enkelte ganske unge Planter af *Avicennia* og *Rhizophora*; ind mod Land smaa Holme med *Batis maritima*; den nu vanddækkede Bund ligger aabenbart undertiden tør, thi Bunden viste et System af Revner, der begrænsede 5—7-kantede Felter af 5—20 Centimeters Diameter.
2. Land; c. 20 M. bred *Batis*-Vegetation, i den yderste Del tæt, indefter aaben, til sidst kun ganske enkelte Individer. Hist og her er *Batis* blandet med *Salicornia ambigua*. I den yderste Rand af *Batis*-Vegetationen findes ofte

en stor Mængde *Sesuvium portulacastrum* og enkelte ganske unge Individer af *Avicennia nitida*. Paa mange Steder er Bunden revnet og danner polygonale Felter.

3. 50—80 M. bred, vegetationsløs Lerslette, hvis Bund synes at være lidt lavere end i 2 og uden Revner.
4. Noget højere Terræn, 180—250 M. bredt, med en aaben Bevoksning af *Sporobolus virginicus*; Bunden ses mellem Planterne; her tillige en stor Mængde *Batis maritima*, der paa de laveste Steder er eneherskende. Desuden c. meterhøje Buske af *Conocarpus erectus*, endvidere *Evolvulus nummularia*, *Capraria biflora*, *Lippia nodiflora*, *Cynodon dactylon*, *Opuntia tuna*, *Sesuvium portulacastrum*, *Heliotropium curassavicum*, *Portulaca oleracea* og *Salicornia ambigua*. Som man ser en ret broget Blanding af Arter, men her er endnu ingen eller dog kun ringe Konkurrence. Overladt til sig selv vil denne Bund sikkert nok efterhaanden blive bevokset med *Conocarpus*-Formationens Fanerofyter ligesom det næste, under 5 omtalte Terræn.
5. 2—4 Meter høj *Conocarpus*-Vegetation paa en af *Sporobolus virginicus* dækket Bund; desuden nogle andre Arter fra foregaende Facies f. Eks. *Evolvulus nummularia* og *Heliotropium curassavicum*.
6. Højere Terræn, vistnok gammel, hævet Lagunebund, med xerofilt Krat af *Croton*, *Acacia* osv.

Længere mod Øst, fra 12 og østefter, er der langs Bredden en fanerofyt Vegetation, Mangrove-Formationens inderste Facies, *Avicennia* + *Laguncularia*-Facies; udenfor denne er hele den østlige Del af Lagunen for største Delen oversaaet med døde Rester af den Bevoksning, som før 1899 har opfyldt store Partier af Lagunen; tilbage stod nu kun Stammerne med de tykkere Grene, de højeste vistnok kun 4—5 Meter høje; de hidrørte alle, saa vidt jeg kunde se, fra *Avicennia*; jeg saa idetmindste ingen Stamme med Støtterødder; formodentlig har Bevoksningen dog ogsaa bestaaet af *Rhizophora*, men denne har maaske ikke været saa modstandsdygtig mod Orkanen som *Avicennia*.

Ved 13 var Forholdene ude fra Lagunen indefter følgende:

1. Lagunen med død *Avicennia*; enkelte Individer af ganske unge *Rhizophora* og, især ind mod Land, unge *Avicennia*.
2. Højere, fortrinsvis af Kalkslam dannet Bund med ganske lidt Vand og dels uden Bevoksning, dels med aaben Bevoksning af *Batis* samt med enkelte 1—3 Meter høje Grupper af *Avicennia*.
3. *Avicennia* + *Laguncularia*-Facies med *Batis*; hist og her vanddækkede eller meget fugtige Partier uden Vegetation; i den inderste Del, hvor Bunden er lidt højere, viser *Sporobolus* sig.
4. Højere, men dog temmelig fugtig, ligesom foregaende væsentlig af Kalkslam dannet Bund med en ret tæt Bevoksning af *Sporobolus virginicus*; her mange store Tuer af indtil over $1\frac{1}{2}$ Meter høj *Fimbristylis spadicea*; pletvis

Juncellus laevigatus og *Bacopa monniera* i stor Mængde. Denne Sporobolus-Bevoksning findes paa en Bund, som andre Steder er dækket af *Conocarpus*-Formationens Fanerofyter.

Den paa en Bund af en saadan Beskaffenhed ogsaa andre Steder ofte optrædende Bevoksning af *Sporobolus* er vistnok et Kunstprodukt, fremkommen ved, at Træer og Buske er huggede bort for Græsningens Skyld. At dette i foreliggende Tilfælde var saaledes, fremgaar af, at der fandtes en Del Stubbe paa Terrænet og desuden enkelte store Individer af *Mancinil* (*Hippomane mancinilla*).

Paa de højere, mere tørre Partier af Terrænet fandtes en Del flere Arter, især *Sida ciliaris*, *Stylosanthes hamatus*, *Evolvulus nummularius*, *Capraria biflora*, *Heliotropium curassavicum*, *Acacia Farnesiana* og et Par Græsser. Indenfor dette Terræn følger det lidt højere, med Sukkerrør dyrkede Land.

Længere mod Øst, hen mod 14, bliver Terrænet mellem Lagunen og det dyrkede Land ganske smalt; indenfor *Avicennia-Laguncularia*-Facies findes her kun en meget smal *Conocarpus*-Formation med *Hippomane mancinilla*, *Pluchea odorata* og enkelte andre.

I den østlige Del af Lagunen er Forholdene meget vekslende, idet Stormfloden har medført store Masser af Sand og Slam, som delvis har opfyldt Lagunen; her er alle Overgange fra en af lavt Vand dækket Bund til ret høj Bund, navnlig som smallere eller bredere Tunger, der fra Øst strækker sig ud i Lagunen og som, idetmindste delvis, er dækket af en lav Fanerofyt-Vegetation af *Conocarpus*, *Pluchea odorata*, *Borrichia arborescens*, *Capraria biflora* o. a. Paa de vanddækkede Strækninger findes enten ingen Vegetation eller der ses enkelte ganske unge Individer af *Avicennia* og *Rhizophora*; *Avicennia* er størst og aabenbart kommen først. Hvor Terrænet er lidt højere, ikke vanddækket men dog meget fugtigt og blødt, findes vidstrakte Bevoksninger af *Batis* og *Salicornia*, men ogsaa her er store Flader uden eller næsten uden Vegetation.

Ved Skildringen af Forholdene langs den lave, brede Sandvold, der begrænsrer Lagunen mod Sydøst, vil jeg begyndeude ved Udløbet, ved 18 (se Kortet); ogsaa her er der ført store Masser af Sand og Slam ind i Lagunen, saa at denne er blevet saa opfyldt, at store Strækninger ligger tørre; man kan saaledes paa visse Steder gaa helt ud i den dræbte *Avicennia*-Skov (Fig. 15). Paa de laveste, vanddækkede Partier ses her enkelte unge Individer af *Avicennia*, og, paa det noget højere Terræn, større og mindre Grupper af *Batis*, *Salicornia* og *Sesuvium*; af de to første gaar, paa dette Sted, snart den ene snart den anden længst ud paa den lave Bund; *Sesuvium* forekommer mest paa et lidt højere Terræn. Det øverste Sandlag var grønt af blaagrønne Alger.

Terrænet mellem 6 og 18 (se Kortet) har jeg ikke undersøgt; ikke fordi det er vanskeligt at komme derover, thi Løbet mellem 17 og 18 var næsten ganske tilsandet, men Tiden tillod ikke en Undersøgelse. Bunden er her dækket af en lav Fanerofyt-Vegetation, der, saa vidt jeg kunde se fra Punkterne 6 og 18, næppe er væsentlig forskellig fra Vegetationen paa den Sandrevle, der begrænsrer Lagunen

mod Sydvest. Ved 6 var der en frodig Mangrove-Vegetation, og ved 17 stod der enkelte smaa Grupper af *Rhizophora* i det lave Vand udenfor Kysten.

Langs Kysten fra 18 og østefter fandtes ikke Spor af Mangrove. Den højere, med lave Fanerofyter bevoksede Del af Sandvolden er højest og bredest mod Øst, bliver hen mod 18 lavere og lavere og gaar tilsidst jevnt over i det lave, flade, mest vegetationsfattige Terraen mellem 16 og 18; men desuden er der paa forskellige Steder i Sandvolden lavere Partier, saa at Bundens Højde er ret vekslede; i Overensstemmelse hermed er det snart *Coccoloba*-Formationens, snart *Conocarpus*-Formationens Arter, som dominerer. Vegetationen er ikke her bleven helt draebt under Orkanen; der fandtes, især mellem 18 og 21, mange helt døde Individer men tillige en Del, som ikke havde mistet alt Liv og som derfor senere havde skudt friske Skud.

Ved 18 foregaar der i Øjeblikket en Landdannelse udenfor den gamle Strandvold, idet der her langs den gamle Kyst er dannet en Række lave, flade Sandvolde, dels uden Vegetation dels spredt bevokset med *Sporobolus virginicus*, *Stenotaphrum americanum*, *Sesuvium portulacastrum* og enkelte *Heliotropium curassavicum*. Nogle Steder er *Sporobolus*-Rhizomerne bleven blottede; formodentlig har Højvande skyldt Sandet bort fra dem. Det viste sig her, at de blottede Rhizomspidser atter voksede ned i Sandet paa samme Maade som Rhizomet hos *Carex arenaria* og *Heleocharis paluster* under lignende Forhold hos os. Mod Øst bliver Nydannelsen smallere og smallere men samtidig lidt højere, og foruden de allerede nævnte Planter findes her tillige *Borrchia arborescens* og smaa Individer af *Laguncularia*.

Ved 19 (se Kortet), hvor Nydannelsen var helt ophørt, var Forholdet følgende, udefra indefter:

1. Langs Kysten en Strimmel med Masser af opskyllede Blade af *Cymodocea* og *Thalassia*.
2. En 3—4 Meter bred Bevoksning af *Sporobolus*, *Stenotaphrum* og *Heliotropium curassavicum*, med Kimplanter af *Hippomane mancinilla*, *Laguncularia* og *Suriana maritima*.
3. En c. 2 Meter bred Bræmme af c. $1\frac{1}{2}$ Meter høj *Laguncularia*.
4. En c. 6 Meter bred Strimmel næsten udelukkende bevokset med *Sporobolus* og *Stenotaphrum*.
5. Lavt Krat af *Borrchia arborescens* med lidt *Suriana maritima*, *Dalbergia hecastophyllum*, *Tournefortia gnaphalodes* og *Ipomaea pescaprae*.
6. Et 30—35 Meter bredt, lidt højere Terraen især med *Laguncularia*; desuden *Conocarpus*, lidt *Coccoloba uvifera*, *Hippomane mancinilla*, *Borrchia arborescens* og *Ipomaea pescaprae*.
7. Dal især med *Salicornia* og *Batis*.
8. Højere Terraen, en gammel kratbevokset Strandvold. Derpaa Lagunen med de fra Øst udskydende, højere, tungeformede Partier, der længst mod Vest opløses i enkelte øformede Pletter med lavt Krat.

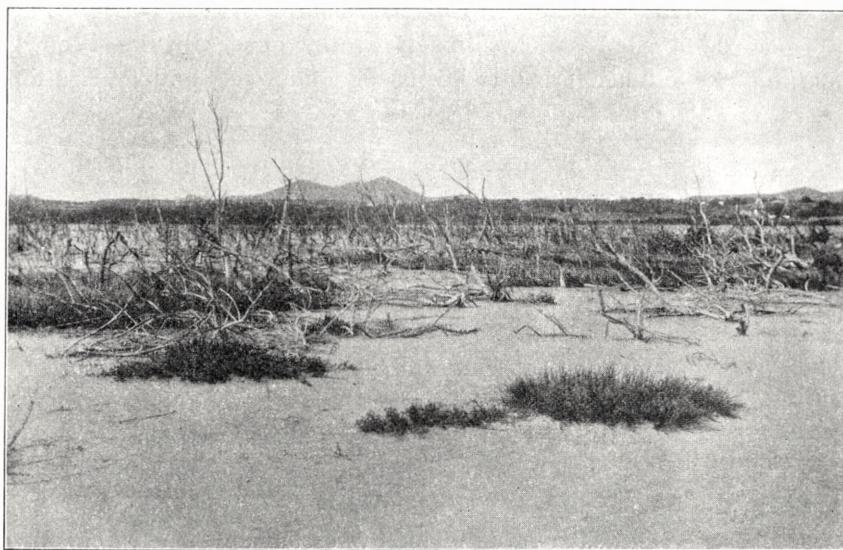


Fig. 15.

Den dræbte *Avicennia*-Skov i den østlige Del af Krauses Lagune, set mod Nordvest fra Punkt 16 paa Kortet Fig. 12; Stedet er bestemt ved Mount Eagle, som ses i Baggrunden, og Plantagen Spanish Town, det hvide Punkt, som ses foran den østlige Del af Mount Eagle. I Forgrunden tilhøjre: *Salicornia ambigua*; til venstre: *Batis maritima*. I den døde Skov ses enkelte unge, levende *Avicennia*-Buske; f. Eks. de mørke Pletter længst tilhøjre. (6. 2. 06).

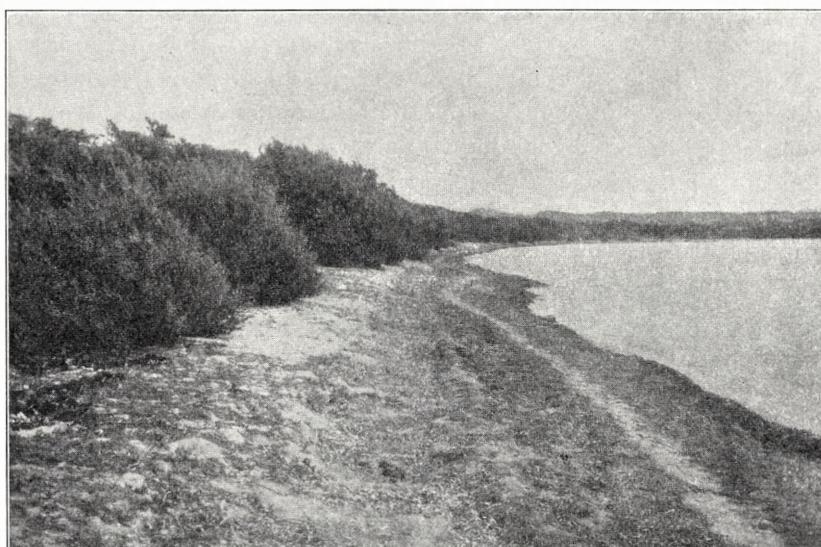


Fig. 16.

Havssiden af den Sandrevle, som begrænser Krauses Lagune mod Sydøst, set mod Nordøst, Bundens af Lime Tree Bay, fra Punkt 21 paa Kortet Fig. 12. Nærmest Havet et 2–3 M. bredt Bælte med opskyldede Blade af Havgræs; derefter en 1–2 M. bred, lidt højere Strimmel hist og her med lidt *Sporobolus virginicus* og *Ipomaea pescaprae*; dernæst *Suriana maritima*-Krat. Længere tilbage dannes den yderste Krat-Bræmme af *Conocarpus erectus*, som her gaar næsten lige til Havet. (6. 2. 06).

Paa et enkelt Sted, ved 20 (se Kortet), skærer Havet i Øjeblikket bort af Kysten, der paa dette Sted staar som en kratbevokset Brink. Ved 21 danner *Suriana maritima* paa en længere Strækning den yderste Rand af Krattet (Fig. 16); Forholdet var her følgende:

1. 2—3 Meter bred Strand med opskyllede Blade af *Cymodacea* og *Thalassia*.
2. 1—2 Meter bred, lidt højere Strimmel med *Sporobolus* og enkelte *Ipomaea pescaprae*.
3. *Suriana maritima*-Krat.

Fra 21 mod Bunden af Lime Tree Bay bliver Strandvolden højere og mere tør, og Krattet dannes her især af *Lantana odorata*, *Corchorus hirsutus*, *Coccocoba uvifera*, *Hippomane mancinilla*, *Conocarpus erectus* og enkelte *Scaevola Plumieri*. Krattet gaar næsten lige til Havet, kun adskilt derfra ved en smal Strimmel af opskyllede Blade af Havgræs. Omrent i Bunden af Lime Tree Bay, forbi 22 (se Kortet), gaar den foran nævnte (Nr. 7 i Oversigten S. 26), med *Salicornia* og *Batis* bevoksede Dal over i græsklædte, navnlig med *Sporobolus* og *Stenotaphrum* bevoksede Strækninger, som her gaar lige ud til Havet. Paa de højere Partier findes enkelte Buske og især lav, forkrøblet Krat af *Borrachia arborescens*.

Jeg har i det foregaaende søgt at give en Fremstilling af Forholdene ved Krauses Lagune saaledes som de var i 1906; jeg ser vel, at denne Fremstilling hverken er fuldstændig eller anskuelig; Forholdene er saa indviklede og forskelligartede, at det er meget vanskeligt, ja ugørligt, at give en anskuelig Helhedsfremstilling; jeg har derfor ment, at det var bedst at give en detailleret Fremstilling af Forholdene paa en Række bestemte Steder, og jeg haaber, at de givne Oplysninger sammenholdt med de vedføjede Fotografier kan tjene som Udgangspunkt ved Undersøgelser af de Forandringer, der sikkert vil ske med Hensyn til Vegetationens Udvikling i Fremtiden.

Paa Grund af de store Forandringer, som i den nyeste Tid er foregaaet, er der neppe noget Sted ved Krauses Lagune, hvor de oprindelige Forhold er helt uforandrede eller hvor de oprædende Formationers forskellige Facies alle er til Stede i deres oprindelige Skikkelse; efterfølgende Oversigt over den beskyttede Kysts Formationer er derfor ikke nogen Fremstilling af Forholdet paa et enkelt Sted men et Forsøg paa at udrede, i hvilket Forhold de forskellige Facies staar til hverandre, og hvilke Facies i vore Strandes Vegetation de maa antages at svare til.

Tidevandsbæltet; Mangrove-Formationen. Benævnelsen Tidevandsbæltet trænger til en nærmere Forklaring, da det ikke, idetmindste ikke altid, falder ganske sammen med det Omraade, der ligger mellem lavest Ebbe og højest Flod; navnlig ikke hvor der, som i Dansk Vestindien, kun er meget ringe Forskel mellem Ebbe og Flod; her staar Mangrove-Formationen tillige dels paa stedse vanddækket Bund dels paa en kun undtagelsesvis vanddækket men stedse fugtig Bund.

Ved Tidevandsbæltet maa derfor forstaas ikke alene Omraadet mellem lavest Ebbe og højest Flod men tillige dels den stadig vanddækkede, lavvandede Bund dels den kun undtagelsesvis vanddækkede, men stedse vandmættede eller dog næsten vandmættede Saltbund. Som jeg tidligere har nævnt, er, paa Grund af Materialets grovere Art, Leddelingen ikke saa fint nuanceret som i vore Strandes Formationer; men hvor Leddelingen er rigest og tydeligst udtalt, kan der dog skelnes mellem tre Facies, nemlig:

Rhizophora-Facies, den yderste, kun af *Rhizophora mangle* dannede Facies.
Derefter

Avicennia-Facies i ganske grundt Vand og paa vaad men ikke til Stadighed vanddækket Bund; dannet af *Avicennia nitida* alene eller sammen med Rhizophora mangle.

Laguncularia-Facies, den inderste af Mangrove-Formationens Facies, der i Regelen optræder som en smal Strimmel langs Stranden, og i Almindelighed bestaar af *Laguncularia racemosa* og *Avicennia nitida*; indefter støder denne Facies op til og blandes med de af Conocarpus-Formationens Arter, som gaar længst ud, især *Conocarpus erectus*. Hvor denne Fanerofyt-Bevoksning ikke er saa tæt, at den ganske skygger over Bunden, ses her ofte tillige Chamæfyterne *Salicornia ambigua*, *Batis maritima* og *Sesuvium portulacastrum*. Jo mereaab en Fanerofyt-Bevoksningen er, des tættere bliver Chamæfyt-Bevoksningen. Hvor Fanerofyterne er helt eller næsten helt forsvundne, idet de f. Eks. er huggede bort, faar vi derfor her en mere eller mindre tæt Chamæfyt-Vegetation, saaledes, som foran omtalt, paa store Strækninger langs Nordsiden af Krauses Lagune. Denne Vegetation ligner i høj Grad Salicornia-Vegetationen paa vore Marsk-Kyster, men i Overensstemmelse med den store Forskel i Klima er Livsformen hos de to Steders Arter ganske forskellig. Det Terræn, som her er Tale om, den inderste Del af Tidevandsbæltet, hører i Danmarks Klima til de Lokaliteter, hvis Planter er særligt uheldigt stillede i den ugunstige Aarstid, Vinteren, og i Overensstemmelse hermed har den eneste Art, som vokser her, *Salicornia herbacea*, den bedst beskyttede Livsform, nemlig Therofyternes; anderledes er Forholdet for dens meget nære Slægtning, *Salicornia ambigua*, i Vestindien; her er den omtalte Lokalitet ikke paa nogen Tid af Aaret særlig uheldig for Plantevæksten, og de optrædende Arters Livsform er i Overensstemmelse hermed en anden, en mindre beskyttet, nemlig Chamæfyternes. Bortset fra Livsformen er der saa godt som ingen Forskel mellem vor *Salicornia herbacea* og Vestindiens *Salicornia ambigua*.

Der er paa Forhaand ingen Grund til at vente, at Grænserne mellem de enkelte Facies i en Formation i et bestemt Klima skal falde sammen med visse Facies-Grænsen i den tilsvarende Formation i et helt andet Klima, hvis Arter gennemgaaende hører til andre Livsformer. Vor *Salicornia*-Formation findes saaledes vel paa det samme Terræn som Mangrove-Formationen, men de to Formationers ydre Grænse falder ikke sammen; paa Grund af, at Mangrove-Formationens typiske Arter er

Fanerofyter, altsaa forholdsvis høje Planter, kan de, navnlig hvor der ikke er Ebbe og Flod, gaa ud paa dybere Vand end vor *Salicornia*, der under saadanne Forhold væsentlig kun vokser paa den vaade Bund langs Kysten; hvad den ydre Grænse angaar, falder vor *Salicornia*-Formation derfor nærmest sammen med den ydre Grænse for Mangrove-Formationens *Laguncularia*-Facies, der, som foran berørt, ogsaa i Vestindien bliver til en *Salicornia*-Facies (eller *Batis*-Facies), naar Fanerofyterne fjernes.

At dømme efter Terræn- og Fugtighedsforholdene falder Mangrove-Formationens og vor *Salicornia*-Formations indre Grænse paa det nærmeste sammen. Men sammenligner man den *Salicornia ambigua*-Vegetation, som ved Krauses Lagune delvis dækker Bunden, hvor Mangrove-Formationens Fanerofyter er fjernede, med vor *Salicornia*-Formation, ser man, at *Salicornia ambigua*-Vegetationen ved Krauses Lagune gaar højere op end vor *Salicornia*-Formation. Dette beror vistnok paa en Forskel i Konkurrence-Forholdene paa de to Steder; hos os grænser *Salicornia*-Formationen indefter op til *Glyceria maritima*-Formationen; i Dansk Vestindien grænser Mangrove-Formationen op til *Conocarpus*-Formationen, begge under normale Forhold fanerofyte Formationer; men naar Fanerofyterne fjernes, og der i Stedet for Mangrove-Formationens inderste Facies, *Laguncularia*-Facies, har udviklet sig en Chamæfyt-Vegetation af *Salicornia ambigua* eller af denne og *Batis maritima*, kommer denne Vegetation i Regelen til at grænse op til en *Sporobolus*-Vegetation, der indtager idetmindste en Del af *Conocarpus*-Formationens Terræn, naar denne Formations Fanerofyter er fjernede. *Sporobolus virginicus* og andre lave Planter, som findes her, gaar imidlertid ikke saa langt ud som *Glyceria maritima* hos os; naar derfor i Vestindien *Salicornia ambigua* og *Batis maritima* gaar højere op end *Salicornia herbacea* hos os, da kommer dette saaledes formodentlig af, at de har fri Bane, at de ikke møder en overmægtig Konkurrence før de er komne saa langt op, at Fugtighedsforholdene alene sætter Grænse for deres videre Fremtrængen. Hos os, derimod, gaar *Glyceria maritima* ud paa den Bund, hvor *Salicornia herbacea* endnu meget vel kunde vokse, hvis der ingen Konkurrence fandt Sted, men hvor den i Konkurrence med *Glyceria maritima* maa bukke under. Paa Steder, hvor der ingen Konkurrence er, fordi *Glyceria maritima* endnu ikke helt har dækket Bunden, ser man da ogsaa *Salicornia maritima* gaa langt op paa *Glyceria*-Formationens Terræn.

Conocarpus-Formationens Terræn svarer paa det nærmeste til vore Strandenge, hvad Formationerne angaar altsaa til *Glyceria*-Formationen (maaske med Undtagelse af dennes yderste Del), *Juncus Gerardi*-Formationen og *Statice armeria*-Formationen. Naturligvis gaar *Conocarpus*-Formationens Arter ikke i lige Grad ud paa den lavere og fugtigere Bund; paa denne sidste er *Conocarpus erectus* i Regelen dominerende, og her faar vi, som ovenfor omtalt, yderst en *Salicornia* + *Batis*-Vegetation, inderst en *Sporobolus*-Vegetation, naar Fanerofyterne fjernes. Det højere Terræn bærer en mere broget Blanding af Arter; her begynder

ogsaa en Del af de xerofile Krats Arter at indfinde sig; men Forholdene er saa vekslende, at jeg ikke tror, det lønner sig her at forsøge paa at opstille forskellige Facies.

Naar man vil foretage en sammenlignende Undersøgelse af de til hinanden svarende Formationer i to helt forskellige Klimater, f. Eks. Danmarks og Dansk Vestindiens, for at se, paa hvilken forskellig Maade de to Omraaders Klima giver sig Udslag i Planternes Livsform, maa man først søge at udfinde, hvilke Formationer der svarer til hinanden og som skal sammenlignes; da Vegetationens floristiske Sammensætning er ganske forskellig, kan de optrædende Arter ikke give noget Holdepunkt i saa Henseende; man maa derfor gaa ud fra en sammenlignende Undersøgelse af Terrænets Natur og saa sammenligne de Formationer, som findes paa det i de to Klimater til hinanden svarende Terræn, i foreliggende Tilfælde de paa beskyttet Kyst optrædende alluviale Stranddannelser, som i større eller mindre Grad staar under det salte Vands Paavirkning. Som nedenstaende vist, har jeg søgt at sammenstille de Formationer, som paa dette Terræn svarer til hinanden, naar man sammenligner Danmark (Nordby Marsk paa Fanø) med Dansk Vestindien (Krauses Lagune); og for sidste Steds Vedkommende har jeg taget Hensyn baade til det normale Forhold og til det Forhold, som indtræder, naar Fanerofyterne er blevne fjernede og endnu ikke atter er indvandrede.

Krauses Lagune paa St. Croix		Nordby Marsk paa Fanø	
Normale Forhold	Hvor Fanerofyterne er fjernede		
Mangrove-Form.	Rhizophora-Facies Avicennia-Facies Laguncularia-Facies	Salicornia ambigua	Salicornia herbacea-Formation
Conocarpus-Form.	Conocarpus erectus, etc. Borrchia arborescens Pluchea odorata, etc. Acacia Farnesiana, etc.	Batis maritima Juncellus laevigatus Sporobolus virginicus, etc. Stenotaphrum, etc.	Glyceria + Suaeda-Facies Glyceria + Aster-Facies Glyceria + Triglochin-Facies Juneus Gerardi-Form. Statice armeria-Form.
			Glyceria-Form. Strandeng

Angaaende det sidste Punkt vil jeg tilføje følgende sammenfattende Bemærkninger:

Hvor Mangrove-Formationen og Conocarpus-Formationen er tilstede i deres endelige Form, f. Eks. i den sydvestlige Rand af Krauses Lagune, dominerer naturligvis Fanerofyterne, og de tilstedeværende Arter af Chamæfyter og andre Livsformer spiller kun en ganske underordnet Rolle; hvad Chamæfyterne *Salicornia ambigua* og *Batis maritima* angaaer, da er deres Plads her begrænset til Mangrove-Formationens inderste Facies og til den yderste, fortrinsvis af *Conocarpus erectus*

dannede Del af Conocarpus-Formationen. Hvor derimod, som langs Nordsiden af den vestlige Halvdel af Krauses Lagune, Fanerofyterne er bleven fjernede, er *Salicornia* og *Batis* dominerende og kan paa vide Strækninger danne en mere eller mindre tæt Vegetation, der dog kun repræsenterer et tidligt Udviklingstrin af den inderste Del af Mangrove-Formationen og den yderste Del af Conocarpus-Formationen, et Udviklingstrin¹, der kun bestaar saa længe disse Formationers Fanerofyter endnu ikke er indvandrede.

¹ I en for nylig trykt Afhandling opfører Dr. Børgesen dette Udviklingstrin som en selvstændig Formation sideordnet med Mangrove-Formationen og Conocarpus-Formationen. (F. Børgesen, Notes on the Shore Vegetation of the Danish West Indian Islands. Bot. Tidsskr. Bd. 29. 1909).

SANDY POINT.

Sandy Point (se Kortet Fig. 17) er en af Sand dannet Halvø, som fra det sydvestlige Hjørne af St. Croix strækker sig c. 3 Kilometer ud i Havet, maalt fra Nordenden af Westend Salt Pond til Halvøens Sydspids. Kun ved to smalle Arme, en længere vestlig og en kortere østlig, staaer den i Forbindelse med Øens Klippebund, hvorfra den paa den øvrige Strækning er adskilt ved den foran nævnte, lavvandede Sø, Westend Salt Pond; denne er en tidligere Lagune, der vel nu under sædvanlige Forhold er ganske aflukket fra Havet, men som dog til Tider skal kunne staa i Forbindelse med dette, der i Stormtider skal kunne skylle ind over de smalle Landstrimler, som skiller Søen fra Havet mod Øst og Vest. Sandy Point danner saaledes et vel begrænset Omraade, som i særlig Grad egner sig for Studiet af den Vegetation, som i Vestindien indfinder sig paa alluviale Dannelser af denne Art.

Som i saa mange andre lignende Tilfælde er denne Sand-Halvøes Form underkastet Forandringer; paa nogle Steder vokser den ved ny Sandaflejninger langs Kysten, paa andre Steder skyldes der bort af denne; det kan derfor for fremtidige Undersøgelsers Skyld have nogen Interesse at vide, hvorledes Forholdene er nu. Desværre mangler vi et nøjagtigt Kort som Udgangspunkt; ved den efterfølgende Redegørelse for de Undersøgelser, jeg har foretaget angaaende



Fig. 17.
Sandy Point med Westend Salt Pond paa St. Croix;
efter Oxholms Kort over St. Croix, 1828. Angaaende Tallene
se Teksten.

Sandy Point og dens Vegetation maa jeg, ligesom ved Krauses Lagune, nøjes med at benytte en Kopi af Oxholms Kort.

Sandy Point er udelukkende dannet af Sand, „Koralsand“, med Undtagelse af visse Strækninger langs Westend Salt Pond, hvor Sandet er mere eller mindre lerblandet; men Halvøen er ikke noget Klitterræn af lignende Art som f. Eks. langs Jyllands Vestkyst; Sandflugt af nogen Betydning finder ikke Sted, og der er derfor kun ringe Forskel med Hensyn til Terrænets Højde over Havet paa de forskellige Steder; Overfladen har vistnok gennemgaaende den Højde, som de af Havet paa forskellige Tider opkastede Sandmasser har naaet. Halvøens Dannelse skyldes formodentlig en sydgaaende Strøm langs Vestkysten af St. Croix og en vestgaaende Strøm langs Sydkysten; hvor disse to Strømme mødes bundfældes de af Strømmene, navnlig østfra, hidførte Sandmasser, hvorved Bunden højnes; i Stormtider kaster saa Havet Sandet ind paa Kysten som lange Sandvolde adskilte ved mere eller mindre tydelige Lavninger, det Hele afrundet af det tilbagestrømmende Vand og senere, naar Sandet er blevet tørt, tillige af Vinden. Naar man derfor paa et af de Steder, hvor den seneste Tilvækst har fundet Sted, gaar fra Stranden indefter, passerer man en Række brede, flade Volde adskilte ved $\frac{1}{4}$ —1 Meter lavere, flade Dale. Vi har her lignende Overladeforhold som paa den yderste Strand paa Vestkysten af Nordenden af Fanø, hvor 2—3 flade Sandrevler idetmindste i Ebbetiden ligger tørre, med mellemliggende flade Dale, gennem hvilke Flodbølgen strømmer ud mod Nord; tænker man sig dette Terræn hævet 1—2 Meter, viser det lignende Terrænforhold som dem der findes f. Eks. her paa Vestsiden af Sydenden af Sandy Point.

Paa Sandy Point er, omend i meget forskellig Grad, alle de Lokaliteter og tilsvarende Formationer repræsenterede, som i Dansk Vestindien findes paa de alluviale Stranddannelser. Sammenlignet med Forholdene i Danmark svarer Sandy Point nærmest til Skallingen, med hvis Flora jeg derfor ogsaa senere vil sammenligne Floraen paa Sandy Point; man vil da faa at se, hvorledes Planternes Livsform i forskellige Jordstrøg er bestemt af Klimaet og selv paa saa specielle og begrænsede Omraader som de alluviale Stranddannelser er ganske i Overensstemmelse med vedkommende Klimas almindelige biologiske Spektrum.

Den beskyttede Kyst og dens Vegetationsformationer er indskrænket til den iøvrigt lange Strækning, paa hvilken Sandy Point grænser op til Westend Salt Pond, altsaa dennes sydlige og vestlige Bred. Ligesom paa den tilsvarende Lokalitet paa Indersiden af Skallingen bestaar Bunden her fortrinsvis af Sand, hist og her mere eller mindre stærkt lerblandet.

Havgræsformationen er i Westend Salt Pond kun repræsenteret af *Ruppia rostellata*.

Tidevandsbæltet, Mangroveformationen.

Som omtalt i Afsnittet „Krauses Lagune“ forstaar jeg ved Tidevandsbæltet ikke alene Omraadet mellem lavest Ebbe og højest Flod men desuden baade den stedse fugtige, men kun undtagelsesvis vanddækkede Bund, og tillige, hvor der enten ikke findes eller kun er ubetydelig Ebbe og Flod, saadanne Lokaliteter, som stedse



Fig. 18.

Nordenden af Westend Salt Pond paa St. Croix set fra 1 paa Kortet Fig. 17 (8. 1. 06). I Forgrunden tæt *Sporobolus virginicus*-Bevoksning med Træstubbe; i Vandkanten lave Buske af *Laguncularia racemosa* (tilhøjre) og *Avicennia nitida* (tilvenstre). Søen er, idetmindste her, meget lavvandet; Sten ses rage op over Vandfladen, og fra Højre skyder en delvis torlagt Strækning sig ud i Søen. I Baggrunden Krattet paa den smalle Landstrimmel mellem Søen og Havet.



Fig. 19.

Fra Sydenden af Westend Salt Pond paa St. Croix, ved 10 paa Kortet Fig. 17 (8. 1. 06). Fra Venstre til Højre: Søen — Skumstribe — smal Sandstrand uden Vegetation — *Sesuvium portulacastrum* — *Sesuvium* og *Batis maritima* — *Sporobolus virginicus*, *Laguncularia racemosa*, *Conocarpus erectus* — *Coccoloba*-Formationen.

er dækkede af lavt Vand. Til disse sidste Lokaliteter hører Westend Salt Pond (Fig. 18—19), idetmindste for store Strækningers Vedkommende, idet Vandet er ganske lavt, i hvert Fald langs Bredderne. Den hertil svarende Formation, Mangrove-Foreningen, er imidlertid kun svagt repræsenteret; navnlig mangler denne Formations yderste, mest karakteristiske Facies, Rhizophora-Facies, idet *Rhizophora mangle* ikke findes i Westend Salt Pond, saa vidt jeg har set. Grunden hertil er neppe Vandets Beskaffenhed; hvor salt dette er, ved jeg ganske vist ikke; dets Udspring og Temperatur indbød ikke til at gøre noget energisk Forsøg paa at afgøre dette Spørgsmaal ad Smagens Vej; jeg antager, at Mangelen af Rhizophora beror paa, at den overhovedet ikke er blevet ført hertil. Heller ikke nogen Avicennia-Facies er udviklet; kun Mangrove-Foreningens inderste Facies, Laguncularia-Avicennia-Facies, findes paa kortere eller længere Strækninger langs den sydlige og vestlige Bred, som her alene kommer i Betragtning; *Laguncularia racemosa* og *Avicennia nitida* og i Regelen tillige *Conocarpus erectus* danner her en ganske smal Bræmme umiddelbart langs Vandkanten. Hvor denne Bræmme ikke var altfor tæt fandtes en Del *Batis maritima* og især *Sesuvium portulacastrum*, navnlig i den inderste Rand af Bevoksningen. Paa andre Steder, f. Eks. mellem 4 og 6, mellem 7 og 8 og ved 10 (se Kortet Fig. 17) fandtes den nævnte Laguncularia-Avicennia-Facies ikke, altsaa i det Hele taget ingen af Mangrove-Foreningens Fanerofyter. Forholdet var her i Regelen det som ses paa Fig. 19:

1. Yderst en smal, 2—5 Meter bred, sandet, svagt skraanende Strandbred uden Vegetation.
2. Derpaa, i Randen af en lidt højere Bund, en oftest ganske smal Bræmme af *Sesuvium*, *Batis* og *Philocerus vermicularis* eller alene af *Sesuvium*, der her gaar længst ud; denne Sesuvium-Batis-Bevoksning, her den eneste Antydning af en Mangrove-Forening, gaar indefter over i
3. en ret tæt Sporobolus-Vegetation, der i høj Grad minder om de Bevoksninger af *Agrostis alba*, som findes hos os paa lignende, mere eller mindre tør Sandbund, f. Eks. paa den lave Bund paa Indersiden af Svenske Knolde paa Skallingen.

Nogle Steder er Sporobolus-Bevoksningen kun lidt blandet med andre lave Planter, især *Sesuvium*, *Philocerus*, *Tephrosia cinerea* og *Canavalia obtusifolia*, paa andre Steder findes mere eller mindre tæt indstrøet lave Individer af forskellige Fanerofyter især *Conocarpus*, *Avicennia*, *Laguncularia*, *Borrchia arborescens*, *Coccoloba uvifera*, *Corchorus hirsutus* og *Ernodea littoralis*: en *Conocarpus*-Formation med Indblanding af Arter især fra de paa ubeskyttet Kyst forekommende Formationer; *Conocarpus*-Formationen grænser jo ogsaa her op til *Coccoloba*-Formationen paa den højere liggende Sandbund mellem Westend Salt Pond og Havet. Vi har da her et Forhold, der ganske svarer til det, der findes ved Nordenden af Fanøs Klitterræn, hvor den sandede Veststrands og de lave Klitters Vegetation mødes med og blandes med Arter fra Formationerne paa den beskyttede Østkyst.

Den ubeskyttede Sandstrand; Pescaprae-Formationen.

Ved den efterfølgende Skildring af Sandstranden og dens Vegetation vil jeg begynde paa Nordvestkysten udfor Nordenden af Westend Salt Pond og derfra følge Kysten om paa Sydøstkysten. Nordvestkystens Sandstrand falder ret stejlt af mod Havet, og der er her stor Forskel i Højde mellem den Linie, hvortil Bølgerne naar op og den Linie, hvortil Vandet atter synker. Mellem 2 og 11 (se Kortet) ses i Strandkanten den ogsaa fra flere andre Steder paa St. Croix kendte Kalksandsten, der stammer fra en nyere Tid, da man har fundet Kulturprodukter i den; den samme Kalksandsten er meget udbredt langs Bredderne af Westend Salt Pond's Nordende.

Sandstranden, der indefter begrænses af en tæt, men i Regelen kun 1—2 Meter høj *Coccoloba uvifera*-Bræmme, er mellem 2 og 11 smal, c. 10—15 Meter bred, og næsten ganske uden Vegetation; kun hist og her findes ind i Kanten af Coccoloba-Formationen enkelte *Sporobolus virginicus*-Kolonier. Henimod 12 (se Kortet) begynder Sandstranden at blive bredere, og fra 12 til Sydvesthjørnet tiltager den jevnt i Bredde; samtidig bliver Pescaprae-Formationen frodigere og breder sig over hele Stranden paa nær dennes yderste, yngste mod Havet vendende Del. Ved 12 begynder tillige det tidligere omtalte parallelt med Kysten gaaende System af lave brede og flade Sandvolde, adskilte ved tilsvarende, kun $\frac{1}{4}$ —1 Meter dybe Dale; i Almindelighed er Forholdet dette, at Sandvoldene har en ganske jevnt affaldende Skraaning paa Landsiden, men derimod en mere eller mindre stejl Skraaning paa den mod Havet vendende Side.

Ved 12, hvor Stranden er c. 25 Meter bred, findes kun en bred, langs Havet liggende Sandvold og indenfor denne en bred Dal; derpaa det lidt højere Terræn, paa hvilket det yderste, 1—2 Meter høje *Coccoloba*-Krat staar. Der er her to Facies i Strandens Pescaprae-Formation; umiddelbart udenfor Coccoloba-Bræmmen kommer en ca. 15 Meter bred, tæt Bevoksning af *Canavalia obtusifolia*, mere eller mindre blandet med *Ipomaea pescaprae*; derpaa, op på Indersiden af Strandvolden, en c. 8 Meter bred Bevoksning af *Ipomaea pescaprae* alene. Efterhaanden som Strandens sydpaa bliver bredere, findes flere Dale eller Lavninger, ved 13 (se Kortet), hvor Strandens er 50 Meter bred, saaledes 3, og ved 14 (se Kortet), hvor Strandens er c. 80 Meter bred, 4 Dale. Med Hensyn til Vegetationen er Forholdet væsentlig ens ved 13 og 14, og jeg vil derfor begrænse mig til en Skildring af Forholdet ved 14, hvor Strandens er bredest.

Der kan her skelnes mellem tre Facies i Pescaprae-Formationen. Ved Fremstillingen af disses Fordeling vil jeg gaa ud fra Dalene; disse optager den største Del af Terrænet og har den frodigste Vegetation, der herfra strækker sig op over de mellemliggende flade Volde; jeg begrænser derfor, og for Oversigtens Skyld, de fire Dale saaledes, at den enkelte Dal regnes fra den øverste Del af den ene Vold til den øverste Del af den følgende.

1. Den 1ste, yderste, c. 12 Meter brede Dal er ganske vegetationsløs.
2. Den 2den Dal, som er c. 16 Meter bred, har en næsten ren Bevoksning af

Ipomaea pescaprae (Fig. 20) med meget lange, paa Sandets Overflade liggende Skud, hvis ældre Partier efterhaanden ofte dækkes af tilblæst Sand. Af andre Arter fandtes her kun *Euphorbia buxifolia* og *Cakile lanceolata*.

3. Den tredie, c. 22 Meter brede Dal optages af en meget frodig og tæt, c. $1\frac{1}{2}$ Meter høj Bevoksning af *Canavalia obtusifolia*, hvori der findes en Del *Ipomaea pescaprae*; desuden *Euphorbia buxifolia*; nogle Steder var *Canavalia* næsten ganske dækket af *Cassytha americana*, som her var stærkt rødgul og i Afstand ganske lignede *Cuscuta americana*, som jeg iøvrigt ikke saa paa Sandy Point.
4. Den 4de Dal, endelig, som var c. 30 Meter bred, var ligeledes væsentlig bevokset med en frodig *Canavalia*-Vegetation (Fig. 21), navnlig i Dalens yderste



Fig. 20.

Fra Vesthjørnet af Sandy Point paa St. Croix, ved 14 paa Kortet Fig. 17 (24, 1. 06). Pescaprae-Formationens yderste Facies: Pescaprae-Facies, set mod Nord; i Baggrunden Hojderne paa Nordvesthjørnet af St. Croix; foran disse Bugten ved Frederikssted, der ligger ved det inderste Hjørne af Bugten.

Del; i den inderste, mod Krattet grænsende Del var *Canavalia obtusifolia* mindre frodig; derimod fandtes her en ret tæt Bevoksning af *Sporobolus virginicus* med *Cenchrus*, *Euphorbia buxifolia* og lidt *Ipomaea pescaprae*.

5. Derefter fulgte en ca. 30 Meter bred Overgangsformation, den foregaaende Facies paa et ældre Udviklingstrin, med en mere eller mindre tæt Bevoksning af $1\frac{1}{2}$ —3 Meter høje Individer af *Chrysobalanus icaco*, *Suriana maritima*, *Ernodea littoralis*, *Corchorus hirsutus* og *Euphorbia linearis*.

Ved at gaa et Stykke ind over det kratbevoksede Terræn indenfor Sandstranden viste det sig, at der ogsaa her fandtes et lignende men ældre System af Sandvolde og Dale som paa Stranden; desuden saas her det samme Fænomen som i vort

Klitterræn, naar man fra de unge Klitter langs Havet vandrer ind over det ældre Klitterræn, at Vegetationen paa de ældre Partier har et langt mere magert og tørt Udseende end Vegetationen paa de yngre Dannelser nærmere Stranden.

Lidt forbi det vestlige Hjørne, ved 15 (se Kortet), danner Kysten en ganske lille Bugt og her skæres der i Øjeblikket bort af Landet; Kratvegetationen, som her især bestaar af *Coccoloba* og *Ernodea*, gaar paa dette Sted helt ud paa den yderste Kant af en af Bølgerne undergravet Skraent. Længere mod Øst, omrent ved 16, begynder Landet atter at vokse; herfra og til Sydhjørnet er Stranden dannet af smallere eller bredere, parallelt med Kysten løbende, lave Sandvolde og mellemliggende Dale, som tiltage i Antal hen mod Sydhjørnet samtidig med at Stranden bliver i tilsvarende Grad bredere.



Fig. 21.

Fra Vesthjørnet af Sandy Point paa St. Croix, ved 14 paa Kortet Fig. 17 (24. 1. 06). Overgangen mellem *Pes-caprae*-Formationens *Canavalia*-Facies og Krattet, der her yderst bestaar af *Chrysobalanus icaco*, *Suriana maritima* og *Ernodea littoralis*. I Baggrunden Højderne paa Nordvesthjørnet af St. Croix. Se iovrigt Teksten.

Udenfor Sydvestenden af Sandy Point er Havet grundt; der ses her i Vandet en stor Mængde løsrevne Blade af Havgræs, især *Cymodocea*; her er en af Pelikanernes mest yndede Fiskepladser, og man ser disse Fugle i stor Mængde flyve over Vandet og hvert Øjeblik styrte sig ned i Havet efter Bytte. Stranden er dækket af store Masser af „Tang“, navnlig Blade af *Cymodocea* og *Thalassia*, som Havet skyller op paa Stranden; noget saadant ses ikke paa Nordveststranden. En anden Forskel fra Nordveststranden bestaar deri, at der i Sydveststrandens Vegetation, ved 19 (se Kortet), kommer et Par nye Arter til; Strandens og dens Vegetation danner her en Overgang til Forholdet paa Sydøstkysten, som jeg straks skal omtale.

Paa det bredeste Sted, ved 19, er Stranden c. 75 Meter bred og viser et System

af indtil 8 Sandvolde og tilsvarende Dale; paa nogle Steder er der færre, idet to Volde kan gaa sammen i en. De yderste 3—5 Dale og mellemliggende Volde er ganske uden Vegetation; de er, især nærmest Havet, dækkede af store Masser af Blade af Havgræs og af opkastede Skaller navnlig af Søpindsvin. Ligesom paa Nordvestkysten er den yderste Vegetation en Pescaprae-Facies; derefter følger der en Canavalia-Facies, hvori der findes en Del andre Arter, nemlig: *Ipomaea pes-caprae*, *Cenchrus echinatus*, *Sporobolus virginicus*, *Sesuvium portulacastrum*, *Euphorbia buxifolia*, *Cakile lanceolata* og *Tournefortia gnaphalodes*; de første af disse er frodigst i Dalene; de tre sidste, især *Tournefortia gnaphalodes*, optræder derimod fortrinsvis paa Sandvoldene; *Tournefortia* findes ikke paa Nordvestkysten men derimod i Mængde paa Sydøstkysten. Derefter følger en Dal, den inderste, med en tæt og næsten ren Bevoksning af *Sporobolus virginicus*, en Sporobolus-Facies; herfra skraaner Bunden jevnt op mod det kratbevoksede Terræn. Paa denne Skraaning vokses foruden en Del *Sporobolus* især *Canavalia obtusifolia* og lidt *Ipomaea pes-caprae*; her laa, tildels begravet i Sandet, Vraget af et Skib. Ogsaa her ser man i den yderste Del af det kratbevoksede Terræn en Afveksling af Volde og Dale. Krattet, som her er temmelig aabent, bestaar især af *Coccoloba uvifera*, *Chrysobalanus icaco*, *Suriana maritima*, *Ernodea littoralis*, *Dodonaea viscosa* og *Dalbergia hecastophyllum*; desuden optræder her en Del *Sporobolus virginicus* og navnlig Masser af *Cassytha americana*. Af de nævnte Fanerofyter gaar *Dalbergia* længst ud; den træffes i Canavalia-Bevoksningen som lave men kraftige Individder med lange nedliggende Grene fra den nederste Del af Stammen.

Saa snart man kommer om paa Sydøstkysten forandres Forholdene. Paa den sydlige Del af denne Kyst (ved 20 i Fig. 17) skærer Havet i Øjeblikket bort af Landet, der ender i en stejl, af Havet undergravet lav Brink, bevokset med den sædvanlige Kratvegetations lave Fanerofyter, hvoraf nogle ligger nedstyrtede paa Strandens delvis begravede i Sandet (Fig. 22). Længere mod Nordøst nedbrydes Kysten vel ikke i Øjeblikket men der sker heller ikke nogen Tilvækst; umiddelbart indenfor en ganske smal Strand bliver Terrænet pludselig lidt højere, bevokset med Krat, i hvis yderste Rand der findes en Del af de sædvanlige Strandplanter, navnlig *Ipomaea*, *Canavalia*, *Sesuvium* og *Sporobolus*. Saaledes er Strandens til om-trent ud for Sydenden af Westend Salt Pond; herfra og mod Nordøst, langs den smalle Landstrimmel, som adskiller Westend Salt Pond fra Havet, finder atter en Tilvækst Sted, eller en saadan har idetmindste fundet Sted i den nyeste Tid; der ses her et bredt, navnlig af Pescaprae-Formationens Planter dækket Parti mellem Havet og Kratvegetationen. Dette ny Terræn begynder ganske smalt mod Sydvest, tiltager herfra til omkring Midten jevnt i Bredde for saa atter at blive smallere mod Nordøst. Paa Midten er dette Terræn c. 50 Meter bredt; indenfor en c. 2 Meter bred Strand følger en 1—2 Meter bred Stribe af opskyllede Blade af *Cymodocea* og *Thalassia*; derefter et c. 22 Meter bredt Parti dannet af tre lave Sandvolde og tilsvarende Dale, bevoksede med *Ipomaea pes-caprae*, *Sporobolus virginicus*, *Sesuvium portulacastrum*, *Cakile lanceolata* og *Euphorbia buxifolia*. I Regelen kan der skelnes



Fig. 22.

Fra Sydøstkysten af Sandey Point paa St. Croix, ved 20 paa Kortet Fig. 17 (24. 1. 06). Paa dette Sted skæres der bort af Kysten.

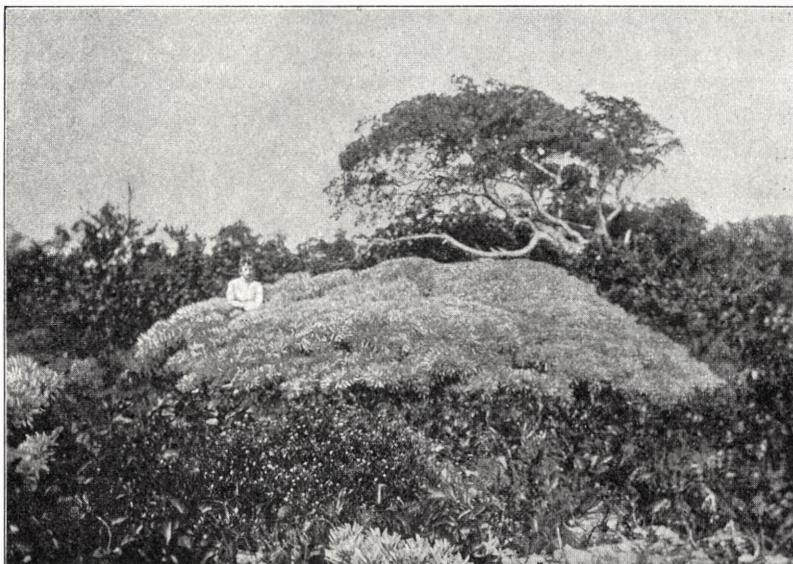


Fig. 23.

Fra Sydøstkysten af Sandy Point paa St. Croix, ved 22 paa Kortet Fig. 17 (26. 1. 06). Pescaprae-Formationens underste Facies: Tournefortia-Facies paa Overgangen til Coccoloba-Formationen. Midt paa Billedet ses en kuppelformet *Tournefortia gnaphalodes* og bag ved denne en *Hippomane mancinilla*. Bundvegetationen bestaar af Pescaprae-Formationens sædvanlige Arter: *Ipomaea pes-caprae*, *Sporobolus virginicus*, *Canavalia obtusifolia*, *Euphorbia buxifolia* og *Cenchrus echinatus*; heri en aaben Bevoksning af *Tournefortia*, *Hippomane*, *Scaevola Plumieri*, *Coccoloba uvifera* og *Caesalpinia crista*.

mellemløbende Facies, idet den dominerende Art skifter, naar man gaar udefra indefter: Yderst en Sesuvium-Facies, hvor *Sesuvium portulacastrum* er dominerende over de andre Arter; derefter en Pescaprae-Facies og en Sporobolus-Facies, hvor henholdsvis *Ipomaea pescaprae* og *Sporobolus virginicus* er dominerende; hist og her findes enkelte Individer af *Scaevola Plumieri* og *Tournefortia gnaphalodes*.

Derefter følger en lav, flad, indtil 10 Meter bred Vold, der er bevokset med de samme Arter som findes i de foregaaende Facies, men hvor det mest i Øjne faldende er bredt kuppelformede Grupper af *Tournefortia gnaphalodes* (Fig. 23—24), en Tournefortia-Facies¹; dette er en Overgangsvegetation til Coccloba-Formationen; enkelte Arter fra denne Formations yderste Rand er allerede indvandret, navnlig *Hippomane mancinilla*, *Coccloba uvifera* og *Caesalpinia crista*.

Indenfor den nævnte, af Tournefortia-Facies dækkede Vold, endelig, følger et noget lavere Terræn, en indtil 14 Meter bred Dal (Fig. 24), bevokset væsentlig med *Sporobolus* og *Ipomaea*; desuden findes her *Euphorbia buxifolia*, *Canavalia obtusifolia*, *Cenchrus echinatus* og, hist og her, enkelte Tournefortia-Grupper og enkelte Individer af *Scaevola Plumieri*. Saa vel denne Dal som den udenfor liggende Vold bliver baade mod Nord og mod Syd smallere og smallere; tilsidst forsvinder Vorden helt, og Dalen gaar over i det smalle, af Pescaprae-Facies dækkede Parti langs Strandene.

I Sammenligning med Nordvestkysten udmaerker Sydøstkysten sig ved en rigere, mere forskelligartet Vegetation og derved, at der ikke her findes en udpræget Canavalia-Facies, og at der i den yderste Rand af Pescaprae-Formationen er en smal Sesuvium-Facies, f. Eks. ligesom langs Vestkysten af Westend Salt Pond; desuden er Overgangsvegetationen mellem Pescaprae-Formationen og Coccloba-Formationen væsentlig karakteriseret ved *Tournefortia gnaphalodes*.

Coccloba-Formationen.

Med Undtagelse af den forholdsvis ganske smalle af Pescaprae-Formationen dækkede Strimmel langs Kysten, er Sandy Point dækket af en Kratvegetation, Coccloba-Formationen, der foruden denne Formations sædvanlige Bestanddele indeholde ikke faa Arter, som i Almindelighed ikke findes, i hvert Tilfælde ikke samlede, i de mere begrænsede Bevoksninger, som udgør Coccloba-Formationen andre Steder i Dansk Veslindien. I Regelen er Krattet tæt, og da det ofte er blandet med tornede Arter, især *Caesalpinia crista*, er det ofte næsten uigennemtrængeligt; kun pletvis er Bevoksningen mere aaben (Fig. 26 og 29). Nogle Steder danner *Coccloba* og *Ernodea littoralis* i Forening eller hver for sig en ganske lav, kun $\frac{1}{2}$ —1 Meter høj, men ret tæt Bevoksning, saaledes især paa en lang Strækning mellem Westend Salt Pond og Sydøstkysten (Fig. 25); men i Almindelighed er Krattet 2—4 Meter højt; kun hist og her rager enkelte Individer lidt højere op. Artsammensætningen er meget vekslende; snart har en snart en anden Art Overvægten; ofte er det *Coccloba uvifera*; andre Steder er det *Ernodea littoralis* (Fig. 29), *Chrysobalanus icaco* (Fig. 26), *Lantana involucrata*,

¹ Opføres af F. BØRGESEN (Notes on the Shore Vegetation of the Danish West Indian Islands, Pag. 236) som en selvstændig Formation sideordnet med Pescaprae- og Coccloba-Formationerne.

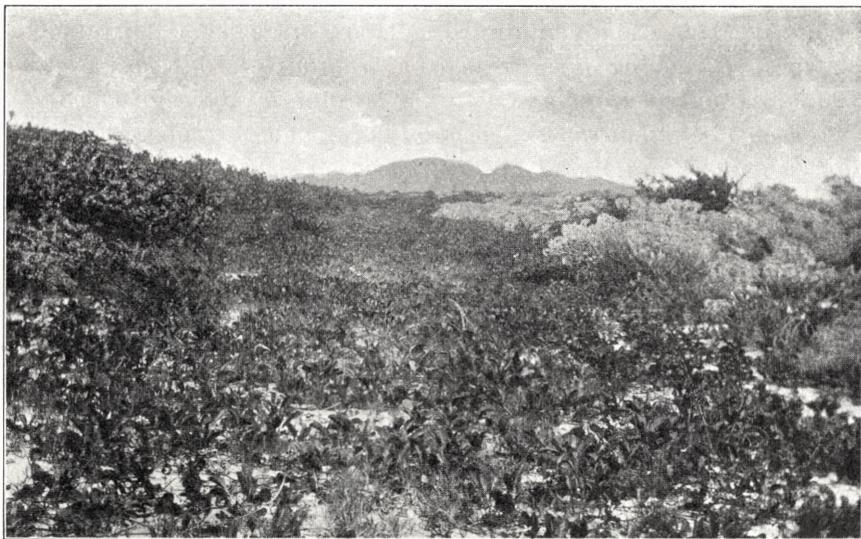


Fig. 24.

Fra Sydostkysten af Sandy Point paa St. Croix, ved 22 paa Kortet Fig. 17, set mod nordøst (26. 1. 06). Til Venstre: Coccloba-Formationen; til Højre: Tournefortia-Facies, i hvilken der ses en *Hippomane mancinilla* (den mørke Busk); i Midten et c. 14 M. bredt, svagt dalformet Terraen bevokset alene med Pescaprae-Formationens sædvanlige Arter: *Ipomaea pescaprae*, *Canavalia obtusifolia*, *Sporobolus virginicus*, *Cenchrus echinatus* og *Euphorbia buxifolia*.



Fig. 25.

Krattet — Coccloba-Formation — paa Sandy Point paa St. Croix, ved 24 paa Kortet Fig. 17 (8. 1. 06). En ganske lav, $\frac{1}{4}$ 1 M. høj Bevoksning af *Coccloba uvifera* og *Ernodea littoralis*; desuden *Lantana involucrata*, *Chrysobalanus icaco*, *Erithalis fruticosa* og *Canella alba*.

Erythalis fruticosa eller *Euphorbia linearis*, som danner den overvejende Del af Vegetationen. Af Arter, som idetmindste pletvis optræder i større Mængde, kan desuden nævnes: *Crochorus hirsutus*, *Croton betulinus*, *C. discolor*, *Rhacoma crosso-petalum*, *Elaeodendron xylocarpum*, *Colubrina ferruginea*, *Bumelia obovata*, *Jacquinia armillaris*, *Convolvulus jamaicensis*, *C. pentanthus*, *Ipomaea triloba*, *Tecoma leucoxylon*, *Anthracanthus spinosus*, *Cordia nitida* og *Clerodendron aculeatum*. Af smaa Kratbunds-planter findes kun faa saa vel hvad Arter som Individer angaar; det er navnlig *Bulbostylis pauciflora*, *Fimbristylis ferruginea*, *Mariscus brunneus*, *Sporobolus virginicus*, *Kallstroemeria maxima* og, navnlig langs en gennem Krattet hugget Vej, *Pectis humifusa*, *Stylosanthes hamata*, *Dactyloctenium aegyptiacum*, *Stenotaphrum americanum* og *Eragrostis ciliaris*.

Efterfølgende Fortegnelse omfatter de Arter, som jeg har fundet paa Sandy Point i den tidlige givne Begränsning af dette Omraade. Foruden de opførte Arter saa jeg idetmindste endnu en Art, en *Psamma arenaria*-lignende Graminé, som jeg ogsaa har set et Par andre Steder i Dansk Vestindien, men altid gold, hvorfor jeg ikke har kunnet bestemme den; desuden forekommer det mig, at jeg saa endnu et Par Arter, men da de hverken findes i mine Optegnelser eller i mine Samlinger, har jeg ikke medtaget dem. Jeg er klar over, at yderligere Undersøgelser efter al Sandsynlighed vil forøge Artslisten en Del; men det som det for mig kommer an paa her, Fanerofyternes Overvægt over de øvrige Livsformer, vil ganske sikkert vedblive at staa ved Magt. I Listen har jeg ved hver Art vedføjet Artens Livsform; nogle Fanerofyter optræder imidlertid paa Sandy Point i en anden, mere beskyttet Livsform end den, hvori de ellers optræder i Dansk Vestindien; i disse Tilfælde er den Livsform, hvori Arten optræder paa Sandy Point vedføjet i Parenthes.

I tidligere Arbejder¹ har jeg givet en Fremstilling af de Livsformer, som der i det følgende bliver Tale om, og jeg har ligeledes tidligere gjort Rede for Grundene til, at jeg ved de planteklimatiske Undersøgelser idetmindste foreløbig kun tager Hensyn til Livsform-Klasserne. For imidlertid at spare Læseren for den Ulejlighed at efterse disse Afhandlinger, vil jeg her saa kort som muligt give en Oversigt over mit Livsform-System og dets Anvendelse.

Jeg gaar ud fra, at hvis Livsformerne skal kunne bruges som Udtryk for Planteklimaet og være praktisk anvendelige, maa de bygges paa en væsentlig og tillige let iagttagelig Side af Planternes Tilpasning til Klimaet; og for at de skal kunne tjene som Basis for en sammenlignende statistisk Undersøgelse, uden hvilken man ikke kommer ud over Turist-Standpunktet i Plantogeografiens, maa Livsform-Systemets Basis være et Enhedssynspunkt.

Jeg har derfor baseret Livsform-Systemet paa og karakteriseret de enkelte Livsformer ved Hjælp af Planternes Tilpasning til at overleve ugunstige Aarstider, navnlig Beskyttelsen af de overlevende Knopper og Skudspidser, paa hvis Bevarelse Individets Eksistens beror.

¹ RAUNKIÆR, C., Planterigets Livsformer og deres Betydning for Geografiens. Kjøbenhavn 1907.

— Livsformerne Statistik som Grundlag for biologisk Plantogeografi. Bot. Tidsskrift. 29. Bind. 1908.

Ved et Omraades biologiske Spektrum forstaar jeg de tilstedeværende Arters procentiske Fordeling paa de forskellige Livsformer eller Livsform-Klasser. Efter den mindre eller større Grad af Tilpasning til at overleve ugunstige Aarstider bliver samtlige Arter paa denne Maade fordelt i Grupper, hvis indbyrdes Størrelse giver et Udtryk for Planteklimaets væsentligste Side; og det har vist sig, at hvert enkelt Hoved-Klima har Tyngdepunktet i hver sin Livsform-Klasse; gaar man fra det ene Klima til det andet, forskydes det biologiske Spektrums Tyngdepunkt til den tilsvarende Livsform-Klasse.

I Figurerne 27—28 har jeg givet en skematisk Oversigt over de 10 Livsformklasser, af hvilke de 8 sidste danner en fortløbende Række, i hvilken hver enkelt

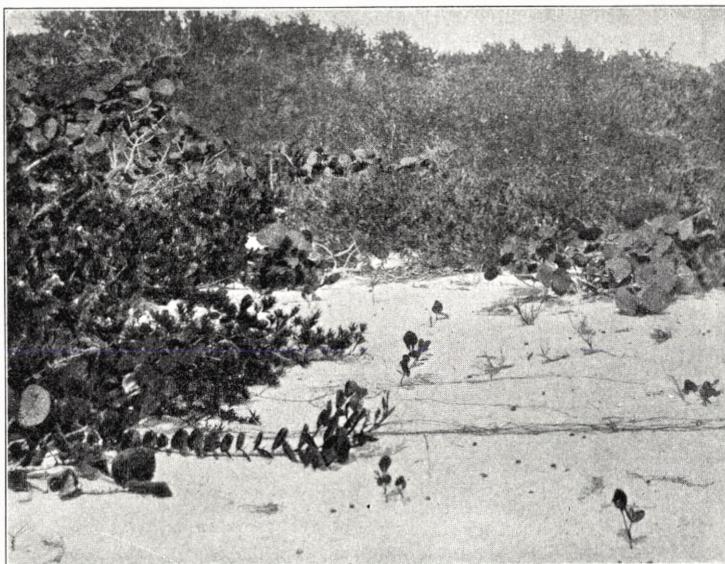


Fig. 26.

Krattet — *Coccothraustes*-Formationen — paa Sandy Point paa St. Croix, ved 18 pa Kortet Fig. 17 (26. 1. 06).
Til Venstre: nedliggende Skud af *Chrysobalanus icaco* og *Ernodea littoralis*; længere tilbage: *Coccothraustes uvifera*.
I Sandet: *Sporobolus virginicus* og unge Planter af *Canavalia obtusifolia* angrebet af *Cassytha americana*, hvis
Stængler vokser hen over Sandet fra den ene Værplante til den anden.

i det Store og Hele er bedre tilpasset til at overleve ugunstige Aarstider end de foregaaende; de to første derimod, Stængelsukulenterne og Epifyterne, kan ikke paa denne Maade anvises Plads i Rækken; jeg har derfor anbragt dem sammen foran de andre. De 10 Livsform-Klasser kan efter sammenfattes i 5 Hovedtyper, 5 Livsform-Rækker: Fanerofyter, Chamæfyter, Hemikryptofyter, Kryptofyter og Therofyter. I mange Tilfælde vil det være tilstrækkeligt at tage Hensyn alene til Livsform-Rækkerne, idet de forskellige Klimater kan sammenfattes i 4 Klima-Rækker svarende til og karakteriserede ved fire af Livsform-Rækkerne, nemlig Fanerofyter, Chamæfyter, Hemikryptofyter og Therofyter; ved Undersøgelsen i Naturen bør man dog bestemme de enkelte Arters Livsform saa detailleret som muligt.

Oversigt over Livsformerne. Hertil Fig. 27—28; fra Venstre til Højre:

- I. **Fanerofyter**, Planter hvis overlevende Knopper eller Skudspidser findes paa frit i Luften fremragende Skud. Herunder 5 Livsform-Klasser:

Klasse 1. Stængelsukulenter.

- 2. Epifyter, ø: fanerofyte Epifyter og fanerofyte Parasiter.
- 3. Mega + Mesofanerofyter, ø: over 8 M. høje Fanerofyter.
- 4. Mikrofanerofyter, ø: 2—8 M. høje Fanerofyter.
- 5. Nanofanerofyter, ø: $\frac{1}{4}$ —2 M. høje Fanerofyter.

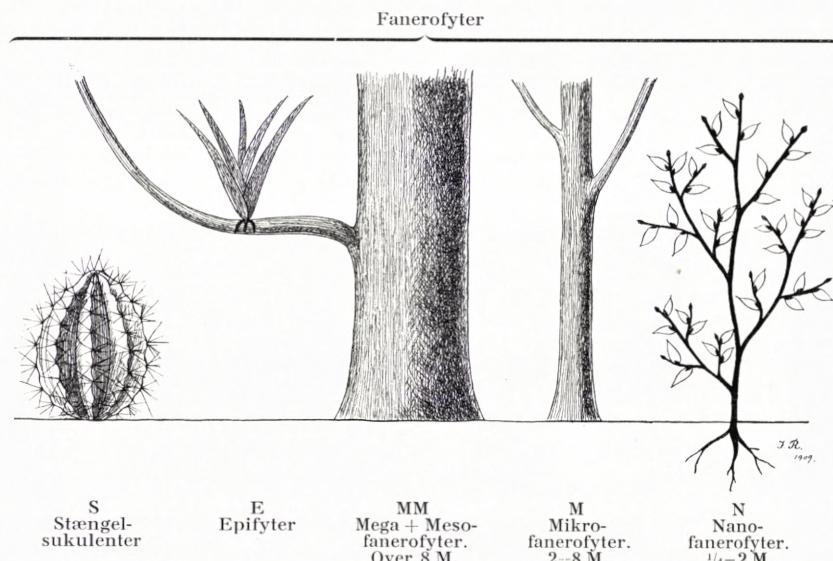


Fig. 27.

Fig. 27—28. Skematisk Fremstilling af Livsform-Klasserne. De Partier af Planterne, som dør bort i den ugunstige Aarstid, er lyse paa Billederne; de blivende Skud eller Skudpartier med de overlevende Knopper derimod sorte. Over Figurerne findes Navnene paa Livsform-Rækkerne, under Figurerne Navnene paa Livsform-Klasserne og de Tegn, Navnenes Begyndelseshogstaver, som, for Kortheds Skyld, benyttes i Stedet for Navnene i de biologiske Spektra.

II. **Chamæfyter**, med kun en Klasse:

- Klasse 6. **Chamæfyter**, ø: Planter hvis overlevende Knopper eller Skudspidser sidder paa Skud eller Skuddele, der befinner sig paa Jordfladen, indtil $\frac{1}{4}$ M. over denne.

III. **Hemikryptofyter**, med kun en Klasse:

- Klasse 7. **Hemikryptofyter**, ø: Planter hvis overlevende Knopper befinner sig i Jordskorpen; de overjordiske Skud eller Skuddele lever kun en Vækstperiode og dør bort ved den ugunstige Aars-tids Begyndelse.

IV. **Kryptofyter**, Planter hvis overlevende Knopper er skjulte i Jorden, i en vis Dybde under Overfladen, eller paa Bunden af Vandet; de overjordiske Skud eller Skuddele lever kun en Vækstperiode. Herunder to Klasser:

Klasse 8. Geofyter, ø: Landplanter hvis overlevende Knopper findes i en vis Dybde i Jorden, forskellig hos de forskellige Arter.

— 9. Helo + Hydrofyter, ø: Planter hvis overlevende Knopper findes i vandmættet Bund eller paa Bunden af Vandet.

V. Therofyter, med kun en Klasse:

Klasse 10. Therofyter, ø: Planter som kun lever en Vækstperiode og som derfor alene ved den i Frøet indsluttede og beskyttede Kim overlever den ugunstige Aarstid.

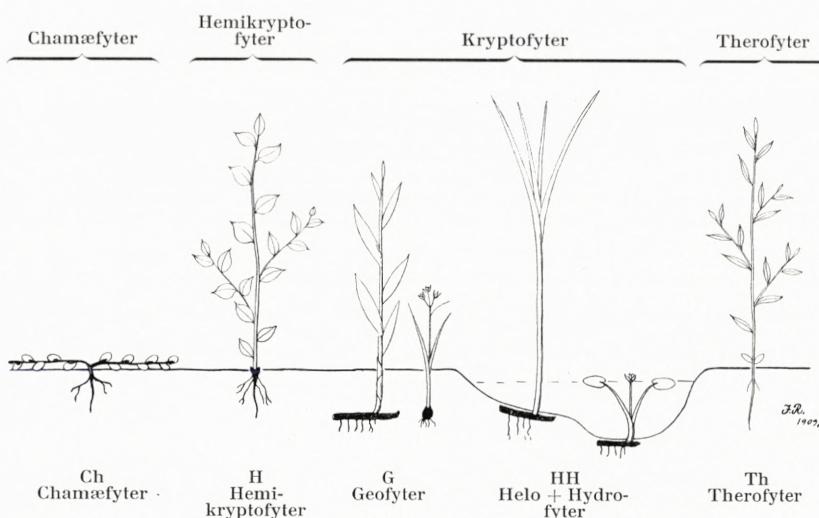


Fig. 28.

De paa Sandy Point fundne Blomsterplanter og deres Livsform.

	Livsform ¹⁾
Epidendrum papilionaceum Vahl.....	E
Bulbostylis pauciflora (Liebm.) C. B. Clarke	H
Fimbristylis ferruginea (L.) Vahl	H
Mariscus brunneus (Sw.) C. B. Clarke	H
Sporobolus virginicus (L.) Kth.	G
Dactyloctenium aegyptiacum (L.) Willd	Th
Stenotaphrum americanum Schrank	Ch
Eragrostis ciliaris (L.) Lk.	Th
Cenchrus echinatus L.	Th
Coccoloba diversifolia Jacq.	M
— uvifera (L.) Jacq.	M
Philoxerus vermicularis (L.) R. Br.	Ch

¹⁾ Bogstavernes Betydning ses i Fig. 27—28.

	Livesform
<i>Batis maritima</i> L.	Ch
<i>Pisonia subcordata</i> Sw.	M
<i>Sesuvium portulacastrum</i> L.	Ch
<i>Cassytha americana</i> Nees.	E
<i>Cakile lanceolata</i> (Willd.) C. G. Schulz	Th
<i>Canella alba</i> Murr.	M (N)
<i>Melochia tomentosa</i> L.	N
<i>Malachra capitata</i> L.	N
<i>Corchorus hirsutus</i> L.	N
<i>Croton betulinus</i> Vahl	N
— <i>discolor</i> Willd.	N
<i>Argythamnia candicans</i> Sw.	N
<i>Euphorbia buxifolia</i> Lam.	Ch
— <i>linearis</i> Retz.	N
<i>Hippomane mancinilla</i> L.	M
<i>Kallstroemeria maxima</i> (L.) W. et A.	Ch
<i>Castela recta</i> Turp.	N
<i>Suriana maritima</i> L.	N
<i>Comocladia ilicifolia</i> Sw.	M (N)
<i>Dodonaea viscosa</i> L.	N
<i>Stigmatophyllum emarginatum</i> (Cav.) Juss.	N
— <i>periplocifolium</i> (DC.) A. Juss.	M (N)
<i>Elaeodendron xylocarpum</i> DC.	M (N)
<i>Rhacoma crossopetalum</i> L.	N
<i>Colubrina ferruginea</i> Brongn.	M (N)
<i>Chrysobalanus icaco</i> L.	M (N)
<i>Caesalpinia bonduc</i> (L.) Roxb.	N
— <i>crista</i> L.	N
<i>Canavalia obtusifolia</i> (Lam.) P. DC.	N (Ch)
<i>Dalbergia hecastophyllum</i> (L.) Taub.	M (N)
<i>Stylosanthes hamata</i> (L.) Taub.	Ch
<i>Tephrosia cinerea</i> (L.) Pers.	Ch
<i>Acacia Farnesiana</i> (L.) Willd.	M (N)
<i>Leucaena glauca</i> (L.) Bth.	M (N)
<i>Pithecellobium unguis-cati</i> (L.) Bth.	M (N)
<i>Turnera ulmifolia</i> L.	N
<i>Bucida buceras</i> L.	MM (M)
<i>Conocarpus erectus</i> L.	M (N)
<i>Laguncularia racemosa</i> Gärtn.	M (N)
<i>Eugenia buxifolia</i> (Sw.) Willd.	N
— <i>axillaris</i> (Sw.) Willd.	M (N)

	Livesform
<i>Bumelia obovata</i> (Lam.) DC.	N
<i>Jacquinia armillaris</i> Jacq.	M (N)
<i>Convolvulus jamaicensis</i> Jacq.	N
— <i>pentanthus</i> Jacq.	N
<i>Ipomaea pescaprae</i> (L.) Sw.	Ch
— <i>triloba</i> L.	N
<i>Solanum racemosum</i> L.	N
<i>Capraria biflora</i> L.	N
<i>Tecoma leucoxylon</i> (L.) Mart.	MM (M)
<i>Anthacanthus spinosus</i> (L.) Nees.	N
<i>Cordia nitida</i> Vahl	M (N)
<i>Heliotropium curassavicum</i> L.	Ch
— <i>parviflorum</i> L.	Ch
<i>Tournefortia gnaphalodes</i> (Jacq.) R. Br.	N
<i>Avicennia nitida</i> Jacq.	M (N)
<i>Clerodendron aculeatum</i> (L.) Griseb.	M (N)
<i>Lantana involucrata</i> L.	N
<i>Stachytarpheta jamaicensis</i> (L.) Vahl	Ch
<i>Echites suberecta</i> Jacq.	M (N)
<i>Forestiera segregata</i> (Jacq.) Kr. et Urb.	N
<i>Erithalis fruticosa</i> L.	N
<i>Ernodea littoralis</i> Sw.	N
<i>Randia aculeata</i> L.	M (N)
<i>Scaevola Plumieri</i> (L.) Vahl	N
<i>Borrichia arborescens</i> (L.) DC.	N
<i>Pectis humifusa</i> Sw.	Ch
<i>Pluchea odorata</i> (L.) Cass.	N

LIVSFORMEN HOS PLANTER PAA NY JORD.

Ved et Blik paa Listen over de paa Sandy Point fundne Arter vil man straks se, at Fanerofyterne dominerer; en nærmere Undersøgelse vil desuden godt-gøre, at dette lille Omraade med kun 80 Arter viser et biologisk Spektrum, der, saa godt det kan forlanges, harmonerer med det biologiske Spektrum for Dansk Vestindien i det Hele taget, og det skønt Sandy Point baade er et geologisk set nyt Land og bestaar af en Jordbund, der er aldeles forskellig fra den, som ellers er den herskende i Dansk Vestindien. Dette fører ind paa det Spørgsmaal, om der indenfor samme Klima overhovedet er nogen væsentlig Forskel mellem det biologiske Spektrum af geologisk set ny Jords Flora og det biologiske Spektrum af geologisk set gamle Landes Flora, og i hvilken Grad Indvandring af ny Arter i en Flora har Indflydelse paa dennes biologiske Spektrum.

Det gælder enhver Flora, at der fra Tid til anden indvanderer ny Arter, og navnlig indslæbes der jo en Mængde Arter overalt, hvor Kulturen naar hen, og dette gælder saa vel i geologisk set gamle som ny Floraer; men de fleste af disse indslæbte Arter er i Regelen kun i Stand til at holde sig ved Hjælp af Kulturen; ved Fremstillingen af det biologiske Spektrum maa disse Arter selvfølgelig lades ude af Betragtningen, da de ikke eller dog kun i ringere Grad er et Udtryk for Planteklimaet men et Udslag af Kultur, og derfor idetmindste undertiden vilde komme til at tilsløre det væsentlige i det biologiske Spektrum, hvis de medtages. Dette gælder navnlig mange Therofyter, som jo i Regelen danner en væsentlig Bestanddel af de indslæbte og til Kulturbund bundne Arter, og som netop paa Grund af deres Livsform er egnede til Forholdene paa den dyrkede, aarligt bearbejdede Jord.

Men blandt de i de enkelte Lande indvandrede og indslæbte Arter er der ogsaa en Del, som formaar at holde sig ved egen Hjælp, idet de er i Stand til at hævde sig i Konkurrencen med de oprindelige Beboere; saadanne Arter maa siges at have faaet Borgerret i Landet og maa medtages ved Fremstillingen af vedkommende Lands biologiske Spektrum. Men Hovedspørgsmaalet drejer sig her ikke om, hvor mange eller hvor faa Arter det er, som saaledes efterhaanden faar Borgerret; det, som det her gælder om, er, hvorvidt de ny, indvandrede Arter i væsentlig Grad forandrer den oprindelige Floras biologiske Spektrum; hvis de ikke gør dette, er det for min biogeografiske Betragtningsmaade ganske ligegyldigt, hvor mange Arter

der er indvandrede; hvis de ny, indvandrede Arter ikke forandrer det biologiske Spektrum, da er det et yderligere Bevis for, at det biologiske Spektrum er et sandt Udtryk for Planteklimaet, idet det viser, at endog de ny tilkomne Arters Fordeling paa de forskellige Livsformer følger den samme Lov som den oprindelige Floras Arter.

I Kulturlande, hvor den oprindelige Flora er gennemgribende forandret, idet mindste hvad Vegetationens Fysiognomi angaaer, og hvor der er indslæbt en stor Mængde ny Arter, maa man naturligvis ikke vente, at disse slet ingen Indflydelse har paa det biologiske Spektrum; men deraf kan man ikke straks slutte, at det biologiske Spektrum er et mindre fuldkomment Udtryk for Planteklimaet; thi da

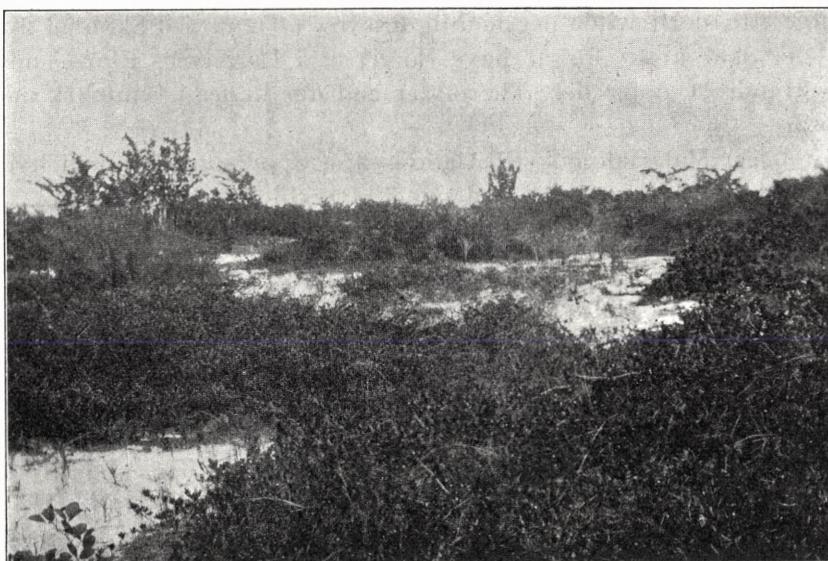


Fig. 29.

Krattet — *Coccoloba*-Formationen — paa Sandy Point paa St. Croix, ved 17 paa Kortet Fig. 17 (24, 1, 06). Lavt Krat af *Ernodea littoralis*;aabne Pletter med *Sporobolus virginicus*, etc.; i Baggrunden ses enkelte *Coccoloba uvifera*.

Bestemmelsen af, hvilke af de ny Arter der maa anses for at have Borgerret og saaledes bliver medbestemmende for Spektrets Udseende, delvis afhænger af Skøn som i alle lignende Tilfælde, er der Mulighed for, at nogle Arter medtages, som maaske ikke burde medtages, og omvendt; i Regelen kommer man vistnok lettest til at tage for mange Arter med.

I Almindelighed er Forholdet dette, at de naturaliserede Arter, de ny Arter, som maa siges at have faaet Borgerret, ikke medfører nogen væsentlig Forandring af det biologiske Spektrum og navnlig at de aldrig tilslører det i det biologiske Spektrum, som er det særlig karakteristiske for vedkommende Planteklima. Kun paa et Punkt kan de ny Arter faa en mærkbart Indflydelse paa Spektret, nemlig paa dettes Therofyt-Procent. Det er jo som bekendt de fleste Steder saaledes, at

Therofyterne udgør en langt større Del af de indvandrede og indslæbte Arter end af den oprindelige Floras Arter; Aarsagerne hertil skal jeg ikke her komme ind paa. Ved Afgørelsen af, hvilke af de ny Arter der maa anses for at have Borgerret i et Lands Flora, kommer man vistnok let til netop at medtage flere Therofyter end man strængt taget er berettiget til, og idetmindste tildels derfor vil de ny Arter ofte komme til at forhøje det biologiske Spektrums Therofyt-Procent noget; men selv i saadanne Tilfælde vil den forhøjede Therofyt-Procent dog aldrig komme til at skjule det karakteristiske i vedkommende Planteklimas Spektrum. Selv om f. Eks. Danmarks Therofyt-Procent af ovennævnte Grund bliver for høj, vil den dog, i den atter til sig selv overladte Flora, aldrig kunne blive saa høj, at den kommer til at trykke Hemikryptofyt-Procenten ned under det for Hemikryptofyt-Klimaet karakteristiske høje Tal; dertil vilde der nemlig kræves, at man ved Skønnet over, hvilke Therofyter der skal anses for at have Borgerret i Danmarks Flora, maatte medregne nogle Hundrede Arter flere Therofyter end der findes i Danmark udenfor den dyrkede Jord.

Der foreligger Materiale nok til Afgørelsen af Spørgsmaalet om, i hvilken Grad de ny Borgere i en Flora forandrer denne Floras biologiske Spektrum. Paa dette Sted skal jeg imidlertid indskrænke mig til at vise et enkelt Forhold, nemlig Indvandringen fra Europa til Nordamerika eller rettere til den Del af Nordamerika, som Britten & Brown's Ill. Flora omfatter, og som hører, hvad der ogsaa fremgaar af de biologiske Spektra i Tab. 1 No. 4—5, til Hemikryptofyt-Klimaet; kun den nordligste Del gaar ind i det boreale Planteklima, hvilket imidlertid ikke har nogen Betydning i denne Sammenhæng. P. KLINCKSIECK¹ har efter Britten & Brown's Ill. Flora givet en Liste over de til det paagældende Omraade indvandrede Arter saa vidt som de tilhører den europæiske Flora. Man kan nu undersøge, hvilke Arter der er indvandrede til et enkelt mere begrænset Omraade, en enkelt Stat, og saa se, hvorledes de ny Borgere paavirker den oprindelige Floras Spektrum; en saadan Undersøgelse har jeg imidlertid endnu ikke foretaget. Men man kan ogsaa gaa en anden Vej. Det er en Kendsgærning, at de allerfleste af de til et Land indvandrede Arter, som har været i Stand til at hævde sig i Konkurrencen med Landets oprindelige Beboere og derfor har faaet Borgerret, er indvandrede fra Lande med samme Planteklima som det, hvori deres ny Fædreland ligger. Man kan derfor undersøge Spørgsmaalet paa den Maade, at man i foreliggende Tilfælde bestemmer det biologiske Spektrum for de Arter, som er indvandrede til Nordamerikas Hemikryptofyt-Klima fra det tilsvarende Klima i Europa; hvis de indvandrede Arters Spektrum afviger stærkt fra det sædvanlige Hemikryptofyt-Klimas Spektrum, vil dette, hvis Indvandringen er meget stor i Forhold til de oprindelige Arters Tal, forandres mere eller mindre paa Grund af Indvandringen; i modsat Fald vil der ingen Forandring finde Sted, selv om Indvandringen er nok saa stor.

Af de c. 370 europæiske Arter, som i 1896 var fundne som naturaliserede i den

¹ KLINCKSIECK, P., Les plantes d'Europe adventices ou naturalisées aux États-Unis d'Amérique, constatées à deux intervalles: 1832 et 1896. Bull. Soc. Bot. Fr. 54, 1907, p. XXX—XLII.

østlige Del af det mellemste Nordamerika, tilhører de 216 ogsaa Danmarks Flora og hører i det Hele taget hjemme i Mellemeuropa; disse Arter viser nu det i Tab. 1 No. 2 fremstillede Spektrum med 47 Procent Hemikryptofyter, altsaa et udpræget Hemikryptofyt-klima-Spektrum, der, trods det ringe Artstal, ikke desmindre ogsaa hvad de andre, her underordnede Livsformer angaa, viser Hemikryptofyt-klima-Spektrets karakteristiske Talsrække; det eneste Tal, der afgiver mærkbart fra det Tal,

Tab. 1.

Arts-tal	Arternes procentiske Fordeling paa Livsformerne.										
	S	E	MM	M	N	Ch	H	G	HH	Th	
1. Europæiske, ogsaa i Danmark fundne Arter, som allerede 1832 var indvandrede til de østlige Stater af U. S. . .	57	—	—	—	2	2	3	58	7	—	28
2. Do. Do. som var indvandrede og naturaliserede i 1896	216	—	—	0,5	4	3	4	47	6,5	3	32
3. Danmark ¹	1084	—	—	1	3	3	3	50	11	11	18
4. Altamaha, Georgia ¹	717	—	—	5	7	11	4	55	4	6	8
5. Syd-Labrador ¹	334	—	—	3	3	8	9	48	12	11	6

som idetmindste er Regelen ellers, er Therofyt-Procenten. Angaaende dette Punkt har jeg foran sagt, at man ved Skønnet over, hvilke Arter der maa betragtes som havende faaet Borgerret, vištnok let kommer til at medtage netop for mange Therofyter, nemlig ogsaa en Del Arter, som vilde forsvinde fra vedkommende Land, hvis al Kultur af Jorden hørte op, og Landet ganske blev overladt til sig selv. Men selv om man holder sig til det foreliggende Spektrum med dets 32 Procent Therofyter, saa vil en Indvandring af denne Beskaffenhed, selv om Indvandringen blev nok saa stor, jo dog aldrig kunne komme til at forandre et Hemikryptofyt-klima-Spektrums væsentligste Træk: den høje Hemikryptofyt-Procent, da dette jo netop er fælles for begge Spektra.

I Listen over de europæiske Arter, som i 1896 var naturaliserede i det nævnte Omraade af Nordamerika, har P. KLINCKSIECK særtegnet de Arter, som efter SCHWEINITZ² allerede 1832 var indvandrede; jeg har ligeledes her udtaget de Arter, som ogsaa tilhører Danmarks Flora, ialt 57, hvis Spektrum ses i Tab. 1 No. 1. Trods det ganske ringe Artstal, stemmer dette Spektrum paa en slaaende Maade overens med det første Spektrum; man maa undres over den Präcision, med hvilken Arternes Livsform følger Klimaet, hvorved det paa Livsformen grundede biologiske Spektrum bliver et saa adækvat Udtryk for Planteklimaet, som man under saa komplicerede Forhold kan forlange.

¹ RAUNKIÆR, C., Livsformernes Statistik etc., S. 52 og 55.

² Se: KLINCKSIECK, I. c., p. XXXI.

Tallet af de indvandrede og indslæbte Arter, som kan staa sig i Konkurrencen med de oprindelige Arter, er kun lille; og selv om de, hvad Livsform angaar, var ensidige, ø: ikke i Overensstemmelse med den oprindelige Floras Spektrum, vilde de dog ikke forandre dette stort; men nu er de erfaringsmæssigt ikke ensidige; det er tværtimod overalt saaledes, at de naturaliserede Arters Spektrum har Tyngdepunktet paa samme Sted i Spektret som den oprindelige Flora, og derved understreges yderligere det biologiske Spektrums Værdi som biologisk Udtryk for Klimaet, som biologisk Klimareagens.

Hvis det overhovedet en Gang vil ske, at de efterhaanden indvandrede og naturaliserede Arter forandrer en Floras biologiske Spektrum saaledes, at dette derved kommer til at betegne et andet Planteklima, vil sikkert selv et flygtigt Blik paa Landets Vegetation belære om, at dennes Sammensætning ikke længere er et Naturprodukt men et Kulturprodukt og opretholdt ved Kultur.

I det foregaaende er omtalt, at de naturaliserede Arter, hvad det procentiske Forhold mellem Livsformerne angaar, i det væsentlige falder sammen med det tilsvarende Forhold i Landets oprindelige Flora, saaledes at Floraens Spektrum ikke bliver væsentlig forandret; dette fremgaar desuden af, hvad jeg paa et andet Sted har vist¹, nemlig dette, at samtlige undersøgte Lokalfloraer i samme Klima men paa højst forskellige Steder paa Jorden stemmer overens med Hensyn til det biologiske Spektrum, skønt saa vel den oprindelige som den adventive Flora er forskellig med Hensyn til Artssammensætning.

Foruden ved Indvandring kan en Flora tænkes forandret ved, at visse oprindelige Arter fortrænges og udryddes ved Kulturen, og det biologiske Spektrum kan derved tænkes forandret saaledes, at det ikke længere er et sandt Udtryk for Planteklimaet. Det er jo en Selvfølge, at naar man paa et større eller mindre Omraade udrydder alle eller dog de fleste vildtvoksende Plantearter, saa at Landet kun er bevokset med Kulturplanter og Ukrudt, saa kan man ikke vente, at dette Kulturprodukt skal være et Udtryk for Naturbetingelserne alene, da det jo væsentlig er betinget af Kultur. Men ved planteklimatiske Undersøgelser spiller dette ingen Rolle; thi her arbejder man ikke med enkelte Kvadratkilometre eller med det, der er endnu mindre, men med Landsdele og Lande; og her bliver Forholdet et andet; thi selv om vi tager et saa lille Omraade som Danmark, da har de i historisk Tid udryddede eller fra Danmarks Flora forsvundne Arter ikke forandret et eneste Tal i Danmarks biologiske Spektrum; for at formindske eller forhøje et Tal med blot en Procent, maa der ikke alene forsvinde 10—11 Arter, men disse Arter maa tillige alle høre til en og samme Livsform; hvis Danmarks biologiske Spektrum skulde forandres saaledes, at det ikke længere viste Hemikryptofytklimaets karakteristiske høje Hemikryptofyt-Procent, maatte der altsaa ikke alene forsvinde over 200 Arter, men disse maatte desuden alle være Hemikryptofyter.

Selv om Danmarks c. 6 % Skov blev udryddet, vilde dette ikke, som WARMING² mener, forandre det biologiske Spektrums Karakter; thi fordi Skovene udryddes,

¹ RAUNKLÆR. C., Livsformerne Statistik etc.

² WARMING, E., Om Planterigets Livsformer. 1908. S. 23.

forsvinder dog derfor ikke de skovdannende Arter; og min Behandlingsmaade er baseret paa Artstallet, ikke paa Individmængden.

Og selv om endelig den fantastiske Tanke blev til Virkelighed, at alle Indvider af Træer og Buske blev udryddede, vilde dette kun medføre, at Danmarks 7 Procent Fanerofyter forsvandt fra det biologiske Spektrum, men denne Forsvinden vilde ikke blot ikke formindske det, som er det karakteristiske ved Danmarks biologiske Spektrum, nemlig den høje Hemikryptofyt-Procent, men det vilde endog forhøje denne med nogle Procent. Og til Trods for, at Fanerofyterne var fjernede, vilde Spektret ikke kunne anbringes andre Steder end der, hvor det ogsaa nu hører hjemme, nemlig i Hemikryptofyt-Klimaet; og hvis man ikke vidste, fra hvilket Land et saadant Spektrum stammede, vilde man ikke blot slutte, at det stammede fra et Omraade indenfor Hemikryptofyt-Klimaet, men man maatte tillige slutte, at dette Omraade enten maatte være ganske særligt ugunstigt, eller snarere at det maatte være et Omraade, fra hvilket flere eller færre Arter Fanerofyter kunstig var blevet fjernede; thi den lave Chamæfyt-Procent vilde øjeblikkeligt belære om, at det hverken kunde stamme fra det arktiske Chamæfyt-Klima eller fra det boreale Klima.

Men nu er desuden et Omraade som Danmark ganske forsvindende lille, naar der som her er Tale om Planteklima; den koldt tempererede Zone lige fra Atlanterhavet til det stille Ocean i den gamle Verden og den tilsvarende Del af Nordamerika viser væsentlig selvsamme biologiske Spektrum, Hemikryptofytklima-Spektret; og selv om hvert Træ og hver Busk udryddedes fra Tusinder og efter Tusinder af Kvadratkilometre, behøvede derfor ikke en eneste Art at forsvinde fra det nævnte Planteklima-Omraade. Jeg husker i Øjeblikket ikke en eneste Art, som i den historiske Tid vides at være forsvundet fra den koldt tempererede Zones Hemikryptofytklimas Omraade — trods Kulturens vældige Indgreb. For at forandre dette Omraades Spektrums Karakter som Hemikryptofytklima-Spektrum maatte der udrygdes idetmindste over 2000 Arter, og disse maatte desuden alle være Hemikryptofyter.

Vi skal nu lidt nærmere beskæftige os med det Spørgsmaal, hvorvidt der er nogen Grund til at antage, at der er en væsentlig Forskel paa det biologiske Spektrum for geologisk set gamle og geologisk set unge Landes Floraer. Jeg vil her referere en af WARMING's Udtalelser, der fremtræder som en Indvending mod Anvendeligheden af mine Livsformer som Udtryk for Planteklimaet. Ved Omtalen af Rigdommen i den tropiske Regnskov i Amazonas og Fattigdommen og Ensartetheden i Nordeuropas og Sibiriens Skove skriver WARMING (l. c. S. 23—24): „Grundene hertil ere vist to, nemlig dels maaske, at Artsudviklingen paa Grund af de uendeligt gunstigere Kaar i Troperne gaar raskere for sig, hvilket jeg forøvrigt maa udtale rent hypothetisk, dels i hvert Fald, at hine Skove have en uendeligt større Alder i Jordens Historie, end vore, der maa være indvandrede efter Istiden. Her kommer da et andet Moment til at spille med ind, nemlig Arternes Vandringsevne og den utvivlsomt endnu ikke afsluttede Kamp mellem dem indbyrdes“. Og efter at der dernæst er henvist til Artsrigdommen i visse Dele af Australien og Sydafrika til-

føjes: „Jeg ser ikke, at der foreligger nogen Nødvendighed for, at Forholdet mellem Livsformerne alle Vegne er det samme i Lande med samme Klima men med vidt forskellig Flora-Alder, og er det ikke dette, tør man vel heller ikke bygge alt for sikre Slutninger paa dette Forhold med Hensyn til Planteklimaet“.

Naar Warming ikke ser „nogen Nødvendighed for, at Forholdet mellem Livsformerne alle Vegne er det samme i Lande med samme Klima men med vidt forskellig Flora-Alder“, kommer dette maaske af, at Warming ikke har undersøgt dette Spørgsmaal nærmere og derfor heller ikke søger at vise, at Forholdet er anderledes end af mig udtalt. Sagen er imidlertid mindre vanskelig at udrede, end man maaske kunde antage, idet vi i forskellige Klimater har unge og gamle Dannelser ved Siden af hverandre og saaledes er i Stand til at undersøge, om der er nogen væsentlig Forskel mellem de biologiske Spektra af disse forskellige Dannelsers Flora. Men selv om man ikke havde Materiale til en saadan Undersøgelse, vilde man ved at underkaste Spørgsmalet en mere indgaaende almindelig Betragtning komme til et Resultat, der falder sammen med mit med Grunde underbyggede Forsøg paa at skabe en biologisk Plantogeografi paa saa vidt muligt eksakt Grundlag. Før end jeg gaar over til en Fremstilling af bestemte Forhold, vil jeg derfor underkaste Spørgsmalet en saadan almindelig Betragtning og dertil vælge Sibiriens Flora, som Warming nævner; Warming bruger ganske vist Udtrykket „Skove“, men jeg maa formode, at Warming dermed mener Floraen som Helhed, idet det kun under denne Forudsætning kan være en Indvending mod min Betragtningsmaade, der ikke angaaer specielt Skovene men Floraen som Helhed.

Sibiriens Flora er geologisk set ung, og der er derfor efter Warmings Mening Grund til at antage, at Kampen mellem Arterne ikke er afsluttet, og at alle de Arter, som kan vokse her, endnu ikke er indvandrede. Dette er sikkert nok ganske rigtigt, da vi jo stadig ser ny Arter indvandre saa her saa der; men, som jeg allerede oftere har fremhævet, er det ikke det, som det her kommer an paa; det som det kommer an paa er at faa Klarhed over, om der er nogensomhelst Grund til at formode, at Indvandringen af ny Arter vil forandre det væsentlige i den nuværende Floras biologiske Spektrum, saa længe Klimaet forbliver det samme.

Lad os da her først se paa, hvorfra Sibirien overhovedet kan faa ny Plantearter.

Af Erfaring ved vi, at ingen eller saa godt som ingen af den tropiske Zones Arter er i Stand til at vokse paa Friland i den koldt tempererede Zone, og endnu mindre er de i Stand til at optage Kampen med denne Zones Arter; en Indvandring af nogen Betydning fra Fanerofyt-Klimaet er derfor udelukket og finder som bekendt heller ikke Sted. Hvis der indvandrer Arter til Sibirien, maa de komme fra Lande med væsentlig samme Klima; de maa komme fra andre Hemikryptofytklima-Omraader; men her har vi jo nu netop allevegne væsentlig den samme Fordeling af Arterne indenfor Livsformerernes Række som i Sibirien; hvis derfor de Arter, som maatte vandre til Sibirien, skal forandre dettes biologiske Spektrum, maa de indvandrede Arter vise et helt andet biologisk Spektrum end Arterne i det Land, hvorfra de stammer; efter det Side 53 omtalte Eksempel og ifølge hvad vi ellers

ved, er der ingen Grund til at antage noget saadant; og desuden, hvis den oprindelige Floras Spektrum skal forandres saaledes, at det kommer til at betegne et andet Planteklima, maa de indvandrede Arters Spektrums Hemikryptofyt-Procent gaa ned fra over 50 til under 30 Procent, og endda maatte Indvandringen være saa stor, at de indvandrede Arters Tal maatte langt overstige de oprindelige Arters Tal. Der er intet som viser, at nogetsomhelst af dette finder Sted hverken i Sibirien eller i noget andet Land paa Jorden.

Tab. 2.

Arts-tal	Arternes procentiske Fordeling paa Livsformerne.										
	S	E	MM	M	N	Ch	H	G	HH	Th	
1. Clova, Skotland ¹ , under 300 M.	304	—	—	3	2	4	7	59	7	5	13
2. Danmark ¹	1084	—	—	1	3	3	3	50	11	11	18
3. Stuttgarts Omegn ¹	862	—	—	3	3	3	3	54	10	7	17
4. Ob-Dalen, 61°—66°32'.....	265	—	—	2,5	2	7	7	50	10	10	11,5
5. Jenisei-Dalen, 56° til Ishavet ²	926	—	—	1	1	4	7	61	11	6	9
6. Amgun-Bureja n. f. Amurfloden ³ ..	441	—	—	3,5	5	9	7	58	11	3	3,5
7. Sydlige Kuriler, s. f. Ketoï-Straedet ⁴	231	—	—	3	6	8	8	55	12	2	6
8. N. Am. Sitcha ¹	222	—	—	3	3	5	7	60	10	7	5
9. — James Bay ¹	268	—	—	3	3	7	7	53	10	7	10
Normalspektrum ¹	400	1	3	6	17	20	9	27	3	1	13

WARMING (l. c., Side 24) synes, at Sibiriens Klima er et lige saa udpræget Træ-Klima som Klimaet ved Amazonfloden. Hvorledes det i Virkeligheden forholder sig vil ses ved en Betragtning af f. Eks. Jenisej-Dalens Flora. Denne omfatter nord for Krasnojarsk 926 Arter, som viser det i Tab. 2 No. 5 fremstillede Spektrum; af disse 926 Arter er 56 Fanerofyter, ø: Trær og Buske, ialt 6 Procent; hvis denne Floras Spektrum skulde skifte Karakter fra Sibiriens Hemikryptofyt-klima-Spektrum til Amazonas Fanerofyt-klima-Spektrum, maatte der til Jenisej-Dalen indvandre over 1200 Arter Trær og Buske, og vel at mærke: Trær og Buske alene; der maatte ikke samtidig komme Arter af andre Livsformer, thi i saa Tilfælde maatte Indvandringen af Trær og Buske være endnu større.

¹ RAUNKIÆR, C., Livsformernes Statistik etc., S. 52—55.

² Planteliste i: SCHEUTZ, N. J., Plantae vasculares Jeniseences, Kgl. Sv. Vetensk.-Akad. Handl. Bd. 22. 1888.

³ Planteliste i: SCHMIDT, Fr., Florula Amguno-Burejensis. Mém. de l'Acad. imper. des sc. de St. Petersbourg. VII Sér. Tome XII. 1868.

⁴ Planteliste i: MIYABE, K., The flora of the Kurile Islands. Memoirs of the Boston Society of natural history. Vol. IV. 1886—1893. Pag. 203—275.

I det følgende skal jeg fremføre et Par Eksempler paa geologisk set endnu yngre Floraer end Sibirien, nemlig Floraerne paa et Par alluviale Dannelser i forskellige Klimater, saaledes Skallingen paa Jyllands Vestkyst og Sandy Point paa St. Croix.

Sandy Point og Skallingen. Sandy Point er ikke alene geologisk set en ny Dannelse, men idetmindste delvis er det ogsaa historisk set en ny Dannelse, idet der den Dag idag finder Landdannelse Sted her. Men det er samtidig en Dannelse, hvis Jordbund er ganske forskellig fra Jordbunden i det Land, ved hvis Kyst den er opstaaet; og da det tillige, fra et planteklimatisk Standpunkt set, er et forsvindende lille Omraade, vilde det ikke undre, om vi her traf en anden procentisk Fordeling af Livsformerne end den, der ellers er den herskende i Vestindiens Fanerofyt-Klima. Men Forholdet er ikke saaledes; selv et saa lille, saa nyt og fra Omgivelserne saa forskelligartet Omraade som Sandy Point følger den Lov, at Livsformernes procentiske Fordeling hos de indvandrede Arter bestemmes af Klimaet og er et Udtryk for dette. Jeg har tidligere givet det biologiske Spektrum for St. Thomas og St. Jan. Dette Spektrum gælder for Dansk Vestindien i det Hele taget, og med dette skal derfor Sandy Points biologiske Spektrum sammenlignes. Tab. 3 No. 1—2 viser Forholdet mellem de to Spektra hvad Livsform-Rækkerne angaaer, nemlig Fanerofyter, Chamæfyter, Hemikryptofyter, Kryptofyter og Therofyter.

Til Sammenligning med Forholdet hos Floraen paa en til Sandy Point tilsvarende, alluvial Dannelse, men i et helt andet Klima nemlig Hemikryptofyt-klimaet, har jeg vedføjet de tilsvarende Tal for Skallingen og for Danmarks Flora som Helhed. Naar jeg har valgt Skallingen til Sammenligning med Sandy Point ligger det i, at dels er Skallingen baade i Beliggenhed i Forhold til det Land,

Tab. 3.

	Arts-tal	Arternes procentiske Fordeling paa Livsformerne.				
		F	Ch	H	Kr	Th
1. St. Thomas & St. Jan	904	61	12	9	4	14
2. Sandy Point	80	74	16	4	1	5
3. Krauses Lagune	32	56	28	10	3	3
4. Danmark	1084	7	3	50	22	18
5. Skallingen	105	1	7	47	19	26
6. Langlig	108	3	9	50	18	20
7. Nordby Marsk (Fanø)	17	—	6	65	12	17
8. La Camargue (Rhones Munding) ..	233	10	8	32	11	39
9. Normalspektrum	400	47	9	27	4	13

hvorfra det har faaet sin Flora, og med Hensyn til Jordbundens Art en af de Lokaliteter i Danmark, som mest minder om Sandy Point; og blandt de Egne, som der her kan være Tale om, er desuden Skallingen en af dem, hvis Flora jeg kender bedst; ikke alene foreligger der hos andre, især hos Warming¹, Oplysninger om en Del Arter, som er fundne paa Skallingen, men jeg har tillige selv flere Gange, navnlig i 1896, undersøgt Skallingen for at faa en saa vidt mulig fuldstændig Fortegnelse over dens Arter af Blomsterplanter. Resultatet heraf er en Planteliste paa 105 Arter, med det i Tab. 3 No. 5 viste Forhold mellem Livsform-Rækkerne. Et Blik paa Tabellen viser, at hvad Livsformerne Statistik angaar, staar Skallingen i samme Forhold til Danmark som Sandy Point til Dansk Vestindien i det Hele taget; i Skallingens Flora er Hemikryptofyterne dominerende ligesom i Danmark i det Hete taget, og paa Sandy Point er Fanerofyterne dominerende ligesom i Dansk Vestindien. Det er værd at lægge Mærke til, at skønt den bevoksede Del af Skallingen neppe er stort større end den bevoksede Del af Sandy Point, saa har Skallingen dog flere Arter end Sandy Point.

Vi skal nu se lidt nærmere paa Arternes Fordeling paa Livsform-Klasserne. I Tab. 4 har jeg givet de biologiske Spektra for Sandy Point og Dansk Vestindien. Som man vil se, er der givet to Spektra for Sandy Point, og Grunden hertil er følgende. Spektret No. 2 er det Spektrum, som Sandy Points Arter viser, naar man opfører dem med den Livsform, under hvilken de i Almindelighed optræder i Dansk Vestindien, og det er dette Spektrum, der først maa sammenlignes med Dansk Vestindiens almindelige Spektrum, naar man vil se, hvorledes Spektret for ny Jords Flora her forholder sig til Spektret for gammel Jords Flora; som man ser, er Overensstemmelsen saa stor, som der kan forlanges af en Flora paa kun 80 Arter. Men Spektret No. 3 er ligeledes meget oplysende. Sagen er nemlig den, at paa Grund af de ugunstige Jordbundsforhold paa Sandy Point, de samme ugunstige Forhold,

Tab. 4.

Arts-tal	Arternes procentiske Fordeling paa Livsformerne.										
	S	E	MM	M	N	Ch	H	G	HH	Th	
1. St. Thomas & St. Jan	904	2	1	5	23	30	12	9	3	1	14
2. Sandy Point	80	—	2,5	2,5	29	40	16	4	1	—	5
3. Sandy Point (særegent)	80	—	2,5	—	7,5	62,5	17,5	4	1	—	5
4. Danmark	1084	—	—	1	3	3	3	50	11	11	18
5. Langlig	108	—	—	—	—	3	9	50	14	4	20
6. Skallingen	105	—	—	—	—	1	7	47	16	3	26
7. Normalspektrum	400	1	3	6	17	20	9	27	3	1	13

¹ Se: Botanisk Tidsskrift, 19. Bind, S. 73—80; 25. Bind, S. 72—74.

hvorfed Jyllands Klitterræn adskiller sig fra de tilgrænsende Egne, er Sandy Points Fanerofytvegetation en Dværgvegetation i Sammenligning med Fanerofytvegetationen i Dansk Vestindien i det Hele taget; dette hidrører imidlertid ikke blot fra, at de lavere Fanerofyter har Overvægten i Indvandringen, der ses af Spektrum No. 2 i Tab. 4, men tillige fra, at mange af de Fanerofyter, som ellers hører til de højere og højeste Fanerofyter, paa Grund af Kaarene paa Sandy Point trykkes ned i en lavere Livsform-Klasse; alle de paa Sandy Point fundne Arter, som ellers er Meso-fanerofyter, er paa Sandy Point Mikrofanerofyter; og de fleste af de paa Sandy Point fundne Arter, som ellers er Mikrofanerofyter, er her Nanofanerofyter; tages der nu Hensyn til denne, den virkelige Størrelse faaes det i Tab. 4 No. 3 givne Spektrum, der foruden at vise det udprægede Fanerofytklima tillige er et slaaende Udtryk for dels Klimaets forholdsvis ringe Nedbør som Helhed dels for de uheldige af Klimaet gennem Jordbunden betingede specielle Kaar paa Sandy Point.

Der er her Grund til at dvæle lidt ved Spørgsmaalet om Jordbundens Betydning for det biologiske Spektrums Udseende, et Spørgsmaal som WARMING (l. c., Side 24—25) har fremdraget som en Indvending mod min biogeografiske Betragtningsmaade idet han skriver: „Der er sluttelig endnu en Faktor, som har Indflydelse paa Forholdet mellem Livsformer, nemlig Jordbunden. Man ser dette saa smukt i Brasiliens Campos (Savanner), hvor Dalene med deres Vandløb ere dækkede med Skov, det øvrige med Campos (Savanne), og Græslen mellem Skov og Savanne kan trækkes aldeles skarpt, som med en Snor. Forholdet mellem Fanerofyter og Hemikryptofyter er helt forskelligt i Skov og i Campos; der er omtrent dobbelt saa mange af de første som af de sidste i Skovene, men omvendt dobbelt saa mange af de sidste som af de første i Campos til Trods for, at Klimaet absolut er det samme — samme Nedbør, samme Varme, samme Vind; kun een Faktor er forskellig: Jordbunden. Jo mere forskelligartede Vækstpladser der findes i et Land, desto større bliver Artstallet; jo mere ensartede de ere, desto ringere. Et Sletteland har ikke saa stor Udsigt til Rigdom som et Bjærgland“.

Det sidst citerede Stykke, det om Arts-Rigdommen og Arts-Fattigdommen eftersom et Omraades Vækstpladser er forskelligartede eller ensartede, indeholder Intet om, at det større eller mindre Artstal forandrer det, som det her kommer an paa, nemlig det procentiske Forhold mellem Livsformerne; det kan derfor ganske lades ude af Betragtning. Hvad Jordbundens Beskaffenhed angaar anfører Warming som Støtte for sin Opfattelse Forholdene i Brasiliens Campos, „hvor Dalene med deres Vandløb ere dækkede med Skov, det øvrige med Campos (Savanne)“ skønt „Klimaet absolut er det samme“; „kun een Faktor er forskellig: Jordbunden“. Hvis dette er en Indvending mod mit Forsøg paa at anvende Livsformerne Statistik som et biologisk Udtryk for Klimaet, maa Warming have overseet, at han udtrykkelig selv fremhæver, at Klimaet er ganske det samme de to Steder: Skov og Savanne; thi da Klimaet er det samme, er det jo hverken Skovenes Flora alene eller Savannens Flora alene, som skal anvendes ved Fremstillingen af vedkommende Landsdels biologiske Spektrum, men Floraen paa begge Steder og i det hele taget

Floraen fra det Omraade, som har samme Varme og Nedbør, ø: samme Hydrotermfigur; og saa faar vi et biologisk Spektrum, der netop giver et udmaerket Billede af Lagoa Santa's Planteklima; i Skoven er Fanerofyterne talrige som i alle Tropeskove; men paa Savannen findes en Mængde Arter, som ikke er Fanerofyter; og derfor bliver Resultatet en for et tropisk Omraade forholdsvis lav Fanerofyt-Procent, som man efter Stedets Hydrotermfigur netop paa Forhaand ogsaa maatte vente, hvis min Betragtningsmaade er rigtig.

Man vil maaske dog nu spørge: men hvorledes forholder det sig da med det Faktum, at kun Dalene med deres Vandløb er dækket af Skov? Man vil maaske med Warming sige, at dette jo dog maa bero paa Jordbundens forskellige Beskaffenhed. Helt bortseet fra, at dette Spørgsmaal kun vedrører Formationslæren, Gruppeningen af Arterne indenfor et givet Klima, og ikke Planteklimaet, der ikke bygger paa en enkelt Formations men samtlige Formationers Arter, saaledes som jeg lige foran har omtalt, saa kunde det maaske dog af anden Grund lønne sig at se noget nærmere paa dette Jordbundsspørgsmaal.

Jordbund og Jordbund kan opfattes forskelligt; i foreliggende Tilfælde er det nemlig ikke Jordbundens Art, det kommer an paa, men Jordbundens Indhold af Vand, der hidrører fra Nedbøren, som jo netop er den ene af de to vigtigste Faktorer, som betinger et Lands Planteklima; naar der derfor er en saa stor Forskel mellem Vegetationen i Dalene og paa den højere liggende Savanne, ligger dette ikke i Jordbunden i snevrere Forstand men i Jordbunden af Nedbørens Størrelse, ø: af Klimaet, bestemte Fugtighedsgrad. Da nu Nedbøren er forholdsvis ringe, bliver de højere Partier, hvorfra Vandet løber bort, saa tørre, at en rig Fanerofyt-vegetation ikke kan trives, medens derimod Dalene, hvortil Vandet strømmer, bliver saa fugtige, at de kan fostre en saadan Vegetation. At det forholder sig saaledes, ser man deraf, at saa snart Nedbøren er større, saaledes som Tilfældet er mange andre Steder i Brasilien, dækkes ogsaa de højere Partier af Landet med Skov; og hvis Lagoa Santa's Nedbør steg betydeligt, vilde sikkert ogsaa Savannen forandres til Skov — skønt Jordbunden var den samme, kun en eneste Faktor var forandret: Nedbøren.

Warming synes her at være inde paa det samme, som førte til et væsentligt Feilgreb hos SCHIMPER, idet han adskilte edafiske og klimatiske Formationer. Om den Del af Brasilien, hvorom der her er Tale, siger Schimper nemlig, at Skoven optræder som edafisk (ø: af Jordbunden betinget) Formation, Savannen derimod som klimatisk Formation¹; men da man med lige saa megen Ret kan sige det modsatte, er det bedst ikke at sige nogen af Delene. Sagen er, at enhver Formation betinges først og fremmest af Temperaturen og af den fra Nedbøren stammende Fugtighed; Nedbøren fordeles forskelligt i Jorden efter dennes Art og Overfladeforhold, og deraf følger Formationsleddelingen; her kan man derfor ikke sige, at den ene Formation er edafisk, den anden ikke; derimod kan man vel sige, at de alle er edafiske,

¹ SCHIMPER, A. F. W., Pflanzengeographie auf physiologischer Grundlage. Jena 1898. Karte 3: „Grasfluren als klimatische Formationen, Gehölze als edaphische Formationen“.

de betinges af Jordbundens Fugtighed; men da denne er betinget af Nedbøren, er det naturligst at sige, at de alle er klimatiske; alt hvad der kan føres tilbage til Klimaet bør efter min Mening udtrykkes paa denne Maade.

Medens Jordbundens Overfladeforhold og fysiske Beskaffenhed har en stor Betydning for den fra Nedbøren stammende Fugtigheds Fordeling og derigennem for Arternes Fordeling i det Omraade, paa hvis samlede Artstal det biologiske Spektrum dannes, synes Jordbundens kemiske Sammensætning derimod at have kun ringe eller saa godt som ingen Betydning med Hensyn til de forskellige Lokaliteters biologiske Spektrum. Paa Sandy Point's af Koralsand dannede Jordbund er indvandret en Flora, der viser væsentlig samme biologiske Spektrum som den Flora, der dækker de danske vestindiske Øers Klippebund; paa Sandy Point synker Regnvandet hurtigt ned i Jorden, fra Klippeterrænet strømmer det hurtigt bort; hvorvidt den mere dværgagtige Vegetation paa Sandy Point hidrører fra, at Regnvandet her hurtigere unddrages Planterne end paa Klippebunden, eller det hidrører fra, at Jordbunden paa Sandy Point er fattigere paa Næring, skal jeg iøvrigt ikke forsøge at afgøre; det har heller ingen Betydning for det foreliggende Spørgsmaal, da det biologiske Spektrum i det væsentlige er ens begge Steder.

Hvad det biologiske Spektrum for den paa de alluviale Dannelser ved beskyttet Kyst indvandrede Flora angaar, da er Forholdet ligeledes dette, at den ny Jords Flora viser det Spektrum, som er karakteristisk for den Flora, der dækker den gamle Jord i samme Klima. Som Eksempler har jeg i Tab. 3 vedføjet de paa-gældende Tal for Krauses Lagune paa St. Croix og for Marsken Syd for Nordby paa Fanø; da Artstallet er saa lille, er der ingen Grund til at give mere detaillerede Spektra; det som det kommer an paa er det, at Floraen omkring Krauses Lagune viser Fanerofyt-klima-Spektrum, medens Floraen paa Marsken Syd for Nordby viser Hemikryptofyt-klima-Spektrum; og den høje Procent henholdsvis af Fanerofyter og Hemikryptofyter svarer saa godt, man kan forlange, til de samme Livsformers Procent i den tilgrænsende Flora.

Da det kan være af Interesse at se det samme Forhold belyst ogsaa ved Eksempler fra andre Planteklimater end de nævnte, har jeg i Tab. 3 No. 8 givet et Eksempel fra et Therofyt-klima-Omraade, nemlig fra de alluviale Dannelser ved Rhones Munding, fra la Camargue; som floristisk Grundlag har jeg her benyttet den af FLAHAULT og COMBRES givne Planteliste¹. Den paa la Camargue's Alluvialbund indvandrede Flora viser det samme Therofyt-klima-Spektrum, som findes i den tilgrænsende Del af Sydfrankrig og i Middelhavslandene i det Hele taget.

Sandy Point, Krauses Lagune, la Camargue, Fanø's Marsk og Skallingen afgiver saaledes Bevis for, at et Lands geologiske Alder ikke har nogen mærkbar Indflydelse paa Floraens biologiske Spektrum.

Det ligger i Sagens Natur, at det er den eller de Livsformer, hvis Procent i det biologiske Spektrum i særlig Grad gaar op over de tilsvarende Tal i Normal-

¹ FLAHAULT, Ch., et COMBRES, P., Sur la flore de la Camargue et des alluvions du Rhone. Bull. Soc. Bot. Fr. Tome 41, 1894, p. 37.

spektret, der i forreste Linie karakteriserer vedkommende Lands Planteklima; de danner Karakteristikens positive Side; men det er ikke uden Betydning ogsaa at se paa Karakteristikens negative Side, hvorved jeg forstaar de Livsformer, hvis Procent gaar ned under Normalspektrets Tal; disse, de vigende Livsformer, trykkes nemlig ikke i samme Grad, efterhaanden som man gaar fra det ene Klima til det andet. Gaar man fra det sydlige Mellemeuropa mod Nord, forsvinder vel efterhaanden Fanerofyterne, men de forskellige Livsformer forsvinder ikke lige hurtigt; først forsvinder de større, Mega-Mesofanerofyterne, sidst de smaa, Nanofanerofyterne.

Resultatet af Klimaforandringen, idet man gaar fra Syd mod Nord, er for alle vigende Livsformer ganske vist det samme, nemlig at deres Tal formindskes, men de Mellemaarsager, de Kombinationer af Forhold, gennem hvilke dette sker, kan være forskellige for de forskellige Livsformer saa vel som for de forskellige Plantearter. Jeg vil som Eksempler vælge Fanerofyterne og Therofyterne. En stor Mængde Therofyter, der meget vel kan vokse paa Kulturbund i Danmark, fortrænges hurtigt, naar Naturen overlades til sig selv, fordi de ikke kan hævde sig i Konkurrencen med de andre Livsformer, især Hemikryptofyterne, som straks tager den af Kulturen forladte Jord i Besiddelse. Paa saadanne specielle Lokaliteter, hvor Forholdene er saaledes, at Hemikryptofyterne kun langsomt tager en i Forvejen blottet Bund i Besiddelse, og især hvor Nydannelse af en mindre gunstig Bund finder Sted, f. Eks. i vore Klitegne, vedbliver der længe at være Pladser, hvor Therofyterne ikke møder den overmægtige Konkurrence, og af den Grund vil der her i Regelen findes et forholdsvis stort Antal Therofyter; hvis man derfor danner et biologisk Spektrum for saadanne specielle Lokaliteters Flora, vil dette Spektrum i Regelen vise en forholdsvis høj Theroft-Procent. Sammenlignet med Spektret for det tilgraensende Land afspejler denne høje Theroft-Procent saaledes til en vis Grad Stedets Natur. Tallene i Tab. 4 No. 4—6 er i denne Henseende oplysende.

Paa en anden Maade forholder mange Fanerofyter sig. Der er ligeledes mange fremmede Fanerofyter, som kan vokse paa Kulturbund hos os, men som ikke kan hævde sig i Konkurrencen med Hemikryptofyterne; men medens Therofyterne forsvinder, delvis fordi der overhovedet ikke levnes dem Plads, forsvinder Fanerofyterne vistnok paa Grund af, at de ikke kan staa sig mod den indvandrende Hemikryptofyt-Vegetation i Konkurrencen om Næringen og, maaske særlig, i Konkurrencen om Vandet. Saadanne Fanerofyter vil i Regelen heller ikke kunne vokse der, hvor der ingen Konkurrence er, hvis Jordbunden er tør og fattig og Fordampningen stærk, f. Eks. i vort Klitterræn. Noget lignende gælder vore egne, i Landet hjemmehørende Fanerofyter; en Del af dem kan ganske vist hævde sig i Konkurrencen med Hemikryptofyterne og andre Livsformer og tilsidst gaa af med Sejren, hvor Forholdene er nogenlunde gunstige, men kan ikke hævde sig i Konkurrencen, hvor Forholdene er mindre gunstige; og hvor Kaarene er i særlig Grad ugunstige, kan de maaske overhovedet slet ikke trives, selv om der ingen Konkurrence er, f. Eks. i vore Klitter. Dette medfører, at naar man fra den sydlige Del af Hemikryptofyt-

Omraadet gaar mod Nord, ser man ikke alene, at Fanerofyterne efterhaanden aftager, men de, der bliver, trænges mere og mere tilbage fra de ugunstige Lokaliteter, og tilsidst findes de kun som ubetydelige Rester paa de gunstigste Lokaliteter.

I Vestindiens Fanerofytklima er der paa Sandy Point 74 Procent Fanerofyter; ved Nordgrænsen af den gamle Verdens Theroftklima er i la Camargue endnu 10 Procent Fanerofyter; herfra aftager de yderligere mod Nord, stærkere for de ugunstige end for de gunstige Lokaliteters Vedkommende; i Hollands Klima er der endnu en ikke ubetydelig Fanerofytvegetation i Klitedalene: i de jyske Klitter er Fanerofytvegetationen meget sparsom; paa Skallingen er Fanerofyt-Procenten gaaet ned til een Procent, repræsenteret af en eneste Art, en Nanofanerofyt, *Salix repens*, der endda her nærmest er trykket ned til at være Chamæfyt.

Vi skal nu tilsidst gennem et Par Eksempler se, hvorledes Forholdet er paa ikke alene geologisk men ogsaa historisk set ny Jord, om der ikke dog her skulde være et andet Forhold mellem Livsformerne, saa at den nylig indvandrede Flora viste et andet biologisk Spektrum end den gamle Jords Flora. Man kan her undersøge den indvandrede Flora paa den ved Kunst for Vegetation blottede Bund, og man kan undersøge Forholdet paa den fra Naturens Haand ny Bund. Jeg vil tage det sidste Forhold først og vælge et Eksempel fra et Hemikryptofytklima-Omraade, nemlig de nydannede Øer i Hjälmaren, og et Eksempel fra et Fanerofyt-klima-Omraade, nemlig Krakatau; det bliver saaledes tillige Eksempler paa højst forskellig Jordbund.

De nydannede Øer i Hjälmaren. Ved Kanalgravning sänkedes i 1882 Hjälmarens Vandspejl 1,2 M. og i 1886 yderligere 0,7 M.; derved fremkom en Række ny Øer, idet en Række større og mindre Grunde tørlagdes; desuden fremkom der store Strækninger nyt Land langs gamle Kyster; vi har saaledes her store Strækninger ny Jord, som kun er 27 Aar gammel, og paa hvilken der efterhaanden er indvandret et ikke ringe Antal Planter. Denne ny Flora er i Aarenes Løb blevet undersøgt flere Gange, nemlig 1886 af CALLMÉ¹, 1892 af GREVILLIUS² og endelig 1903—1904 af BIRGER³; man er saaledes endog i Stand til at følge Udviklingen fra Begyndelsen. I den sidst nævnte Afhandling³ har BIRGER taget Hensyn til de foregaaende Arbejder og sammenstillet Resultaterne af samtlige Undersøgelser; og dette floristiske Materiale har jeg her benyttet, idet jeg har bestemt Livsformen hos de

¹ CALLMÉ, ALFR., Om de nybildade Hjälmaröarnas vegetation. Bih. t. K. Vet. Akad. Handl. 12 (1887) III. No. 7.

² GREVILLIUS, A.Y., Om vegetationsförhållandena på de genom sänkningarna 1882 och 1886 nybildade skären i Hjälmaröarna. Bot. Not. 1893.

— Om vegetationens utveckling på de nybildade Hjälmaröarna. Bih. t. K. Vet. Akad. Handl. 18 (1893) III. No. 6.

³ BIRGER, SELIM, De 1882—1886 nybildade Hjälmaröarnas vegetation. Arkiv för Botanik. Bd. 5. 1905—1906.

enkelte Arter og derpaa fremstillet det biologiske Spektrum for den Flora, der fandtes henholdsvis 1886, 1892, 1903—1904, og for alle de iagttagne Arter tilsammen. Ved Begrænsningen af Floraen har jeg fulgt de samme Regler som ved Fremstillingen af det biologiske Spektrum for Danmarks Floras Vedkommende. Tab. 5 viser Arternes Fordeling i de 5 Livsform-Rækker; No. 1—3 viser paa denne Maade de nydannede Øers biologiske Spektrum henholdsvis 1886, 1892 og 1903—04; No. 4 viser det biologiske Spektrum for samtlige paa de nydannede Øer fundne Arter;

Tab. 5.

	Arts-tal	Arternes procentiske Fordeling paa Livsformerne				
		F	Ch	H	Kr	Th
1. De ny Øer i Hjälmaren 1886	91	9	5	46	14	26
2. — — — 1892	140	12	3	52	20	13
3. — — — 1903—4	148	17	3	53	18	9
4. — — — 1886—1904	192	14	3	51	16	16
5. De ny Øer i Hjälmaren + det ny Land langs gamle Øers Kyster 1886—1904	228	13	4	52	16	15
6. Danmark	1084	7	3	50	22	18

at Artstallet her er betydelig større end ved den sidste Undersøgelse kommer af, at en Del af de ved den første eller de to første Undersøgelser iagttagne Arter ikke blev fundet senere, hvad enten dette nu i det enkelte Tilfælde hidrører fra, at Arten igen er forsvundet fra Øerne, eller at den er blevet overset ved den senere Undersøgelse. I No. 5 har jeg givet det biologiske Spektrum for alle de Arter, som er fundne dels paa de nydannede Øer dels paa det nydannede Land langs Kysterne af de i Forvejen tilstedevarende Øer. Til Sammenligning har jeg endelig i No. 6 vedføjet det biologiske Spektrum for Danmarks Flora.

Alle disse Spektra stemmer overens deri, at de viser Hemikryptofyt-klima-Spekrets høje Hemikryptofyt-Procent, hvoraf ses, at det biologiske Spektrum for selv ganske ny Jords Flora beherskes af de samme Love, som medfører, at det biologiske Spektrum i det Hele taget bliver et træffende Udtryk for Planteklimaet. Allerede 4 Aar efter de ny Øers Fremkomst, medens der endnu kun er indvandret 91 Arter, viser denne ny Flora et biologisk Spektrum med 46 Procent Hemikryptofyter, der i 1892 og 1903—4 stiger henholdsvis til 52 og 53 Procent. Angaaende Hemikryptofyterne er der saaledes intet usædvanligt at bemærke; det samme er Tilfældet med Chamæfyt- og Kryptofyt-Procenten. Derimod er der i de 18 Aar, fra 1886—1904, foregaaet en noget større Svingning i Fanerofyt- og Therofyt-Procenten. Jeg kan i Øjeblikket ikke give det biologiske Spektrum for Hjälmaren-Egnens Flora i det Hele taget og har saaledes ikke de bestemte Tal, med hvilke Tallene i de ny

Øers Spektrum nærmest skal sammenlignes; men det maa i hvert Tilfælde betragtes som sikkert, at de ny Øers Spektrum i 1886 har en højere Therofyt-Procent end den omgivende Egns Flora; de enaarige Planter synes jo ogsaa altid at være forholdsvis rigt repræsenterede blandt de Arter, som idetmindste indenfor Hemikryptofyt-Klimaet, først indfinder sig paa ny Jord og paa den ved Kultur blottede Jord; man ser ogsaa, at den forholdsvis høje Therofyt-Procent snart synker, først til 13 i 1892 og endelig til 9 i 1904. Det skal dog her bemærkes, at selv om det er sikkert nok, at Therofyterne er rigere repræsenterede i Floraen paa ny Jord i de

Tab. 6.

	Arts-tal	Arternes procentiske Fordeling paa Livsformerne.									
		S	E	MM	M	N	Ch	H	G	HH	Th
1. De ny Øer i Hjälmaren 1886.....	91	—	—	3	3	3	5	46	7	7	26
2. — — 1892.....	140	—	—	6	3	3	3	52	7	13	13
3. — — 1903—4...	148	—	—	8	4	5	3	53	5	13	9
4. — — 1886—1904	192	—	—	6	3	5	3	51	5	11	16
5. De ny Øer + de ny Dele af gamle Øer 1886—1904	228	—	—	5	3	5	4	52	6	10	15
6. Danmark	1084	—	(0,1)	1	3	3	3	50	11	11	18

allerførste Aar end senere, saa er Forholdet dog saaledes, at man i Regelen faar et for stærkt Indtryk af Therofyternes Overvægt; undersøger man nemlig mere indgaaende en Mark, der, efter at have været dyrket i en Aarrække, er bleven overladt til sig selv, vil man vel finde, at Therofyterne er forholdsvis rigt repræsenterede, men dog ikke saa rigt, som det ved første Øjekast syntes; thi ser man nøjere efter, viser det sig, at en Mængde ved første Undersøgelse oversete Arter, som hører til andre Livsformer, især Hemikryptofyter, allerede er tilstede omend kun som Kimpplanter; og efter faa Aars Forløb har disse andre Livsformer baade hvad Artstal og Individmængde angaaer trængt Therofyterne tilbage til den mere beskedne Plads, som de indtager i Hemikryptofyt-klimaet, naar Naturen i længere Tid er overladt til sig selv.

Hvad Fanerofyterne angaaer begynder de i 1886 med 9 Procent men stiger i de følgende Aar, saaledes til 12 Procent i 1892 og til 17 Procent i 1903—4; skønt jeg, som sagt, ikke kan give det biologiske Spektrum for Hjälmaren-Egnens Flora som Helhed, maa jeg dog antage, at den Fanerofyt-Procent, som de ny Øers Flora viser i 1903—4, er højere end den tilsvarende Procent i den omgivende Egns Flora. Tages der Hensyn til ikke blot de ny Øer men tillige til det ny, langs de gamle Øers Kyster dannede Lands Flora, viser Spektret kun 13 Procent Fanerofyter, som maaske ikke er langt fra det normale i en Skovvegn i Mellemverlige. Men hvorledes

det nu end forholder sig hermed, saa staar det fast, som her er Hovedsagen, at den paa de ny Øer i Hjälmaren indvandrede Flora viser Hemikryptofytklima-Spektrum ligesom det omgivende Lands Flora. Tab. 6 viser yderligere, at Arternes Fordeling i Livsform-Klasserne er i saa god Overensstemmelse med det almindelige Hemikryptofytklima-Spektrum, som kan forlanges af en Flora med det foreliggende Artstal.

Krakatau. Ved en Undersøgelse over det biologiske Spektrum for den paa historisk set ny Jord indvandrede Flora egner Vulkanøen Krakatau i Sundastrædet sig i særlig Grad til Sammenligning med de ny Hjälmaren-Øer; thi Krakataus nuværende Jordbund opstod omrent samtidig med Hjälmaren-Øerne, nemlig i 1883, og ligesom disses ny Flora er Krakatau's ny Flora bleven undersøgt og beskrevet tre Gange, saaledes 1886 af TREUB¹, 1897 af PENZIG² og 1906 af ERNST³. Før 1883 var Krakatau dækket af uigennemtrængelig Urskov, en Fanerofytvegetation; i Sommeren 1883, navnlig ved det vældige Udbrud 26.—27. August, tilintetgjordes denne Vege-

Tab. 7.

	Artstal	Arternes procentiske Fordeling paa Livsformerne.				
		F	Ch	H	Kr	Th
1. Krakatau 1886	15	59	7	20	7	7
2. — 1897	49	70	6	14	6	4
3. — 1906	73	78	6	8	3	5
4. — 1886—1906	90	77	4	10	3	6
5. Edam	74	55	15	7	4	19

tation ganske, idet de to Trediede af Øen forsvandt i Havet og den tilbagestående Trediedel dækkes af et gennemsnitligt 30 M. tykt Lag af glødende Slagger og Aske. Den efter 1883 paa Krakatau indvandrede Flora er betydelig fattigere end den paa Hjälmaren-Øerne, idet der i 1886 kun fandtes 15, i 1897 kun 49 og i 1906 kun 73 Arter; ialt er der fundet 90 Arter. I Tab. 7 ses, hvorledes disse Arter fordeles sig i de 5 Livsform-Rækker, og i Tab. 8 ses de mere detaillierte biologiske Spektra, nemlig Arternes Fordeling i Livsform-Klasserne; man vil heraf se, at Floraen lige fra Begyndelsen af viser Fanerofytklima-Spektrum i Overensstemmelse med det udprægede Fanerofytklima, i hvilket Krakatau befinder sig; de bestemte Tal for dette Klimas biologiske Spektrum kan jeg ganske vist ikke give; det er hverken for Javas eller Sumatras Vedkommende muligt i Øjeblikket; men

¹ TREUB, M., Notice sur la nouvelle Flore de Krakatau. Annales du Jardin bot. de Buitenzorg, 7, 1888.

² PENZIG, O., Die Fortschritte der Flora des Krakatau. Sammest. 1902.

³ ERNST, A., Die neue Flora der Vulkaninsel Krakatau. Vierteljahrsschrift d. naturf. Gesellsch. in Zürich. 1907.

at vi her har Fanerofytklima-Spektrum, er sikkert nok; for dog at have et om end kun meget lille Omraades Flora til Sammenligning, har jeg bestemt Livsformen hos de paa den lille, ud for Batavia liggende Koralø Edam fundne Arter, ialt 74, hvis biologiske Spektrum ses i Tab. 7 No. 5 og Tab. 8 No. 5; Overensstemmelsen mellem de biologiske Spektra af denne Ø's og Krakataus Flora er saa stor, som

Tab. 8.

	Artstal	Arternes procentiske Fordeling paa Livsformerne.									
		S	E	MM	M	N	Ch	H	G	HH	Th
1. Krakatau 1886	15	—	—	20	13	26	7	20	7	—	7
2. — 1897	49	—	4	23	16	27	6	14	6	—	4
3. — 1906	73	—	3	16	30	29	6	8	3	—	5
4. — 1886—1906	90	—	3	18	27	29	4	10	3	—	6
5. Edam	74	—	1	14	20	20	15	7	4	—	19

kan forlanges af et saa ringe Artstal, og til Trods for at baade Jordbundens Alder og Beskaffenhed er højst forskellig. Ligesom de foregaaende Eksempler viser da dette, hvilken Betydning det biologiske Spektrum har som biologisk Udtryk for Klimaet, som Middel til at give en træffende Karakteristik af Planteklimaet.

Foruden ny Jord i strengeste Forstand, Jord, som aldrig før har baaret Planter, fremkommer der jo ogsaa gennem Kulturens Indvirken ny Jord, ø: en Bund paa hvilken der bliver Plads for en mere eller mindre rig Indvandring af ny Planter. Det er imidlertid saaledes, at hverken den ene eller den anden Form for ny Jord har nogen Indflydelse paa det biologiske Spektrums Udseende. For den fra Naturens Haand ny Jords Vedkommende er dette vist i det foregaaende. Her skal jeg nu til Slutning dvæle et Øjeblik ved den gennem Kulturen frembragte ny Jord.

Ved enhver Benyttelse af Jorden forstyrres i større eller mindre Grad den relative Ligevægt i den oprindelige Flora; Afgræsning, Skovbrug, Høslet, Agerbrug og Havebrug er de vigtigste Kulturindgreb, hvorved den oprindelige Ligevægt forstyrres, og de betegner forskellige Grader af Indgrebets Størrelse. Jordens Benyttelse alene til Græsning frembringer saaledes en betydelig Forstyrrelse af den oprindelige Ligevægtstilstand, men den er dog kun ringe i Sammenligning med det Indgreb, som Jordens Benyttelse til Agerbrug og Havebrug medfører; thi herved udryddes ganske eller dog næsten ganske de oprindelige Plantearter paa det benyttede Terræn. Allevegne hvor Kulturen griber ind finder da en Ligevægtsforstyrrelse Sted, hvad enten denne nu er stor eller lille, og der skabes derved ny Jord i ovennævnte

Forstand; der skabes Betingelser for en Indvandring af ny Arter og for en ny Kamp om Pladsen, saa snart Mennesket ikke længere holder Kulturtilstanden vedlige. At det biologiske Spektrum forandres, naar Mennesket udrydder den oprindelige Flora og dyrker ganske bestemte Kulturplanter i Stedet, er en Selvfølge og kan ikke anvendes som en Indvending mod et videnskabeligt System. Hvis derimod det biologiske Spektrum af den Flora, som efterhaanden atter tager den af Kulturen forladte Bund i Besiddelse, i Almindelighed blev et andet end den oprindelige Floras biologiske Spektrum, da vilde dette her idetmindste være en Ulempe for min Betragtningsmaade; men at Sagen heller ikke forholder sig saaledes, behøver jeg neppe at give specielle Eksempler paa, da det jo netop er en Jagtagelse, som man saa godt som overalt har Lejlighed til at gøre, at saa snart et Stykke Jord gaar ud af Kultur og overlades til sig selv, begynder der en Forandring af Vegetationen i den Retning, at denne mere og mere, efter som Tiden gaar, nærmer sig til de Forhold, der herskede før Kulturen greb ind: det oprindelige biologiske Spektrum vender atter tilbage paa den af Kulturen opgivne Bund. Lader man i en Skovvegn i Danmark, f. Eks. i Nordsjælland, et Stykke Mark gaa ud af Kultur, indfinner sig efterhaanden de samme Planter, ogsaa Fanerofyter som Eg, Bøg, El, osv., som før Menneskets Indgreb dannede Vegetationen, og som den Dag idag danner Vegetationen paa de Steder, der, som Skov, Overdrev, osv., har været mindre utsat for Kulturens Indgreb. Lader man paa samme Maade i Vestjyllands Hedeegne en Mark gaa ud af Kultur, indvandrer i Løbet af faa Aar igen Hedens Planter. Paa samme Maade gaar det andre Steder og i andre Klimater; lader man i Vestindien et Stykke Land gaa ud af Kultur, bliver det i Løbet af ganske faa Aar tæt bevokset med en Fanerofytvegetation ligesom de Pletter, der aldrig har været under Kultur.

Det underer mig derfor, at WARMING heri kan se en Indvending mod Anvendeligheden af mit System eller blot en Vanskelighed for dette, da det jo tvertimod paa den smukkeste Maade bekræfter Rigtigheden af min Betragtningsmaade.

Jeg har tidligere omtalt, hvorledes det forholder sig med den Indvending, som WARMING mener der ligger i den Mulighed, at et Lands Skove, f. Eks. Danmarks, blev udryddede. Efter at have omtalt det tænkte Eksempel: Udryddelsen af Danmarks c. 6 % Skov, skriver Warming (l. c., Side 23): »Ganske paa samme Maade gaar det andensteds, selv i Tropelande; „naar Menneskene forlade Blumenau (i Syd Brasilien), siger A. Møller, vilde Landet efter 10 Aars Forløb helt være bevokset med Træ“, og samme Skæbne spaar H. Cotta Tyskland i Løbet af 100 Aar, hvis Mennesket forsvandt«. Der maa til disse Eksempler dog tilføjes, at omkring Blumenau vil Landet ikke alene blive bevokset med Træer, Fanerofyter, men denne Fanerofytvegetation vil tillige efterhaanden blive sammensat af et forholdsvis stort Antal Arter, saaledes som Skoven i det Hele taget er i denne Egn; og den Flora, som tager den af Kulturen forladte Bund i Besiddelse, vil vise og viser Fanerofyt-klima-Spektrum, som Floraen i vedkommende Egn som Helhed ogsaa viser nu. Og angaaende Eksemplet fra Tyskland, maa der ligeledes her tilføjes, at den Vegetation

af Træer, hvormed, efter Cotta's Mening, Tyskland om 100 Aar vilde blive bevokset, hvis Mennesket forsvandt, kun vilde indeholde forholdsvis faa Arter af Fanerofyter, ganske som Tysklands Skove nu, men derimod en stor Mængde Arter af Hemikryptofyter og andre Livsformer; den vilde i det Hele taget vise udpræget Hemikryptofyt-klima-Spektrum, hvilket jo netop ogsaa nu er Tilfældet med Floraen paa de store Strækninger, som altid har været og endnu er bevokset med Skov i Tyskland. Disse Eksempler indeholder saaledes ikke blot ingen Indvending mod Anvendeligheden af mit System, men de illustrerer endog paa en slaaende Maade dettes Betydning, idet de viser, at Mennesket er ude af Stand til, selv ved de vældigste Indgreb, at frembringe en varig Forandring af Naturen saaledes, at denne Forandring kan holde sig uden Kulturens Hjælp; det viser sig tværtimod allevegne, at naar Kulturens Indgreb ophører, vender Naturen, hvad Arternes Fordeling paa Livsformerne angaar, atter tilbage til det oprindelige Forhold, saa at det Land, der overlades til sig selv, efter kortere eller længere Tids Forløb atter viser det biologiske Spektrum, som svarer til vedkommende Lands Planteklima, og som det viste før Landet kom under Kultur. Og ikke alene dette; men det vil endog falde Mennesket vanskeligt at forandre væsentlig et Lands, ikke at tale om en hel Klimazones, biologiske Spektrum; saa længe der f. Eks. i Danmark eksisterer Landevejsrabatter, Grøftekanter, stejle Bakkeskraaninger og andre lignende Lokaliteter, som ikke behandles med Plov eller Spade, vil den Flora, som her i Danmark holder sig ved egen Hjælp, vise Hemikryptofyt-klima-Spektrum i Overensstemmelse med det faktiske, tilstede-værende Klima; og det tilsvarende gælder for alle andre Klimaters Lande.

Medens Kulturen let kan komme til at vende op og ned paa de Resultater, som den floristiske Plantogeografi, der bygger paa Systematikens Arter, er kommen til, vil det derimod falde den vanskeligt i det væsentlige at forandre det paa Livsformernes Statistik grundede biologiske Spektrum. Og selv om det fantastiske skete, at ethvert vildtvoksende Planteindivid blev udryddet af Verden, saa at der af Planter kun eksisterede Individer af Kulturplanter, vilde ogsaa disse Planter alene, idet-mindste i Hovedtrækkene, give en Forestilling om de eksisterende Planteklimaters Art. Man huske blot, at i det tropiske Fanerofyt-klima trives der forholdsvis langt flere fanerofyte Nutteplanter end i Hemikryptofyt-klimaet, i hvilket der omvendt trives forholdsvis langt flere hemikryptofyte Nutteplanter end i Troperne. Saa længe der vokser Planter paa Jorden, vil vi derfor i Planternes Livsform og det paa denne grundede biologiske Spektrum have et Udtryk for Planteklimaet.

UNDERSØGELSER
OVER
DE I FORSKELLIGE PLANTEDELE
INDEHOLDTE KALKSALTE
AF
BILLE GRAM

D. KGL. DANSKE VIDENSK. SELSK. SKRIFTER, 7. RÆKKE, NATURVIDENSK. OG MATHEM. AFD. VIII. 2

KØBENHAVN
BIANCO LUNOS BOGTRYKKERI
1909

I. Oversigt over tidligere Undersøgelser.

Den almindelige Forekomst af Kalksalte, som aflejres i forskellige Planteorganer, har tidligt været iagttaget, og de udskilte Saltes Art og Forhold har været Genstand for talrige Undersøgelser. Disse har været rent kemiske, som SCHEELES Undersøgelse over Rabarber¹⁾, ved hvilken S. paaviste, at Krystalstjernerne i Rabarber ikke bestod af Kalciumsulfat, som kort forinden angivet af MODEL, men af Kalciumoxalat, og S. beviser dette gennem en Række af Reaktioner, som endnu er fuldkommen fyldestgørende. En anden Gruppe Undersøgelser er foretaget ad mikroskopisk Vej, støttet til mikrokemiske Reaktioner og fysiologiske Forsøg, ligesom der ogsaa foreligger Arbejder, som udelukkende eller væsenligst er baseret paa teoretiske Overvejelser over foreliggende Arbejder.

LIEBIG²⁾ ansaa de organiske Syrer som Mellemled ved Kulsyrens Overgang til Sukker; efter iltrigere Syrer følger iltfattigere. Dannelsen af Sukker, Stivelse, Pektin og Gummi foregaar ikke paa en Gang af Kulsyrens Kulstof og Vandets Bestanddele, men der dannes Forbindelser, som bliver fattigere paa Ilt og rigere paa Brint. Uden Salte af organiske Syrer kan Sukker, Stivelse, Gummi eller Pektin ikke dannes.

SANIO³⁾ hævder, at det udskilte Salt er et Affaldsprodukt, som dannes ved Omsætninger i Planten og derefter ophobes og uskadeliggøres. Stoffet er Kalciumoxalat, der ikke genopløses. HOLZNER⁴⁾ antager, at Oxalsyren, som han forudsætter at være et Produkt af Æggehvilstofferne, har den Opgave at binde Basen af det optagne Kalciumfosfat og -sulfat. SACHS⁵⁾ tiltræder Holzners Anskuelse og fører den videre, idet han sætter Aflejringen af Kalciumoxalat ved Bastbundter i Forbindelse med det fra Jorden optagne Kalciumsulfat, som dekomponeres af Oxalsyre for at den frigjorte Svovalsyre kan finde Anvendelse ved Dannelsen af Sirørenes svovlholdige Æggehvilstoffer. Frasets Hypotesen om Oxalsyrens Oprindelse fra Æggehvilstofferne, finder EMMERLING⁶⁾, at de kemiske Undersøgelser, som han har anstillet til Belysning af Oxalsyrens Forhold over for Kaliumnitrat — uden og ved samtidig Tilstedeværelse af Salpetersyre — og over for Kalciumnitrat, bekræfter Holzners Anskuelser, hvilke han supplerer paa følgende Maade: Det er en af Oxalsyrens og maaske andre organiske Syfers Funktioner at frigøre Mineralsyrerne af de optagne Salte, for at Syrerne derved kan bringes i en for Assimilationen — navnlig for Dannelsen af Æggehvilstofferne — skikket Form; de samtidigt dannede

Salte af organiske Syrer bliver at betragte som Biprodukter. DE VRIES⁷⁾ benægter Rigtigheden af Holzners Anskuelser og finder, at Oxalsyrens Betydning ligger deri, at den binder det for Planten skadelige Overskud af Kalk, som den bringer i uoplöselig Form. Kalciumoxalatet er derfor at anse som et Affaldsstof.

AÈ⁸⁾ betragter Oxalatet som et Reservenæringsstof; han mener, at det om Efteraaret føres fra Bladene ind i Grenene og i følgende Foraar ud i de unge Blade, hvor det opløses for derpaa at tjene som Næringsstof. Paa Foranledning af et Arbejde af A. BEIER⁹⁾, som slutter, at Mineralstofferne rimeligvis lige som Forraadsstoffer allerede om Efteraaret ophobes i Traet for først at opløses i følgende Foraar, og at Kalken overvejende er bundet til Æblesyre, bemærker AÈ, at der foreligger flere positive Beviser for, at Druserne bestaar af Kalciumoxalat.

SCHIMPER¹⁰⁾ fremsætter afvigende Anskuelser om Kalkens Forhold i Planterne. Dens Betydning er mindst en dobbelt, idet den danner opløselige Forbindelser med Kulhydraterne og derved gør disse transportable, dernæst tjener den til at tilføre Planterne assimilerbart Kvælstof, Svovl og Fosfor. Medens Kalken i første Tilfælde ikke kan erstattes af nogen anden Base, kan dette finde Sted med Saltene af de anførte uorganiske Syrer.

Hvad Kalciumoxalatet angaaar, fremsætter Schimper den Anskuelse, at Saltet forekommer i Planten som primært, sekundært og tertiatert Kalciumoxalat*. Som primært betegner S. det Salt, der dannes under Bladets Udvikling, uafhængigt af Lysets Paavirkning, som sekundært det, der dannes i det udvoxede Blad under Indvirkning af Lys, medens det tertiare dannes om Efteraaret, naar Bladet tømmes. Naar det almindelig har været antaget, at Kalciumoxalatet efter at være dannet i Løvbladet ikke mere undergaar nogen Forandring, men forbliver paa det Sted, hvor det er udskilt, hævder S. i Modsætning hertil, at Løvbladenes Kalciumoxalat i Virkeligheden er næsten lige saa bevægeligt som Assimilationsprodukterne, om end Hensigten med dets Vandring er en ganske anden. Opløsning af allerede dannet Kalciumoxalat og Gendannelse (Udkrystallisation?) paa andet Sted foregaar ingenlunde sjældent i Løvbladet; i saadanne Tilfælde optræder Saltet først i grønne Celler og ophobes senere i særlige Celler i Nærheden af Karstrenge. En Vandring fra Bladene og ind i Stammen maa ogsaa antages at foregaa. Naar det ligeledes almindelig har været antaget, at Kalken bl. a. tjener til at binde og uskadeliggøre den giftige Oxalsyre, betegnes denne Antagelse som en Hypotese, der savner et hvert Grundlag, og som S. i Overensstemmelse med De Vries maa betegne som uholdbar. S. mener meget mere at maatte slutte, at Oxalsyren kun dannes for at binde den ubenyttede Kalk, og at den i saa Henseende kan erstattes af andre Syrer.

Kort Tid efter fremkom KOHLS Bog¹¹⁾, der bl. a. og væsenligst omhandler de samme to Emner: Kalciumoxalatets Forhold i Planten og Kalkens Betydning for Transporten af Kulhydraterne. Skønt det ikke er vanskeligt at paavise Uoverensstemmelser om Enkeltheder i Schimpers og Kohls Anskuelser, er Ligheden mellem

* S. bruger i Flæng Udtrykkene primært, sekundært, tertiatert Kalciumoxalat og den primære, sekundære og tertiare Kalciumoxalatdannelse.

de to Arbejder i Stoffet, dets Behandling og de fundne Resultater paafaldende. Man sammenligne f. Ex. de to Forfatteres Karakteristik af Kalciumoxalatet.

Kohl skelner mellem primært, sekundært, tertiarørt og kvartært Kalciumoxalat. Det primære Salt udkrystalliserer under Planteorganernes Udvikling; det dannes uafhængigt af Lys og Klorofyl og paavirkes ikke af Transpirationen, hvilket allerede fremgaar deraf, at de paagældende Organer endnu er fuldstændigt indesluttede i Knop. Saltets Mængde plejer at forøges, indtil Organet har opnæaret sin typiske Form. Aflejringsstederne er mindre bestemte og regelmæssige, end Tilfældet er for det sekundære og tertiarøre Oxalat, om end en perifer Lejring i Organerne synes at være fremherskende.

Det sekundære Oxalat er allerede efter sin Oprindelse væsenligt forskelligt fra det primære. Det dannes i den klorofylholdige Celle, og alene i denne. Dets Dannelse er afhængig af Lys og Klorofyl, men uafhængig af Assimilationen (støttet til Schimpers Kulturforsøg i kulsyrefrei Luft med *Pelargonium zonale*, hvorefter de nydannede Blade ikke viste Indhold af Stivelse, men lige saa store og lige saa mange Kalkdruser som de under normale Forhold udviklede Blade). Det findes derfor i Bladkødet og i den klorofylholdige Del af Bladstilk og Stængel. Undertiden udskilles det i Palissadecellerne (*Juglans regia*, *Citrus vulgar.* o. a.), undertiden alene i Svampparenkymet (*Datura Stramonium*, *Atropa Belladonna*, *Hyoscyamus niger* o. a.), eller i begge Vækformer (*Althaea officinalis*). Det sekundære Oxalat skyldes det fra Jorden optagne Kalciumnitrat, -sulfat og -fosfat. Uden rigelig Tilførsel af disse Salte kommer Oxalatet ikke til Udvikling og efter at være dannet kan det, naar Tilførselen af de anførte uorganiske Syrs Kalksalte udebliver, genopløses. Dette Oxalat er lige saa bevægeligt i Planterne som Assimilationsprodukterne, idet det dog bliver et Spørgsmaal, om Saltet vandrer paa den Maade, at det holdes i Opløsning — f. Ex. ved Æggehvidestof — eller efter en Dekomposition.

Det tertiarøre Oxalat aflejres paa Steder, hvor der finder en rigelig Cellulosedannelse Sted. Dets Dannelse sættes i Forbindelse med Transporten af Kulhydrater, idet K., efter de Kendsgerninger han har konstateret, maa antage, at Stivelse vander i Form af en organisk Kalkforbindelse, — som Kalk-Dextrose, — Glykose eller mulig andre Kalkforbindelser. I saa Tilfælde maa der, overalt hvor Dextrose eller Glykose forbruges til Dannelse af Cellulose eller Stivelse, blive Kalk disponibel, som med Oxalsyre giver Kalciumoxalat. Som en mindre sandsynlig Aarsag til Kalciumoxalatets Forekomst ved Bastbundter anføres Holzners og Sachs' Tydning. Det tertiarøre Salt forekommer som Regel i rigelig Mængde i Knolde, Rodstokke, Rødder og Kimblade.

Det kvartære Kalciumoxalat dannes om Efteraaret, naar Bladene tømmes og skyldes Dobbeltdekomposition mellem Kalksalte og Kaliumoxalat.

I Modsætning til Schimper har Kohl altsaa 4 Former (?) af Oxalat, idet Kohl betegner det Oxalat, som dannes i Nærheden af tykvæggede Celler (Bast, Stenceller og Kollenkym) som tertiarørt, medens Schimpers tertiarøre Salt bliver Kohls kvartære.

Om Maaden, hvorpaas Kalciumoxalatet vandrer, er der, for saa vidt, Uoverensstemmelse, som Kohl tager Afstand fra Schimpers Angivelse herom, uden at det klart fremgaar, hvorledes K. selv tænker sig Forholdet. K. angiver saaledes, at Saltet vandrer, idet det holdes i Opløsning ved Æggehvidestof eller efter en Dekomposition, ligesom det andet Steds anføres, at Saltet efter at være dekomponeret ikke behøver at gendannes, idet Komponenterne kan forbruges, Kalken f. Ex. ved Binding til Kulhydrat.

De Schimper-Kohlske Anskuelser om Kalciumoxalatets Forhold i Planterne kritiseredes af HANSEN¹²⁾ og af WEHMER^{13, 14)}; denne Sidstes Kritik baseredes paa et experimentelt Arbejde, til hvilket han benyttede samme Undersøgelsesobjekter, som Schimper havde anvendt. W. foretog saaledes Undersøgelser af Blade af *Symporicarpus*, *Alnus* og *Crataegus*. Materialet indsamledes paa forskelligt Tidspunkt, fra 30. Maj til 5. Oktober. Den mikroskopiske Undersøgelse af Bladene foretages efter Indlægning i Kloral, for de ældre Bladets Vedkommende efter nogle Dages forudgaaende Indlægning i Alkohol, som var mættet med Svovlsyrling. W. formaaede ikke at paavise Forhold, som tydede paa en Vandring af Oxalatet fra Bladene ind i Stængel og Stamme, ej heller kunde han iagttagte, at de tidligt i Mesofylllet dannede Druser genopløstes og senere aflejredes i Krystalkammerceller ved Nerverne. Aflejringen paa dette Sted begynder tvært imod paa et tidligt Udviklingstrin af Bladet, medens en samtidig Forringelse i Antal af Druserne i Maskennetet mellem Nerverne ikke lod sig paavise. Ved senere Kulturforsøg i Næringsvædske, som W. foretog med Grene af *Symporicarpus*, fandt han, at de nydannede Knopper efter længere Tids Væxt var rige paa Oxalat, medens Druserækkerne i den sekundære Bark tilsyneladende var uforandrede.

Naar Schimper fastholder, at Kalciumoxalatet opløses og vandrer uden Sønderdeling, bemærker W. iøvrigt hertil, at selv under den Forudsætning, at Oxalatet kun opløstes som Spor, kunde dette under de givne Forhold betinge betydelige Virkninger, lige som det endvidere vides, at andre Salte, der er saa godt som uoplöselige i Vand, kan opløses i visse Saltopløsninger uden Sønderdeling, og at man foruden med denne Kendsgerning maa regne med Muligheden af, at selv svagere organiske Syrer ved Massevirkning kan bevirke en Sønderdeling af Oxalatet. Det bør — mener W. — ikke betvivles, at Forhold af denne Art vil kunne faa Indflydelse, men i det overvejende Antal Tilfælde vil man ikke være berettiget til at tillægge disse Forhold nævneværdig Betydning. For de foreliggende Undersøgelsesobjekters Vedkommende pointeres yderligere Schimpers Iagttagelsesfejl, idet Wehmer hævder, at hans egne Iagttagelser absolut ikke taler for en Vandring af Oxalatet.

G. KRAUS¹⁵⁾ anser ligesom Aè Kalciumoxalatet som et Næringsstof, der om Efteraaret føres fra Bladene ind i Grenene og i følgende Foraar ud i de unge Blade for at bruges som Næringsstof.

K. henviser til de gennem en Aarrække fremkomne Arbejder, efter hvilke Kalciumoxalatet skal være opløseligt og genoptages i Stofskiftet. Naar Lærebøgerne til Trods herfor „vedvarende og haardnakket“ betegner Kalciumoxalatet som et

Affaldsstof (Exkret), mener han, at Grunden hertil maa søges i Beskaffenheten af de fremsatte Beviser, væsentlig mikrokemiske Reaktioner, som i de bedst begrundede Tilfælde har været foretaget under saadanne Forhold, at Resultaterne ingen Rolle spiller som Bevis for Saltets Forhold til Stofskifteprocesserne i det Store. Det ene afgørende Bevis, som den kvantitative kemiske Analyse afgiver, har stadig manglet.

Kraus har da bearbejdet et Forsøgsmateriale, som af nogle vedføjede Dateringer ses at være samlet gennem en Aarrække, et af Forsøgene er dateret 1888 — samme Aar Schimpers Afhandling fremkom. En paatænkt Anvendelse af *Rhizoma Rhei* som Forsøgsmateriale maatte opgives, idet Indvindingen af brugbart Oxalat umulig gjordes ved Rabarberens andre Bestanddele. Selv efter længere Tids forudgaaende Behandling med Vand dannede de med Saltsyre vundne Udtræk tykflydende, brune Opløsninger, af hvilke Oxalatet ikke lod sig fremstille i saa ren Tilstand, som ud-krævedes for dets Titrering. Ulige bedre anvendelig fandtes *Rumex obtusifolius*, ihvorvel Rodstokkens Indhold af Oxalat er ringere. I Modsætning til Rabarber er Rodstokkenes Væxt mere ensartet, hvad der bedre tillader en indbyrdes Sammenligning mellem de i Arbejde tagne Portioner. Krystaldruserne ligger i Bark, Marvstræaler og Marv, de er saa ensartet udyiklet og fordelt, at de øjensynligt har samme Oprindelse og Bestemmelse. Det første Forsøg foretages med Rodstokke af paa Fri-land voxende Planter og paa den Maade, at Mængden af Kalciumoxalat bestemmes i saa vidt muligt ensartet udviklede Rodstokke; dels i Slutningen af April, forinden Planten havde dannet blomsterbærende Skud, dels i Slutningen af Maj, efter Udvikling af blomsterbærende Skud. Resultaterne var dog ikke tilfredsstillende, idet Rodstokkene kun viste en meget lille Formindskelse af Oxalatmængden; kun i et enkelt Tilfælde, hvor der anvendtes kraftige og oxalatrigre Rodstokke fandtes der en tydelig Forskel.

Det fremgik dog af Forsøgene, at det var ønskeligt, at søge Oxalatets Forhold yderligere belyst under gunstigere Vilkaar. I den Hensigt foretages Bestemmelser af Oxalatmængden i Rodstokke, som efter Opgravningen underkastedes Mørkekultur, dels i rent Sand, dels i Sand, hvortil der var sat en rigelig Mængde Kridt. Til Vanding benyttedes henholdsvis destilleret Vand og Ledningsvand. Det analytiske Resultat fandtes overordentlig tilfredsstillende.

De to Kulturrækker viste:

- 1) Ved Mørkekultur aftager Tørstofmængden meget betydeligt.
- 2) Indeholder Substratet Kalk, er der ved Siden af den stærke Formindskelse af Forraadsstoffer enten ingen Forminskelse af Oxalatet eller en Førøgelse af dette.
- 3) Dyrkes Planten i kalkfrit Substrat, aftager Oxalatmængden meget betydeligt, under visse Forhold ganske som de øvrige Forraadsstoffer.
- 4) Oxalatet har under disse Forhold aabenbart overtaget den Opgave at give den for Udviklingen af de overjordiske Dele nødvendige Kalk.
- 5) Man kan slutte, at Kalciumoxalatet ogsaa under Plantens normale Udvikling

efter Behov genopløses og inddrages i Stofskiftet, ø: Oxalatet kan om fornødent atter blive Forraadsstof.

Mørkekulturer med *Rumex obtusifolius* fra 10. Novbr. 1890—13. Jan. 1891.

De opgravede Rodstokke udsøgtes parvis, muligst ens udviklede. Den ene Halvdel tørres efter Fastsættelse af Volumen og benyttes til Kontrolforsøg. Den anden Halvdel plantes i Urtepotte og underkastes Mørkekultur. En Del dyrkes i rent Sand og vandes med destilleret Vand, en anden Del i rent Sand med Tilsætning af en rigelig Mængde Kridt, til Vanding benyttes Ledningsvand.

A. Kalkfri Sandkultur.

	Objekt	Længde Cm.	Volumen Cem.	Tørstof I Cem.	Tab i Vægt pCt.	Oxalat	I Cem.	Tørstof pCt.
I. a) Kontrol	2 Rødder*	12 og 15	25	9,0	0,36	0,286	0,0114	3,18
b) Forsøg	—	13 og 20	40	8,83	0,221	38,6	0,313	0,007
II. a) Kontrol	1 Rod	36,0	30	11,6	0,38	0,410	0,0136	3,53
b) Forsøg	{ 1,5 Cm. tyk }	36,0	40	12,03	0,30	21,05	0,338	0,0097
III. a) Kontrol	1 Rod	41,0	36	15,0	0,41	0,454	0,0127	3,03
b) Forsøg	som II	30,0	40	13,69	0,342	16,59	0,399	0,009
IV. a) Kontrol	1 Rod	27,0	32	13,6	0,42	0,370	0,0116	2,71
b) Forsøg	omtr. fingertyk	23,0	36	11,84	0,33	21,43	0,315	0,0089
V. a) Kontrol	{ 2 smaa finger- } 18 og 11	30	10,55	0,35	0,315	0,0105	3,0	
b) Forsøg	{ tykke Rødder } 18 og 10	30	8,77	0,292	19,43	0,290	0,0093	

Tørstofmængden er gennemsnitlig aftaget 22,87 pCt., Oxalatet 26,1 pCt.

B. Kalkholdig Sandkultur.

	Objekt	Længde Cm.	Volumen Cem.	Tørstof I Cem.	Tab i Vægt pCt.	Oxalat	I Cem.	Tørstof pCt.
I. a) Kontrol	1 Rod	13,5	22	8,6	0,39	0,250	0,011	2,91
b) Forsøg	fingertyk	15,0	27	7,10	0,26	33,34	0,290	0,013
II. a) Kontrol	Rod	13,5	42,0	12,3	0,29	0,432	0,0103	3,51
b) Forsøg	tommel- fingertyk	13,5	37,0	10,83	0,29	0,389	0,0105	
III. a) Kontrol	Rod	15,5	25,0	8,6	0,34	0,275	0,011	3,2
b) Forsøg	fingertyk	14,5	38,0	13,04	0,343	0,306	0,009	
IV. a) Kontrol	{ som fore- } 11,0	27,0	10,1	0,39	0,260	0,0096	2,5	
b) Forsøg	{ gaaende } 15,0	28,0	6,08	0,217	44,36	0,330	0,0118	

K. meddeler dernæst Resultaterne af en Række Bestemmelser, som han har foretaget af Kalciumoxalat i Bark af forskellige Træer og Buske. For Enkelheder herom maa der henvises til Afhandlingen; men i Tilslutning til denne Del af Arbejdet knyttes der Meddelelser om Forsøg, hvis Maal er at paavise, at Mængden af Kalciumoxalat undergaar en Forandring ved Væxtperiodens Indtræden, og saaledes at der ogsaa her foregaar en Opløsning og et Forbrug af Oxalatet. Ved Forsøgene foretages Sammenligning mellem:

* ø: Rodstokke.

- 1) Grene, som toges under Hvileperioden med Grene fra Væxtperiodens Indtræden.
- 2) Grene som toges paa forskellig Tid efter Væxtperiodens Indtræden.
- 3) Grene fra Hvileperioden sammenlignet med Grene, der havde været underkastet Mørkekultur.

De til Analyse — Kontrol og Forsøg — udvalgte Grene udsøgtes parvis saa ensartet tykke og lange, at de havde næsten nøjagtig samme Vægt.

Som fælles Resultat af disse Forsøg fremgik, at Barkens Indhold af Kalciumoxalat aftog i Mængde ved Spiringen. Kvæntitativt kan denne Formindskelse i de specielle Tilfælde være forskellig. I et og andet Tilfælde kunde en Formindskelse overhovedet ikke paavises; det anføres, at dette Forhold mulig blot er et Tilfælde.

Oxalatformindskelsen foregaar efterhaanden i Løbet af Foraaret. Kirsebærgrenene tabte f. Ex. fra Begyndelsen indtil Midten af April 16,25, indtil Begyndelsen af Maj 32,9 pCt. Tilsvarende og end mere udpræget var Forholdet for *Ribes sanguineum*. Intet viser tydeligere end denne Oxalatets gradvise Aftagen, at dets Opløsning staar i Forhold til Vegetationsprocessen. Det anføres paa ny, at ogsaa disse Forsøg viser Uholdbarheden af Betegnelsen Exkret for Kalciumoxalat, selv om der ikke er Tale om en Bevægelighed og Udnyttelse som ved de organiske Forraadsstoffer (Stivelse, Sukker, Inulin o. s. v.).

Forsøgs Tabeller:

I. Etaarige Grene fra Hvileperioden og Foraar 1888—89.

- 1) *Ribes Gordonianum*. 30 Grm. Stof indeholdt:
 i December 0,680 = 2,26 % Oxalat (af Tørstof),
 i April 0,567 = 1,87 -
 Forskel 0,113 = 16,62 -
- 2) *Quercus macranthera*. 22 Grm. Stof indeholdt:
 27. Februar 0,340 = 1,55 % Oxalat,
 31. Maj 0,194 = 0,89 -
 Forskel 0,146 = 42,94 -
- 3) *Pyrus Malus*. 20 Grm. Stof indeholdt:
 16. December .. 0,475 = 2,35 % Oxalat,
 27. April 0,417 = 2,05 -
 Forskel 0,068 = 12,10 -
- 4) *Lonicera tatarica*. 25 Grm. Stof indeholdt:
 16. December .. 0,583 = 2,32 % Oxalat,
 27. April 0,453 = 1,80 -
 Forskel 0,130 = 22,30 -
- 5) *Ribes aureum*. 15 Grm. Stof indeholdt:
 2. November .. 0,291 = 1,94 % Oxalat,
 26. April 0,260 = 1,73 -
 Forskel 0,031 = 11,69 -

6) <i>Ribes Grossularia.</i>	15 Grm.	Stof indeholdt:
1. November	0,275	= 1,82 % Oxalat,
26. April	0,216	= 1,44 -
Forskel	0,059	= 21,45 -

II. Etaarige Grene, Foraaret 1890.

1) <i>Prunus avium.</i>	15 Grm.	Stof indeholdt:
4. April	1,058	= 7,05 %
17. April	0,540*	
Forskel	48,77 %	
2) <i>Pyrus Malus.</i>	24 Grm.	Stof indeholdt:
17. Januar	1,426	
3. April	0,713	
17. April	0,713	
Forskel	50 %	
3) <i>Prunus Cerasus.</i>	14 Grm.	Stof indeholdt:
3. April	0,677	
17. April	0,567	
5. Maj	0,454	
Forskel	16,25 til 32,94 %	
4) <i>Ulmus campestris.</i>	24 Grm.	Stof indeholdt:
17. Januar	0,990	
3. April	0,659	
17. April	0,659	
Forskel	34,03 %	
5) <i>Rosa canina.</i>	17 Grm.	Stof indeholdt:
17. Januar	0,664	
3. April	0,578	
17. April	0,572	
5. Maj	0,475	
Forskel	28,46 %	
6) <i>Ribes sanguineum</i> (angivet i lige Mængder):		
14. Marts	0,820	
3. April	0,712	
16. April	0,507	
Forskel	13,17 til 38,17 %	
7) <i>Ribes saxatile</i> (Ingen Mængdeangivelse):		
14. Marts	0,491	
3. April	0,469	
16. April	0,410	
Forskel	4,48 til 16,50 %	

* Tabellernes uensartede Affattelse er Originalens.

- 8) *Ribes caucasicum.* 27,5 Grm. Stof indeholdt:
 14. Marts 0,945
 16. April 0,642
 Forskel 32,07 %
 9) Ved tilsvarende Analyser af *Corylus* fandtes mellem 17. Januar og 17. April en Forskel af 12 %; ved *Crataegus Oxyacantha* i samme Tidsrum en Forskel af 59,23 %; medens der ved *Pyrus communis* ikke fandtes nogen Forskel.

III. Grene fra Hvileperioden sammenlignet med tilsvarende, som var drevet frem ved Mørkekultur.

- 1) *Lonicera tatarica.* c. 150 Grm. Stof:
 1,52 %, efter Kultur 1,36 %.
 2) *Salix laurina.* 30 Grm. Stof:
 0,34 %, efter Kultur 0,307 %.
 3) *Pyrus communis.* 20 Grm. Stof:
 0,637 %, efter Kultur 0,432 %.
 4) *Populus alba.* (Stofmængde?).
 Der fandtes ingen Forskel.

Til Belysning af Spørgsmaalet om Oxalatets Vandring er begrænset til de tyndere Grene eller tillige omfatter Aflejringerne i Stamme- og ældre Grenbark, undersøgte K. tillige Stammebark af Hestekastanie, Robinie og Tandbladet Løn; i alle Tilfælde undersøges Bark af to Træer. Der fandtes følgende Formindskelse af Oxalatmængden:

For Hestekastanie:

- | | | | | | | |
|----|----------|--------|-----------|--------|---------|--------|
| 1) | 8. April | 1,577, | 15. April | 1,468, | Forskel | 6,92 % |
| 2) | — | 1,36 | — | 1,144 | — | 15,8 - |

For Robinie:

- | | | | | | | |
|----|----------|--------|-----------|--------|---------|---------|
| 1) | 8. April | 0,185, | 26. April | 0,164, | Forskel | 13,95 % |
| 2) | — | 0,162 | — | 0,140 | — | 13,34 - |

For Tandbladet Løn:

- | | | | | | | |
|----|----------|--------|-----------|--------|---------|---------|
| 1) | 7. April | 0,756, | 15. April | 0,648, | Forskel | 14,28 % |
| 2) | — | 0,648 | — | 0,562 | — | 13,12 - |

Idet Kraus henviser til Sanios Karakteristik af det i Planten udskilte Kalciumpoxalats Reaktioner, ansører han, at det senere er blevet antaget som almen Kendsgerning, at Saltet ikke paavirkes af Eddike- og Plantesyrer; men efter de fundne Forhold, hvorved K. har paavist en Opløselighed af indtil c. 60 % af Saltet, maa man simpelt hen erkende Kalciumpoxalats Opløselighed i Cellen. Opløsningen maa skyldes Cellesaften og sandsynligvis organiske Syrer og disses Salte. Det bliver

da Spørgsmaalet, om Oxalatets Opløsning kan foregaa i en saa fortyndet Opløsning af Syrerne og Saltene, som Cellesaften repræsenterer.

Til Undersøgelse af dette Forhold foretages Forsøg for kvalitativt og kvantitativt at finde Kalciumoxalatets Opløselighedsforhold i Opløsninger af organiske Syrer og Salte af dem. Der anvendtes amorf Kalciumoxalat (Handelsvare) og Krystaller, som fremstilles ved Slemning af pulveriseret Kvilljabark. Som Opløsningsmidler anvendtes $\frac{1}{10}$, $\frac{1}{100}$ og $\frac{1}{1000} \%$'s Opløsninger af Vin-, Citron-, Æble-, Fumar-, Malein- og Druesyre, samt $\frac{1}{10} \%$'s Opløsninger af Kalium- og Ammoniumcitat og surt Ammoniumtarrat. Det fandtes ved disse Forsøg, at der opløstes Kalcium, idet Filtraterne gav skyede Udskilninger efter Tilsætning af Ammoniumoxalat. Der foretages derefter kvantitative Bestemmelser af den Mængde Kalcium, som opløstes ved Behandling af 1 Grm. amorf Kalciumoxalat med $\frac{1}{10} \%$'s Syreopløsninger. Efter flere Dages Henstand under jævnlig Omrystning samledes Kalciumoxalatet paa vejet Filter. Den tilbageblevne Maengde var efter Behandling med Vinsyre 0,982, med Citronsyre 0,985, med Maleinsyre 0,9802, med Fumarsyre 0,9945 og med Druesyre 0,9906 Grm.

De af Kvilljabark fremstillede Krystaller forholdt sig paa lignende Maade. Efter en flere Uger vedvarende Behandling med $\frac{1}{10} \%$'s Citronsyreopløsning viste Krystallerne stærk Korrosion. Der henvises endvidere til de i Naturen paaviste tilsvarende Forhold, som er angivet af PFEFFER, der har iagttaget Spor af Opløsning af Krystallerne i Lupinens Kimblade, samt TSCHIRCHS Iagttagelser over Korrosion og Opløsning af Krystalstjernerne i Begonieblade og i spirende Frø. — Det er derfor muligt, at Kalciumoxalatets Opløsning skyldes de organiske Syrer, om det end ingenlunde er bevist. At Opløseligheden er saa skarpt begrænset til Vegetationsperioden, mener K. er betinget af Transpirationen, som bevirker, at Værene i denne Periode udsættes for en kraftig Gennemskyning.

AMAR¹⁶⁾ har foretaget Forsøg med forskellige Caryophyllaceer. De først udviklede Blade af Planter fra Friland indeholdt Kalciumoxalat; naar Planterne deretter dyrkedes i kalkfri Næringsvædske, viste de senere dannede Blade intet Oxalat, medens de ældre Blades Oxalatkrytaller ikke opløstes. A. mener, at Kalciumoxalatet er et Affaldsstof, som skyldes det fra Jorden optagne Kalciumnitrat, der ikke assimileres fuldstændigt. Overskudet af Kalcium udskilles som unyttigt Oxalat. I Modsætning til flere andre Forfattere mener A. endvidere at maatte slutte, at Kalciumoxalatet snarere dannes for at befri Planten for Kalcium end for Oxalsyre.

Gennem kemiske Analyser er det oplyst, at Oxalatet forekommer i Planterne saa vel i opløselig som i uopløselig Form. Det fremgaar bl. a. af Berthelots og Andrés Undersøgelser¹⁷⁾. I *Mesembryanthemum crystallinum* fandt de Oxalatet ganske overvejende til Stede i opløselig Form, medens det i *Amarantus caudatus* overvejende og i alle Organer forekom som uopløseligt Salt.

Iagttagelser over Kalciumoxalat, som opløses under Frø og Frugters Spiring, foreligger fra Pfeffer¹⁸⁾, Tschirch¹⁹⁾ og CZAPEK²⁰⁾.

Tschirch anfører lige som Pfeffer Skærmplantefrugter, samt Mandler og Frø af *Myristica surinamensis*; han angiver tillige Korrosion og Opløsning af Krystal-

stjerner i Begonieblade; ved at henlægges paa fugtigt Sand bragtes Bladene til at danne Rødder, derefter anbragtes de i kalkfri Næringsvædske.

Czapek har ved sine Undersøgelser over Mælkesaftbeholderne hos *Convolvulaceer* fundet, at de ikke fuldmodne Frø indeholder et rigeligt Antal Oxalatdruser, medens de modne Frø indeholder langt færre eller slet ingen Druser; i de modne Frø paa-viste han tillige Druser, som kendeligt var blevet mindre. Om det Kalksalt, som i stor Mængde forekommer i Ørkenplanters Bark, udtaler JÖNSSON²¹⁾, at det, saa vidt kemiske Reaktioner kunde oplyse, i Hovedsagen var Kalciumpoxalat, men at Tilstedeværelsen af andre Salte ikke er udelukket.

I et tidligere Arbejde²²⁾ har jeg vist, at Krystalstjernerne og til Dels Globoiderne i Fennikelfrugternes Proteinkorn bestaar af Kalciump- (og sandsynligvis ogsaa af Magniump-) malat og -succinat; medens Oxalat kun findes som Spor. Paavisningen skete ad kemisk Vej, i det Kalciump- og Magniumpsaltene opløstes, Blysaltene udfaldedes, hvorefter de ved Behandling med Svovlbrinte vundne Opløsninger af de fri Syrer anvendtes til en Række Identitetsprøver. Ved mikrokemiske Reaktioner fandtes Forholdet at være almindeligt for Skærmplantefrugter. Det er herigennem bevist, at Krystalstjernerne i disse Frugters Frøhvile ikke, som angivet af Pfeffer, er Kalciumpoxalat.

I det Følgende skal der gives en Oversigt over moderne Fysiologers Stilling til disse Spørgsmaal.

Pfeffer²³⁾ har, Pag. 486: I den turgescente Plante forekommer de organiske Syrer i opløst Tilstand, bortset fra den Oxalsyre, som er udskilt i Form af Kalciumpoxalat. Dette Salt findes ikke i alle Planter, men er dog almindelig udbredt og kan findes i saa stor Mængde, at det udgør 50 %, hos visse Kaktus indtil 80 % af Tørstoffet (Schleiden). Kun undtagelsesvis forekommer Krystaller af Magniumpoxalat, Kalciumptartrat og -citrat. Syrerne tjener som plastisk Materiale, til Forøgelse af Turgor, i Opløsnings- og Neutralisationsøjemed o. s. v.; yderligere formaar Planterne ved stærk Syreprroduktion at fortrænge eller dræbe Konkurrenter, medens de sure Safter og de stikkende Naale af Kalciumpoxalat afgiver en vis Beskyttelse mod Dyr. At organiske Syrer er anvendelige som Næringsstof, fremgaar af Ernæringsforsøg med Svampe (WEHMER), fremdeles af Crassulaceernes afvigende Assimilation. Som Reservenæringsstof funktionerer de organiske Syrer vist nok kun i enkelte Tilfælde, om end højere Planter ofte turde have Evne til at optage Æble- Citron- endog fri Oxalsyre i Stofskiftet. Selv Kalciumpoxalatet, der sædvanlig forbliver intakt, hjem-falder i mange Tilfælde til Opløsning og videre Oparbejdning. Da Kalciumpoxalatets Forsvinden af Rhizomer, Bark m. m. efter Kraus (Pag. 54), Kohl (Pag. 48) kun indtræffer ved Kalkmangel, synes det, at Saltets Genoptagelse i Stofskiftet væsentlig sker af Hensyn til Kalken*.

Med Henblik paa Oxalsyrens ringe Forbrændingsvarme turde dens Forarbejdning i Almindelighed ikke yde større Nutte. (Wehmers Svampekulturer).

* Pfeffers Gengivelse af Kraus' Forsøg og Anskuelse er ikke korrekt. K. mener jo netop at have bevist, at Kalciumpoxalatet ganske regelmæssigt opløses og genoptages i Stofskiftet ved Vækterperiodens Indtræden.

Aabenbart kan Syrerne indenfor visse Grænser genseidig erstatte hverandre. Dog maa der regnes med deres specielle Egenskaber, for Oxalsyren f. Ex. dens høje Aviditet, Giftighed, ringe Forbrændingsvarme og Kalciumsaltets Uopløselighed. Den lette umiddelbare Iagttagelse af Oxalatkristallerne har iøvrigt foranlediget, at Opmærksomheden overvejende og ofte ensidigt er blevet koncentreret paa Oxalsyren.

JOST²⁴⁾ anker gentagne Gange over de ved forskellige Forsøg fremsatte Anskuelser, hvilke han ikke finder fyldestgørende, fordi de udelukkende støtter sig til mikrokemiske Analyser. Han kræver Beviserne ført gennem kemiske Analyser (bl. a. Pag. 172 og 174).

Czapek²⁵⁾ omtaler den udbredte Forekomst af Oxalat hos Tokimbladede, idet han tillige nævner de af Kohl angivne Undtagelser (*Orobanchaceer*, *Rhinantaceer* og *Lentibulariaceer*). Som Identitetsprøver paa Kalciumoxalat anføres de sædvanlige, og C. tilføjer, at han ikke finder, at der i disse Reaktioner haves noget paalideligt Værn mod Forvexlinger med Kalksalte af andre organiske Syrer; det er tvært imod sandsynligt, at Kalciummalat, -citrat, -tartrat og -oxalat hyppigt er blevet forvexlet. Den kemiske Analyse maa her ubetinget kontrollere de mikrokemiske Forsøg.

Med Wehmers Svampekulturer som Grundlag drages der tilsvarende Slutninger om Oxalsyrens Forhold i højere Planter, idet den opfattes som et ufuldstændigt Hætningsprodukt af Hexosegrupper, medens samtidig Muligheden og Sandsynligheden af andre Dannelsesmaader betones. Som uholdbar betegnes Liebigs Anskuelse, saavel som den tilsvarende af Berthelot og André fremsatte Antagelse, efter hvilken Oxalsyren i *Rumex acetosa* skulde dannes i Bladene ved en ufuldstændig Reduktion af Kulsyren. Schimpers og Kohls Sondring mellem primært, sekundært, tertiar (kvartær) Kalciumoxalat betegnes som uheldig. En Række Iagttagelser, bl. a. af Schimper, viser den Indflydelse, Lyset har paa Antallet af de i Bladet dannede Kalciumoxalat-Krystaller. Ved Mørkekultur eller ved begrænset Belysning — indtil 2 Timer daglig — opnaar Bladene omrent normal Størrelse, men mangler Oxalataflejringer. De her igennem indvundne Erfaringer er dog ikke utvivlsomme, idet man har ladet sig nøje med mikroskopiske Iagttagelser, uden at støtte disse til kvantitative Bestemmelser af Oxalsyren. Det i højere Planter aflejrede Kalciumoxalat maa anses som Exkret. Oxalsyrens Binding til Kalcium maa tydes som en passende Form til at holde den giftige Oxalsyre paa et Koncentrationsminimum. Det er dog ikke udelukket, at Planten i forskellig Retning kan drage økologisk Nutte af dette Indholdsstof. Uagtet Oxalsyren biokemisk er et Exkret, er det saaledes ikke udelukket, at Krystallerne under visse Forhold kan opløses i den levende Celle. Saadanne Opløsningsfænomener er hyppigt iagttaget (Frank, Sorauer, De Vries, Åe, Tschirch og Czapek (Pfeffer er ikke nævnt)). Da disse Angivelser aldrig er kontrolleret ad analytisk Vej, maa man for Tiden betegne de Slutninger, der er draget heraf, som meget for vidtgaende.

G. Kraus har paa Grundlag af kvantitative Bestemmelser ment, at Kalcium-

oxalatet i Traeers Bark^{*} maa betegnes som Reservenæring. Efter de foretagne Bestemmelser foregaar der fra Vinter til Foraar og under Spiringen en Formindskelse af Kalciumoxalatmængden. Det samme Forhold gør sig gældende for *Rumex obtusifolius*. Bortset fra, at de paagældende Mindreindhold slet ikke kan opfattes som andet end ledsagende sekundære Fænomener af de livligt foregaaende Omsætninger i Organerne, og at Opfattelsen af Kalciumoxalatet som et Reservenæringsstof kræver et andet Grundlag, staar der imod Kraus' Bestemmelser en Række Kendsgerninger, som Wehmer har paavist for Grene, Knopper og Blade. W. kunde saaledes ikke paavise noget Forbrug af de under Bladets Udvikling aflejrede Druser, ejheller fandt der om Foraaret nogen Opløsning Sted af de om Efteraaret i Knopperne dannede Oxalatdruser, og i de unge Blade dannes Kalciumoxalatet først efter at Bladene har udfoldet sig fuldstændigt af Knoppen. Disse Forhold har Wehmer især skildret for *Symporicarpus racemosus*' Vedkommende. Der findes endvidere hos W. talrige Kendsgerninger, som gør de af Schimper fremsatte Anskuelser om Kalciumoxalatets Vandring ret usandsynlige.

W. JOHANNSEN²⁶⁾ angiver under Stofskiftets Fysiologi, Pag. 352: Da Kalciumoxalatet sædvanligvis ikke opløses, indses det, at Bladene efterhaanden bliver rigere og rigere paa dette Stof. Pag. 167: Kalciumoxalatets Forhold i Plantens Stofskifte er endnu ikke helt opklaret; i de fleste Tilfælde maa Krystallerne opfattes som Affallsstof, unyttigt for Planten. Under Hungerperioder synes dog en Del af det at kunne opløses, for saa vidt det ligger i levende Celler; men som Helhed findes Krystallerne navnlig i ældre Væv; gamle Blade og gammel Bark indeholder meget Kalciumoxalat, der bortkastes med dem. I Celler, der ophober Forraadsstof, findes det ikke, eller kun i ringe Mængde. Kalciumcitrat kan optræde paa lignende Maade og forvexles let dermed (Wehmer).

Der er i ovenstaaende Uddrag givet en Oversigt, der selv om den ikke er ganske fuldstændig dog omfatter de væsenligste Specialarbejder, og i alle Tilfælde repræsenterer de forskellige Opfattelser, der er kommet frem ved Behandlingen af dette Emne. Ganske modstridende Anskuelser er gjort gældende. En Iagttager ser, at der foregaar en Opløsning af Krystaller i et Blad, en Anden benægter, at der foregaar en Opløsning. Det tilsyneladende saa simple Spørgsmaal er selvfølgelig mere kompliceret og er blevet det yderligere, dels paa Grund af Mangler ved de anvendte Undersøgelsesmetoder, dels — og ikke mindst — ved Fremsættelsen af Anskuelser, som for største Delen var bygget over ganske uklare og usandsynlige Hypoteser. Forholdet er jo faktisk det, at en Række Arbejder siden 1888 har været præget af de Schimper-Kohlske Anskuelser — for eller imod. Naar det nu kræves, at de mikrokemiske Reaktioner, hvoraf man har betjent sig ved de fleste af disse Arbejder, burde være støttet af makrokemiske og kvantitative Analyser (Jost, Czapek) og udtales, at Opmærksomheden overvejende og ofte ensidigt har været koncentreret

* Der citeres kun Forsøgene med *Ribes sanguineum*, *Rosa canina* og *Pyrus Malus*.

paa Oxalsyren (Pfeffer) er Kravet og Paastanden berettiget, men Erfaringen herom er fremgaaet af de paagældende Arbejder.

Forinden jeg kommer ind paa en kritisk Omtale af de Uoverensstemmelser, som findes mellem de foreliggende Arbejder og de Resultater, hvortil jeg er kommen, skal jeg meddele mine egne Undersøgelser.

II. Egne Undersøgelser.

Den Opgave, jeg satte mig, var at søge oplyst, hvorvidt de Kalksalte, som findes udskilt i forskellige Organer, og som man i Regelen finder betegnet som Kalciumoxalat, virkelig bestod af dette Salt. Efter de Erfaringer, jeg havde gjort ved direkte mikroskopiske Undersøgelser af Droger og ved mikrokemiske Reaktioner, som anstilledes paa de indeholdte Kalksalte, var jeg bleven overbevist om, at det i nogle Droger indeholdte Kalksalt, som i Litteraturen angaves at være Kalciumoxalat, ikke var dette Salt; i andre Tilfælde kunde jeg paavise, at almindelig anvendte mikrokemiske Reaktioner kunde forløbe paa saadan Maade, at man kom til Fejlslutninger om Kalksaltets Art. Endelig kunde jeg i en Række Droger, i hvilke der efter Angivelserne i Litteraturen ikke skulde indeholdes Kalksalt, med Sikkerhed paavise disses Tilstedeværelse. Exempler paa disse Iagttagelser vil blive anført i Redegørelsen for de enkelte Undersøgelser. Side om Side med den kemiske Undersøgelse af Drogerne er der foretaget en mikroskopisk for at paavise de indeholdte Kalksaltes Form, deres Aflejringssteder og Opløselighedsforhold.

Til Brug ved den kemiske Undersøgelse prøvedes det forsøgsvis at bringe Kalksaltene i Opløsning ved Udtrækning med Vand, fortyndet Eddikesyre og fortyndet Salpetersyre, idet Materialet udrystedes gentagne Gange med Vædskerne i den angivne Rækkefølge i et Wagnersk Rysteapparat. Hensigten var allerede ved Udrystningen at faa de lettere opløselige Kalksalte skilt fra de tungere opløselige. Det viste sig imidlertid, at der ved gentagen Udrystning med Eddikesyre opløstes noget Kalciumoxalat, hvorved Metodens Fordelagtighed blev ret problematisk, og ved Udrystningen med Salpetersyre følte jeg mig aldrig rigtig sikker paa, at alt Kalciumoxalat var opløst; selv efter vedholdende Behandling kunde jeg ved mikroskopisk Undersøgelse af Stoffet af og til finde uopløst Kalksalt. Metoden ændredes da saaledes, at Materialet først udørtes med Vand, henstod kort Tid under Omrøring, hvorefter Vædsken frafiltreredes. Stoffet bragtes paa Filtret, udvadskedes gentagne Gange med Vand, koldt og kogende, hvorefter det udkogtes 2 Gange med fortyndet Saltsyre. Ved Kontrolprøver overbeviste jeg mig om, at alt Kalksalt var opløst.

De paa denne Maade vundne vandige og saltsure Udtræk koncentreredes. Til det vandige Udtræk sattes c. 4 Rumfang Vinaand, hvorved Kalk- og undertiden

Magnesiasalte udfældedes som fyldige Bundfald. Det koncentrerede saltsure Udtræk neutraliseredes i varm Tilstand med Kaliumkarbonat og for at faa en fuldstændig Udfældning af Kalksaltene tilsattes 2—3 Rumfang Vinaand. Til Filtratet fra de med koldt og varmt Vand udtrukne og derefter ved Tilsætning af Vinaand udskilte Kalksalte sattes Kalciumacetat og noget mere Vinaand; herved udskiltes Kalksaltene af de Syrer, som havde været til Stede i alkalibunden eller fri Tilstand.

Der kom herefter til at foreligge 3 Grupper af Kalksalte, som vilde være at undersøge for at bestemme de i dem indgaaede kalkfældende Syrer. 1) I Vand opløste Kalksalte, 2) i Saltsyre opløste Kalksalte og 3) Kalksalte af kalkfældende Syrer, som havde været til Stede i Form af akalibundne eller fri Syrer. De fremstillede Kalksalte var selvfølgelig meget urene, hvilket allerede kunde skønnes af Bundfaldenes Farve. Saltene af 1 og 3 dannede sædvanligvis graalige Bundfald, Saltene af 2 hyppigt mørke, næsten sorte Bundfald. For at renses og bringes i en for Undersøgelsen skikket Form overførtes Kalksaltene til Kalisalte gennem Bly-saltene, idet de opløstes i fortyndet Salpetersyre; i Filtratet afstumpedes Salpetersyren saa vidt muligt ved Kaliumkarbonat, hvorpaa Blysaltene udfældedes med Blyacetat, for fuldstændig Udfældnings Skyld tilsattes 2 Rumfang Vinaand. Efter Henstand frafiltreredes Blysaltene, udvadskedes med fortyndet Vinaand, opslemmedes i Vand og dekomponeredes ved Tilledning af Svovlrinte, hvormed Vædsken henstod Natten over. Filtratet med de fri Syrer neutraliseredes med Kaliumkarbonat efter Udjagning af Svovlrinten. Med de saaledes fremstillede Opløsninger af Kalisaltene foretages derpaa Adskillelsen af de kalkfældende Syrer paa sædvanlig Maade. En ringe Mængde af Opløsningen undersøges paa Svovlsyre, saafremt den fandtes til Stede, udfældedes Baryumsulfatet i saltsur Vædske ved Baryumklorid, under Iagttagelse af at Baryumklorid ikke tilsattes i Overskud. Ved tilstrækkelig Udtrækning af Materialet med koldt og varmt Vand vil Svovlsyren som Regel kun findes i det vandige Udtræk og i det vinaandige Filtrat fra dettes Kalksalte, 1 og 3. For Vinsyre, som iøvrigt aldrig paavistes, prøvedes i eddikesur Vædske ved Tilsætning af et lige Rumfang Vinaand. I den for Vinaand befriede Vædske prøvedes paa Oxalsyre ved Tilsætning af Kalciumacetat til den kogende Vædske. Filtratet tilsattes efter Afkøling Ammoniakvand i Overskud, hvorved Fosfat og Tannat udfældedes. Filtratet herfra prøvedes paa forskellig Maade paa Kalciumcitrat, idet det dels indkogtes til ringe Rumfang under Overholdelse af ammoniakalsk Reaktion, dels i passende Koncentration lidt efter lidt tilsattes et lige Rumfang Vinaand. I Filtratet udfældedes tilstedeværende Kalciummalat og -succinat samlet ved Tilsætning af Vinaand, det frafiltrerede og med fortyndet Vinaand ($4 + 1 Aq$) udvadskede Bundfald omdannedes paa ny gennem Blysaltene til Kalisalte. Malat og Succinat skiltes da efter BARFOED²⁷⁾, idet Vædsken koncentreredes til ringe Rumfang — i Regelen c. 2 Ccm. — og tilsattes 6 Rumfang Vinaand. Herved udfældedes Malat som en olieagtig Masse, oftest med rødlig Farve, medens Succinatet holdtes i Opløsning.

De med Svovlrinte dekomponerede Blysalte af det vandige og saltsure Udtræks Kalksalte gav undertiden ganske uklare Filtrater, ligesom Filterne hurtigt

tilstoppedes; efter Tilsætning af 1—2 Rumfang Vinaand kunde der i saa Tilfælde faas klare Filtrater.

Ved Fældningen af Fosfat og Tannat med Ammoniak viste det sig hyppigt ved den mikroskopiske Undersøgelse af Bundfaldet, at krystallinsk Kalksalt (Citrat, Malat) samtidig var fældet. Fældningen gentoges da, efter at Bundfaldet var opløst med Anvendelse af et Par Draaber Saltsyre i Vand.

Den Stofmængde, som toges i Arbejde, har været noget forskellig efter Mængden af de indeholdte Kalksalte; den udgjorde indtil 20 Grm. luftørret Stof og er i væsentlig Grad begrænset ved de under Analysens Gang dannede meget voluminøse Bundfalde, som man af Hensyn til Udvadskningen ikke kan have alt for store. Identificeringen af de fremstillede kalkfældende Syrer er sket dels mikroskopisk, dels ved forskellige Identitetsprøver. Citronsyren er foruden ved Kalksaltets Opløselighedsforhold identificeret ved Stahres Reaktion. Æblesyren — og i faa Tilfælde Ravsyren — er, naar Syrens Mængde har tilladt det, identificeret ved Bestemmelse af Ækvivalenttallet, altid ved Beskaffenheten af det ved 6 Rumfang Vinaand udskilte Kalisalt. Til Ækvivalentbestemmelserne er Sølvsaltene benyttet. Kalsaltene syntes mig mindre anvendelige, idet Angivelserne om den Temperatur, ved hvilken de afgiver Krystalvandet, er forskellig. Sølveitratet var dog ikke direkte anvendeligt, idet det forpuffer ved Ophedning, om end mindre voldsomt end Oxalatet. Ravsyren er altid identificeret efter Barfoeds Metode. Jerntveiltesaltet udfældedes af den tykflydende, svagt sure Opløsning med Ammoniakvand. Succinatet frafiltreredes, udvadskedes indtil Filtratet var klorfrit, tørredes ved 100°, blandedes med tørt, surt Kaliumsulfat og underkastedes Sublimation i Reagensglas paa Sandbad ved en indtil 170° stigende Temperatur. Sublimatet undersøgtes derpaa mikroskopisk.

I enkelte Tilfælde har Forholdene krævet, at Gangen i Analysen maatte ændres. Det har exempelvis været Tilfældet ved Undersøgelsen af *Radix Althaeæ*, hvor jeg paa Grund af Rodens store Indhold af Slim maatte anvende Dialysator. Unge Blade af *Crataegus monogyna* gav et vandigt Udtræk, som — ligeledes paa Grund af indeholdt Slim — ikke lod sig filtrere. Udtrækket af Crataegusblade, der var indsamlet om Efteraaret, kunde derimod filtreres.

Mængden af Kalciumoxalat i det saltsure Udtræk er bestemt kvantitativt som CaO .

I en særlig Portion af det luftørrede Stof paa omrent 2 Grm. foretages følgende Bestemmelser:

Vand (efter Tørring ved 100°), Aske, i Saltsyre uopløselig Rest af Aske (Sand), den samlede Mængde Kalk som CaO og Svovalsyre. Disse Bestemmelser opføres ved de enkelte Analyser under 4.

Til Bestemmelsen af CaO renses den saltsure Opløsning af Asken paa sædvanlig Maade ved Tilsætning af Natriumkarbonat og Natriumacetat, Kogning med Jerntekloridopløsning og Udvadskning af Bundfaldet med svag Ammoniumacetatopløsning. Af det kogende Filtrat udfældedes Kalciumoxalatet. I et Par Tilfælde har

jeg til Sammenligning fældet Kalciumoxalatet uden forudgaaende Behandling. Det synes af de fundne Tal at fremgaa, at Mængden af Fosfat har været for ringe til at kunne faa Indflydelse. Svovalsyren er bestemt som $H_2 SO_4$ af Baryumsulfatet.

Af Analyserne fremgaar det, hvor stor en Mængde Kalk Stoffet i alt har indeholdt og med nogenlunde Nøjagtighed, hvor meget af denne der har været bundet til Oxalsyre, idet dette vil svare til den Mængde CaO , som det saltsure Udtræks Kalciumoxalat giver. Teoretisk kan der gøres den Indvending, at der ved Udtrækningen med Vand kan have fundet Omsætninger Sted (mellem lettere opløselige Kalksalte og Kaliumoxalat), men Resultatet vil da blot blive, at den fundne Mængde CaO af indeholdt Kalciumoxalat er lidt for højt ansat. Ved de enkelte Analyser er angivet Mængden af Total- CaO , hvormeget af denne, der har været bundet til Oxalsyre og den Mængde, der har været bundet til andre kalkfældende Syrer. Efter den Letopløselighed, som Sulfatet udviste, og efter den mikroskopiske Undersøgelses Resultater gaar jeg ud fra, at Svovalsyren har været til Stede som Kalisalt. Fosforsyren, hvis Mængde ikke er ret stor, har vel været til Stede som Kalk- eller Magnesiasalt, og muligt er det jo, at andre Syrer (f. Eks. Akonitsyre) kan have været til Stede. Det er af denne Grund, at der i Analyserne er angivet, at Rest af CaO fortrinsvis har været bundet til Citron-, Æble- og Ravsyre.

Tussilago Farfarus.

Bladets Bygning er vist i Fig. 1 a. Medens man kun undtagelsesvis finder Krystaller i Snit af det friske Blad, vil man i Snit af Drogen eller af Spiritus-Materiale,

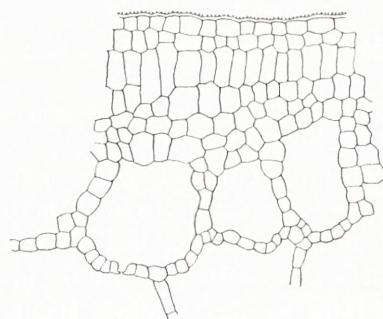


Fig. 1 a.

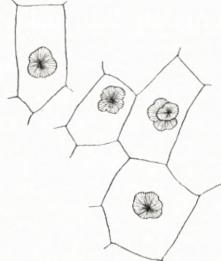


Fig. 1 b.

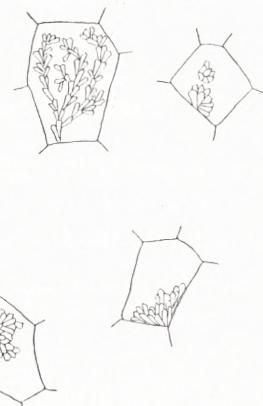


Fig. 1 c.

som indlægges i Vinaand eller i Glycerin og Vinaand, finde talrige Krystaller, der dels har Form som Sfærer, Fig. 1 b, dels af løst byggede Krystalbundter, hvis Form er meget vekslende, idet Krystallerne kan være ordnet buskformet, som ret regelmæssige Stjerner, eller mere uregelmæssigt, Fig. 1 c. Aflejringsstederne er saavel Palissadeceller som Svampparenkym. Krystallerne er fuldstændigt eller for største Delen opløselige i Vand. Ved Tilsætning af Svovalsyre dannes talrige Gipsnaale.

Jos. MOELLER angiver²⁸⁾, Pag. 82 og²⁹⁾ Pag. 90, at Bladet ikke indeholder Krystaller, samme Angivelse har PLANCHON & COLLIN³⁰⁾, Bd. II, Pag. 49. Andre Forfattere, f. Ex. FLÜCKIGER og GILG, udtaler sig ikke om Krystalindhold. SOLEREDER anfører i al Almindelighed om *Compositae*³¹⁾ Pag. 523: Indhold af Kalciumoxalat som naaleformede, prismatiske eller smaa oktaedriske Krystaller, Sfærokrystaller, som (efter Kohl) bestaar af Gips. Derimod har ARTHUR MEYER³²⁾ Bd. II, Pag. 218, set Krystallerne, hvilke han tegner og beskriver omtrent som jeg, men han angiver, at det er Oxalat.

Kemisk Undersøgelse. Anvendt 15 Grm. lufttørret Stof.

1) I det vandige Udtræk fandtes:

Sfovlsyre. Fosfor- og Garvesyre. Citronsyre i ringe Mængde. Æble- og Ravsyre.

2) I det saltsure Udtræk fandtes:

Oxalsyre, ubetydelig Mængde. Fosfor- og Garvesyre, ubetydelig Mængde. Citron-, Æble- og Ravsyre i ringe Mængder. Ved Glødning af Kalciumoxalatet fandtes 0,04 % CaO i lufttørret Stof.

3) Kalkfældende Syrer, som havde været til Stede i alkalibunden eller fri Tilstand:

Sfovlsyre, Spor. Fosfor- og Garvesyre i ringe Mængder. Citronsyre, ringe Mængde. Æble- og Ravsyre, rigelige Mængder.

Ved Bestemmelsen af Æblesyrens Ækvivalenttal fandtes dette at være 67,2.

4) Vand 7,13 %. Aske 15,08 %. I Saltsyre uopløselig Rest af Aske 1,37 %, CaO 3,01 %. Sfovlsyre 3,78 %. Alt i lufttørret Stof.

Den til Oxalsyre bundne CaO udgjorde 0,04 %. Resten, 2,97 %, har fortrinsvis været til Stede som Malat, Succinat og Citrat.

98,67 % af CaO -Mængden har ikke været bundet til Oxalsyre.

Mentha piperita.

Fig. 2 a viser et Tversnit af Bladet. Tages Snit af Spiritus-Materiale eller af Drogen vil de efter Indlægning i Vinaand eller Glycerin og Vinaand vise talrige Sfærokrystaller og løse Krystalstjerner. Sfærokrystallerne er ofte noget utsynligt radiært stribede, Fig. 2 b.

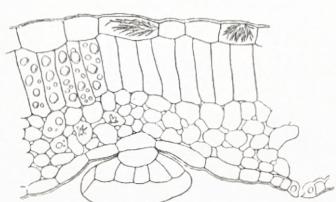


Fig. 2 a.



Indlægges Snittene i Vand, oploses Kalksaltet til Dels og paa saadan Maade, at man derefter ser fine Krystaller, som er ordnede til meget løse Stjerner eller Sfærer. Aflejringsstederne er saavel Palissadeceller som Svampparenkym. Ved Tilsætning af Sfovlsyre dannes talrige Gipsnaale.

I begge Fladers, men fortrinsvis i Oversidens, *Epidermis* findes et i Sfærer eller Buskform udkrystalliseret Stof, som iøvrigt gentagne Gange er iagttaget. Ud over nogle foretagne mikrokemiske Prøver har jeg ikke nærmere undersøgt det.

Stoffet er opløseligt i Kaliumhydroxydopløsning, uopløseligt i Syrer, f. Ex. i Svolesyre, det er altsaa ikke Kalksalt. Jeg skal gøre opmærksom paa, at det samme eller et lignende Stof i senere Tid gentagne Gange er paavist andre Steder, foruden i andre Mentha Arter, f. Ex. i Bladene af *Conium maculatum*, og at den Formodning har været fremsat, at det skulde kunne afledes fra *Carotin*.

Solereder³¹⁾, Pag. 719, angiver i al Almindelighed om *Labialae*: Den oxalsure Kalk er, hvor den forekommer i Blad og Axede, til Stede som smaa naaleformede, stavformede eller oktaedriske Krystaller, ofte flere i hver Celle; sjældent i Form af Druser: *Lycopus*, *Pycnanthemum linifolium*. Hos andre Forfattere har jeg ikke fundet Angivelser om Indhold af Krystaller i dette Blads Mesofyl, fraregnet Tschirch. T. har nemlig set Sfærer ved Nerverne, men mistyder disse Krystaller, idet han antager dem identiske med det i *Epidermis* forekommende Stof³³⁾, Pag. 74.

Kemisk Undersøgelse. Anvendt 20 Grm. lufttørret Stof.

1) I det vandige Udtræk fandtes:

Svolesyre. Fosfor- og Garvesyre. Citronsyre, ret rigelig Mængde. Æble- og Ravsyre i rigelige Mængder.

Ved Bestemmelsen af Æblesyrens Ækvivalenttal fandtes dette at være 67,6.

2) I det saltsure Udtræk fandtes:

Fosfor- og Garvesyre, mindre Mængder. Citronsyre. Æblesyre i ringe Mængde.

3) Kalkfældende Syrer, som havde været til Stede i alkalibunden eller fri Tilstand:

Svolesyre. Fosfor- og Garvesyre i ringe Mængder. Æblesyre, rigelig Mængde. Ravsyre, mindre Mængde.

4) Vand 8,95 %. Aske 15,40 %. I Saltsyre uopløselig Rest af Aske 5,73 %. Ca O 3,08 %. (Ved en anden Bestemmelse, som foretages uden Udfældning af Jern og Fosforsyre fandtes 3,14 % Ca O). Svolesyre 1,00 %. Alt i lufttørret Stof.

Der er slet ikke paavist Oxalsyre. Den samlede Ca O-Mængde har fortrinsvis været til Stede som Malat, Citrat og Succinat.

Pilocarpus species. (*Folia Jaborandi*).

Fig. 3 viser et Tværsnit af Bladet. Saa vel i Palissader som i Svampparenkym forekommer der Krystalstjerner, ikke sjældent findes flere i een Palissadecelle, som da har Tværskillevægge mellem Krystalstjernerne. Disse Krystalstjerner er almindelig kendt og beskrevet som Kalciumoxalat. Jeg har tillige paavist Tilstedeværelsen af løsere byggede Krystalstjerner og forskelligt formede Konglomerater, som er lettere opløselige end de tætte Krystalstjerner. Behandles Snit med Klorammoniumopløsning (20 %) i nogle Timer (jeg har ladet henligge i 3 T.), vil man ved Eftersøgning finde, at Krystalstjernerne er opløst, enten fuldstændigt eller med Efterladelse af Grupper af Smaakorn, som antyder de for største Dele opløste Krystalstjerner.

Kemisk Undersøgelse. Anvendt 20 Grm. lufttørret Stof.

1) I det vandige Udtræk fandtes:

Sfovlsyre. Fosfor- og Garvesyre. Citronsyre, mindre Mængde. Æble- og Ravsyre, rigelige Mængder.

Ved Bestemmelsen af Æblesyrens Ækvivalenttal fandtes dette at være 68,9. Ved Bestemmelsen af Ravsyrens Ækvivalenttal fandtes dette at være 61 (Teoretisk 59).

2) I det saltsure Udtræk fandtes:

Oxalsyre, mindre Mængde. Citronsyre, mindre Mængde. Æble- og Ravsyre, mindre Mængder. Ved Glødning af Kalciumoxalatet fandtes 0,48 % Ca O.

3) Kalkfældende Syrer, som havde været til Stede i alkalibunden eller fri Tilstand:

Sfovlsyre, ringe Mængde. Æble- og Ravsyre, rigelige Mængder.

4) Vand 7,54 %. Aske 9,95 %. I Saltsyre uopløselig Rest af Aske 2,27 %. Ca O 3,45 %. Sfovlsyre 0,46 %. Alt i lufttørret Stof.

Den til Oxalsyre bundne Mængde Ca O udgjorde 0,48 %. Resten, 2,97 %, har fortrinsvis været til Stede som Malat, Succinat og Citrat. 86,1 % af Ca O-Mængden har ikke været bundet til Oxalsyre.

Digitalis purpurea.

Fig. 4 viser et Snit af Bladet. Tages Snit af Spiritus-Materiale eller af Drogen vil de ved Indlægning i Vinaand eller Glycerin og Vinaand vise Sfærokrystaller og løsere eller tættere byggede Krystalstjerner. Efter Indlægning i Vand oploses Krystallerne, i hvert Tilfælde for største Delen; i vandigt Præparat har jeg paavist faa Krystalstjerner. Ved Tilsætning af Sfovlsyre dannes et rigeligt Antal Gipsnaale. Aflejringsstederne er Palissadeceller og Svampparenkym; Krystalstjernerne har jeg udelukkende fundet i Svampparenkymet, Sfærer i Haarene.

I Litteraturen angives Bladet at mangle Krystaller, f. Ex. Gilg³⁴⁾, Pag. 305; Flückiger³⁵⁾, Pag. 671; Arthur Meyer³²⁾, Bd. II, Pag. 202; Jos. Moeller²⁸⁾ Pag. 83; Tschirch³³⁾ Pag. 391 og³⁶⁾ Bd. IV, Pag. 393; Planchon & Collin³⁰⁾, Bd. I, Pag. 548. Derimod angiver ældre Forfattere, som Otto³⁷⁾, Pag. 270: Indhold af oxalsur Kalk

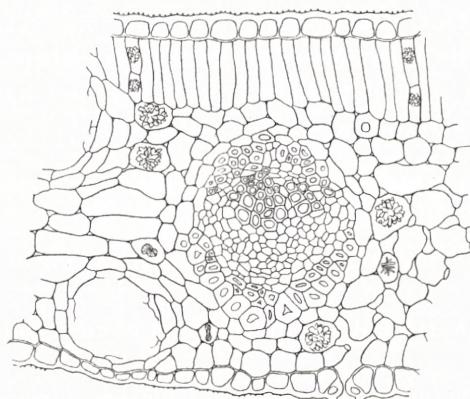


Fig. 3.

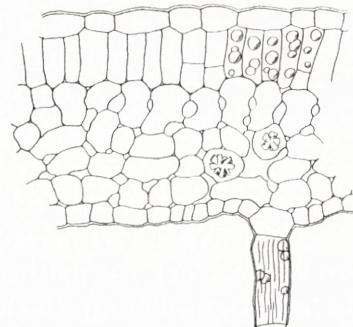


Fig. 4.

og Wiggers³⁸⁾, Pag. 308: 2 % Kaliumoxalat, samt Vinsten. Solereder³¹⁾, Pag. 660, angiver i al Almindelighed om *Scrophulariaceae*: Den oxalsure Kalk er sædvanlig udskilt i Form af smaa prismatiske, oktaedriske eller naaleformede Krystaller.

Kemisk Undersøgelse. Anvendt 15 Grm. lufttørret Stof.

1) I det vandige Udtræk fandtes:

Sfovlsyre. Fosfor- og Garvesyre. Citronsyre, ringe Mængde. Æblesyre, rigelig Mængde. Ravsyre, ringe Mængde.

2) I det saltsure Udtræk fandtes:

Citronsyre, ringe Mængde. Æblesyre, mindre Mængde. Ravsyre, ringe Mængde.

3) Kalkfældende Syrer, som havde været til Stede i alkalibunden eller fri Tilstand:

Sfovlsyre. Citronsyre, ringe Mængde. Æblesyre, rigelig Mængde. Ravsyre, mindre Mængde.

Ved Bestemmelsen af Æblesyrens Ækvivalenttal fandtes dette at være 66,0.

4) Vand 10,90 %. Aske 8,34 %. I Saltsyre uopløselig Rest af Aske 0,39 %. CaO 1,13 %. Sfovlsyre 1,35 %. Alt i lufttørret Stof.

Der er slet ikke paavist Oxalsyre. Den samlede CaO-Mængde har fortrinsvis været til Stede som Malat, Citrat og Succinat.

Crataegus monogyna.

Der er foretaget Undersøgelser af Blade, som indsamledes 24. Juni og 20. Oktober 1908.

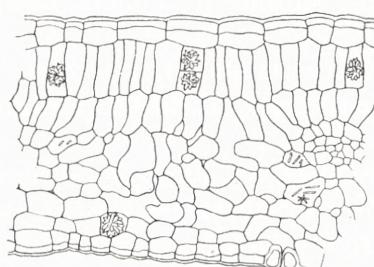


Fig. 5 a.

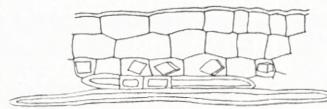


Fig. 5 b.

Bladets Bygning ses af Fig. 5 a, som er tegnet efter Oktober-Blad. Begge Fladers *Epidermis* har forslimende Indervægge. Der findes tætte Krystalstjerner aflejret saavel i Palissadeceller som i Svampparenkym. Langs Nerverne forekommer Belægning med Krystalkammerceller, Fig. 5 b; endvidere forekommer fine naaleformede Krystaller, som bedst ses i Parenkymet omkring Nerverne. Ved sammenlignende Undersøgelse fandtes det, at Oktoberbladene indeholdt flere Krystalstjerner og Enkeltkrystaller i Krystalkammerceller. Ved Tilsætning af Sfovlsyre danner talrige Gipsnaale. Ved Behandling med Klorammoniumopløsning (20 %) opløses

Krystalstjernerne fuldstændigt eller for største Delen; medens Enkeltkrystallerne i Krystalkammercellerne bliver uopløste.

Kemisk Undersøgelse.

- a) Juni-Blade. Anvendt 10 Grm. lufttørret Stof.

Det vandige Udtræk lod sig ikke filtrere paa Grund af Bladenes Indhold af Slim. Undersøgelsen er derfor foretaget med det saltsure Udtræk.

I det saltsure Udtræk fandtes:

Sfovlsyre. Oxalsyre, mindre Mængde. Citronsyre, mindre Mængde. Æblesyre. Ravsyre, ret rigelige Mængder.

Ved Glødning af Kalciumoxalatet fandtes 0,59 % CaO .

- 4) Vand 8,27 %. Aske 5,50 %. I Saltsyre uopløselig Rest af Aske 0,243 %. CaO 1,95 %. Alt i lufttørret Stof.

Den til Oxalsyre bundne Mængde CaO udgjorde 0,59 %. Resten, 1,36 %, har fortrinsvis været til Stede som Citrat, Malat og Succinat.

69,74 % af CaO -Mængden har ikke været bundet til Oxalsyre.

- b) Oktober Blade. Anvendt 15 Grm. lufttørret Stof.

1) I det vandige Udtræk fandtes:

Sfovlsyre. Fosfor- og Garvesyre. Citronsyre, Spor. Æblesyre, ret rigelig Mængde. Ravsyre, rigelig Mængde.

Ved Bestemmelsen af Ravsyrens Ækvivalenttal fandtes dette at være 60,0.

2) I det saltsure Udtræk fandtes:

Oxalsyre, ret rigelig Mængde. Citronsyre, mindre Mængde. Æblesyre, mindre Mængde.

Ved Glødning af Kalciumoxalatet fandtes 1,54 % CaO .

- 3) Kalkfældende Syrer, som havde været til Stede i alkalibunden eller fri Tilstand.

Sfovlsyre. Æblesyre, mindre Mængde. Ravsyre, ret rigelig Mængde.

- 4) Vand 8,38 %. Aske 10,47 %. I Saltsyre uopløselig Rest af Aske 0,48 %. CaO 5,04 %. Sfovlsyre 1,75 %. Alt i lufttørret Stof.

Den til Oxalsyre bundne Mængde CaO udgjorde 1,54 %. Resten, 3,50 %, har fortrinsvis været til Stede som Succinat, Malat og Citrat.

69,44 % af CaO -Mængden har ikke været bundet til Oxalsyre.

Thea sinensis.

Til mikroskopisk og kemisk Undersøgelse er benyttet grøn Te, Handelssorten *Twankay*, som bestaar af udfoldede, men ikke udvoxede Blade.

Fig. 6 viser et Tværsnit af Bladet med en Idioblast. Svampparenkymet indeholder løsere og tættere byggede Krystalstjerner, hvis Forekomst er almindelig

kendt og som i Litteraturen angives at være Kalciumoxalat, f. Ex. Flückiger³⁵⁾, Pag. 641; Gilg³⁴⁾, Pag. 220; Tschirch³³⁾, Pag. 10; Planchon & Collin³⁰⁾ Bd. II, Pag. 741. Jos. Moeller²⁸⁾, Pag. 111, angiver Krystaldruser. Solereder³¹⁾, Pag. 149, anfører i al Almindelighed om *Ternstroemiaceae*: Kalciumoxalatet er til Stede i Form af Rafider, Styloider, Druser og almindelige Enkeltkrystaller.

Jeg har foruden disse Stjerner paavist Enkeltkrystaller i Palissadecellerne, samt Sfærer i Palissader og Svamparenkym, af og til endog i *Epidermis*. Dette sidste Forhold maa sikkert sættes i Forbindelse med den Behandling, de friske Blade undergaar, idet de efter at have mistet Saftspændingen rulles under Tryk; Saften, som bl. a. indeholder lettere opløselige Kalksalte, vil herved bredes ud over Bladet. Henlægges Snit i et Par Timer i Klorammoniumopløsning (20 %), vil man finde, at Kalksaltet for største Delen er opløst; nogle af de tætteste Krystalstjerner omkring Hovednerven er tilbage, mere eller mindre paavirket af Opløsningsmidlet. Efter at Snittene havde henligget Natten over, kunde jeg kun hist og her paavise uopløste Rester af Krystalstjernerne.

Kemisk Undersøgelse. Anvendt 15 Grm. lufttørret Stof.

1) I det vandige Udtræk fandtes:

Svovlsyre. Fosfor- og Garvesyre. Citronsyre, ringe Mængde. Æblesyre og Ravsyre, ret rigelige Mængder.

2) I det saltsure Udtræk fandtes:

Oxalsyre, ringe Mængde. Citron- Æble- og Ravsyre i mindre Mængder. Ved Glødning af Kalciumoxalatet fandtes 0,21 % *Ca O*.

3) Kalkfældende Syrer, som havde været til Stede i alkalibunden eller fri Tilstand:

Æble- og Ravsyre.

4) Vand 7,28 %. Aske 8,83 %. I Saltsyre uopløelig Rest af Aske 2,75 %. *Ca O* 0,84 %. Svovlsyre 1,56 %. Alt i lufttørret Stof.

Den til Oxalsyre bundne *Ca O* udgjorde 0,21 %. Resten, 0,63 %, har fortrinsvis været til Stede som Citrat, Malat og Succinat. 75,0 % af *Ca O*-Mængden har ikke været bundet til Oxalsyre.

Hyoscyamus niger.

Der er foretaget Undersøgelser af 1ste Aars grundstillede, stilkede Blade, som jeg indsamlede i overordentlig store Exemplarer ved Vemmetofte Strand og af andet Aars siddende Blade, som forelaa i Droege af særlig smukt Udseende. De siddende Blades store Indhold af Krystaller er almindelig kendt. Krystallerne er i Litteraturen beskrevet som Kalciumoxalat; de forekommer som Enkelt- og Tvillingkrystaller, Konglomerater og Stjerner, medens der omkring Nerverne tillige er aflejret Krystalsand.

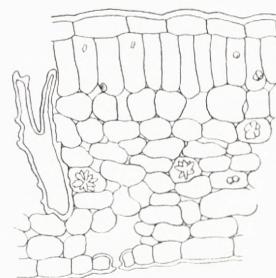


Fig. 6.

Mærkeligt nok er det undgaaet Opmærksomheden, at Krystallerne som Regel viser een, sjældnere to eller tre Sfæriter, der er indsænkede i Krystallerne, Fig. 6 a. Siim har i sit Arbejde over *Hyoscyamus*³⁹⁾ heller ikke beskrevet dette Forhold. Ved Gennemgang af Litteraturen har jeg fundet Sfæriterne angivet af MITLACHER⁴⁰⁾, som

beskriver dem i Texten, medens det tilhørende Billede (laant fra Vogl) ikke viser dem. Nogen paalidelig diagnostisk Betydning har Sfæriterne dog ikke, idet de ogsaa forekommer i Enkelkrystaller hos *Datura Stramonium* og *Atropa Belladonna*, om end langt fra i alle Krystallerne. Iøvrigt er Krystaller med Sfæriter jo tidligere paavist i andre Planter (Kohl).

I første Aars stilkeblade har jeg paavist talrige store Sfæriter, samt mere eller mindre uregelmæssigt formede Krystalstjerner, der maaske snarest burde betegnes Konglomerater, desuden Enkelkrystaller, Fig. 6 b. Sfæriterne og en Del

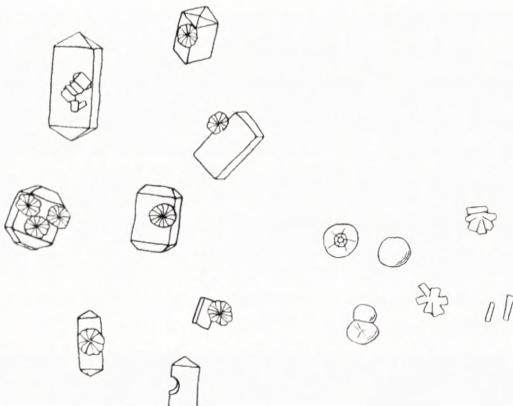


Fig. 6 a.

Fig. 6 b.

af Krystalstjernerne er ret let opløselige (Vand, Klorammonium, Eddikesyre). Undersøges Snit, som har henligget i Vinaand, vil man finde, at mange af Sfæriterne er blevet straalet-krystallinske.

Kemisk Undersøgelse.

a) 1ste Aars stilkeblade. Anvendt 10 Grm. lufttørret Stof.

1) I det vandige Udtræk fandtes:

Sfovlsyre. Oxalsyre, ringe Mængde. Fosfor- og Garvesyre. Citronsyre, mindre Mængde. Æble- og Ravsyre, rigelige Mængder.

Ved Glødning af Kalciumoxalatet fandtes 0,12 % CaO .

Ved Bestemmelsen af Æble- og Ravsyrens Ækvivalenttal fandtes henholdsvis Tallene 67,7 og 58,4.

2) I det saltsure Udtræk fandtes:

Oxalsyre, ret rigelig Mængde. Citron- og Æblesyre i mindre Mængder.

Ved Glødning af Kalciumoxalatet fandtes 1,30 % CaO .

3) Kalkfældende Syrer, som havde været til Stede i alkalibunden eller fri Tilstand:

Sfovlsyre. Fosfor- og Garvesyre, ringe Mængde. Citronsyre, ret rigelig Mængde. Æble- og Ravsyre, rigelige Mængder.

4) Vand 8,33 %. Aske 20,80 %. I Saltsyre uopløselig Rest af Aske 2,14 %. CaO 2,19 %. MgO 2,13 %. Sfovlsyre 1,09 %. Alt i lufttørret Stof.

Den til Oxalsyre bundne CaO udgjorde 1,30 %. Resten, 0,89 %, har fortrinsvis været til Stede som Citrat, Malat og Succinat. Efter den seje Beskaffenhed, som det ved Tilsætning af Vinaand til det vandige Udtræk fremkomne Bundfald udviste, kunde det formodes, at Bundfaldet for en væsentlig Del var Magnesiasalte. Bestemmelsen af MgO bekræfter dette.

40,64 % af CaO -Mængden har ikke været bundet til Oxalsyre.

b) Andet Aars siddende Blade. Anvendt 10 Grm. Stof.

1) I det vandige Udtræk fandtes:

Sfovlsyre. Oxalsyre. Fosfor- og Garvesyre. Æble- og Ravsyre.

Ved Glødning af Kalciumoxalatet fandtes 0,93 % CaO .

2) I det saltsure Udtræk fandtes:

Oxalsyre, rigelig Mængde. Citronsyre, ringe Mængde. Æble- og Ravsyre, mindre Mængder.

Ved Glødning af Kalciumoxalatet fandtes 2,87 % CaO .

3) Kalkfældende Syrer, som havde været til Stede i alkalibunden eller fri Tilstand. Kalksaltene dannede et fyldigt og rigeligt Bundfald. Mængden bestemtes efter Tørring ved 100°, den udgjorde 5,32 %.

Sfovlsyre. Citronsyre, ringe Mængde. Æble- og Ravsyre, rigelige Mængder.

4) Vand 10,84 %. Aske 14,58 %. I Saltsyre uoplöselig Rest af Aske 1,08 % (Drogens gode Beskaffenhed fremgaar bl. a. af det for Bulmeurtblade ualmindelig lave Indhold af Sand). CaO 3,45 %. Sfovlsyre 0,75 %. Alt i lufttørret Stof.

Den til Oxalsyre bundne Mængde CaO udgjorde 2,88 %. Resten, 0,57 %, har fortrinsvis været til Stede som Malat, Succinat og Citrat.

16,52 % af CaO -Mængden har ikke været bundet til Oxalsyre.

Datura Stramonium.

Bladet indeholder i Svampparenkymets øverste Cellelag talrige Krystalstjerner, desuden Enkeltkrystaller, hvis Antal vexler stærkt i forskellige Blade, og ved Nerverne Krystalsand. Enkeltkrystallerne kan, som allerede anført under *Hyoscyamus*, føre Sfæriter. Kalksaltet angives almindeligt at være Kalciumoxalat.

Kemisk Undersøgelse. Anvendt 10 Grm. lufttørret Stof.

1) I det vandige Udtræk fandtes:

Sfovlsyre. Oxalsyre. Fosfor- og Garvesyre. Citron- Æble- og Ravsyre i mindre Mængder.

Ved Glødning af Kalciumoxalatet fandtes 0,84 % CaO .

2) I det saltsure Udtræk fandtes:

Oxalsyre, rigelig Mængde. Citronsyre, mindre Mængde. Æble- og Ravsyre, ringe Mængder.

Ved Glødning af Kalciumoxalatet fandtes 3,00 % CaO .

- 3) Kalkfældende Syrer, som havde været til Stede i alkalibunden eller fri Tilstand:

Sfovlsyre. Citronsyre, mindre Mængde. Æblesyre, mindre Mængde. Ravsyre, rigelig Mængde.

Ved Bestemmelsen af Ravsyrens Åkvivalenttal fandtes dette at være 60,4.

- 4) Vand 6,15 %. Aske 14,15 %. I Saltsyre uopløselig Rest af Aske 1,22 %. CaO 4,03 %. Sfovlsyre 0,21 %. Alt i lufttørret Stof.

Den til Oxalsyre bundne Mængde CaO udgjorde 3,00 %. Resten, 1,03 %, har fortrinsvis været til Stede som Citrat, Malat og Succinat.

25,56 % af CaO -Mængden har ikke været bundet til Oxalsyre.

Crocus sativus. (Stigmata Croci).

Til den mikroskopiske Undersøgelse anvendtes Safran, som saa vidt muligt affarvedes ved gentagen Behandling med fortyndet Vinaand ($5 + 1 Aq$). I Snit af den saaledes behandlede Droege paavistes i Parenkymet Sfærokrystaller, som hyppigt

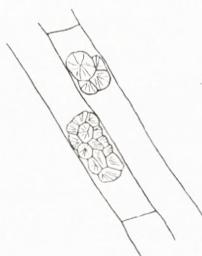


Fig. 7 a.

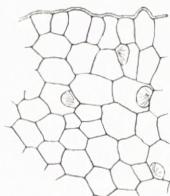


Fig. 7 b.



Fig. 7 c.

var lejrede i Grupper og viste en mere eller mindre tydelig radiær Stribning; desuden paavistes Krystalkorn, Fig. 7 a, b og c. Med Sfovlsyre dannes Gipsnaale.

De i Litteraturen foreliggende Angivelser om Kalksalt-Krystaller i Safran er meget uoverensstemmende. Nogle Forfattere angiver saaledes Indhold af Kalciumoxalat, f. Ex. Arthur Meyer³²⁾, Bd. II, Pag. 346; Vogl⁴¹⁾, Pag. 357; Tschirch³³⁾, Pag. 92. Jos. Moeller²⁸⁾, Pag. 139 og²⁹⁾, Pag. 100, finder, at der med Sfovlsyre undertiden dannes fine, i Vand opløselige Krystalnaale; Oxalatkristaller mangler. Planchon & Collin og Flückiger angiver Intet om Krystaller. MOLISCH⁴²⁾, benægter Tilstede-værelsen af Kalciumoxalat i Safran.

RUDOLF MÜLLER⁴³⁾, Pag. 823, har søgt at bringe Klarhed over de forskellige Angivelser. Han paaviser Indhold af Krystaller og finder, at Tilsætning af Sfovlsyre bevirket Dannelsen af Krystalnaale, som — trods Opløseligheden i Vand — vel kan tænkes at være Gipsnaale; men om det indeholdte Kalksalts Art lykkes det ham ikke at give positiv Oplysning.

Kemisk Undersøgelse. Anvendt 10 Grm. lufttørret Safran.

- 1) I det vandige Udtræk fandtes:

Svovlsyre, Spor. Fosforsyre, ringe Mængde. Citronsyre, ringe Mængde.
 Æblesyre, mindre Mængde. Ravsyre, rigelig Mængde.

- 2) I det saltsure Udtræk fandtes:
 Citronsyre, mindre Mængde.
- 3) Kalkfældende Syrer, som havde været til Stede i alkalibunden eller fri
 Tilstand.
 Svovlsyre. Citronsyre og Æblesyre, mindre Mængder. Ravsyre, ret
 rigelig Mængde.
- 4) Vand 9,11 %. Aske 4,84 %. I Saltsyre uopløselig Rest af Aske 0,58 %.
 $Ca O$ 0,72 %. Svovlsyre 0,56 %. Alt i lufttørret Stof.
 Den samlede Mængde $Ca O$ har fortørnvis været til Stede som Succinat,
 desuden som Citrat og Malat.

I en anden Prøve Safran paavistes et meget ringe Indhold af Kalciumoxalat, som ved Glødning gav 0,08 % $Ca O$.

Punica Granatum (Cortex Granati).

Der er foretaget Undersøgelser af Handelsvaren og af unge Grene, som Hr. Apoteker H. J. MØLLER efter min Anmodning har bragt hjem fra Italien. Jeg bringer Hr. Apoteker Møller min Tak for dette Materiale.

Tværsnit af Barken viser et ganske regelmæssigt Skifte mellem Cellelag, der indeholder Krystalstjerner og Lag af stivelseførende Parenkym med Sistrenge, Fig. 8. Krystalstjernerne er gennemgaaende karakteriserede ved de enkelte Krystaldeles lidet tilspidsede Form. Krystalstjernerne har derfor ikke særligt Præg af „Morgenstjerne“, snarest kunde de betegnes som rosetformede. Barken indeholder tillige et mindre Antal Enkeltkrystaller. Ved Henliggen i Klorammoniumopløsning (20 %) opløses Krystalstjernerne til Dels, idet der efterlades uopløst et lidt større eller mindre Antal Partikler af Stjernerne. Enkeltkrystallerne opløses ikke. I Litteraturen angives Kalksaltet ganske almindeligt at være Kalciumoxalat. Nogle Forfattere anfører alene Krystalstjernerne, som ogsaa udgør det langt overvejende Flertal.

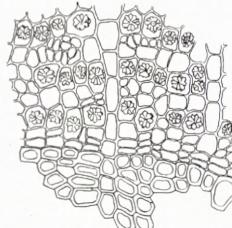


Fig. 8.

Kemisk Undersøgelse.

- a) Handelsvaren, bestaaende af tyk Bark af overjordiske Axede. Anvendt 10 Grm. lufttørret Stof.
 - 1) I det vandige Udtræk fandtes:
 Svovlsyre. Fosfor- og Garvesyre. Æblesyre. Ravsyre.
 - 2) I det saltsure Udtræk fandtes:
 Oxalsyre, stor Mængde. Fosfor- og Garvesyre. Citronsyre. Æble-
 og Ravsyre, ringe Mængder.
 Ved Glødning af Kalciumoxalatet fandtes 5,67 % $Ca O$.

- 3) Kalkfældende Syrer, som havde været til Stede i alkalibunden eller fri Tilstand:
 Fosfor- og Garvesyre. Æblesyre, ringe Mængde. Ravsyre, ret rigelig Mængde.
- 4) Vand 8,34 %. Aske 17,70 %. I Saltsyre uopløselig Rest af Aske 1,63 %. Ca O 9,07 %. Svovalsyre 0,54 %. Alt i lufttørret Stof.
 Den til Oxalsyre bundne Mængde Ca O udgjorde 5,67 %. Resten, 3,40 %, har fortrinsvis været til Stede som Citrat, Succinat og Malat.
 37,49 % af Ca O -Mængden har ikke været bundet til Oxalsyre.
- b) Bark af unge Gren. Grenenes Alder var — bestemt efter Aarringene — indtil 4 Aar. Da Materialet ved Modtagelsen var tørt, og jeg ønskede at foretage Undersøgelsen udelukkende af Barken, udblødtes Grenene med fortyndet Vinaand. Derefter afskrabedes Barken. I Alt vandtes c. 8 Grm.

Kemisk Undersøgelse. Anvendt 5 Grm. lufttørret Stof.

- 1) I det vandige Udtræk fandtes:
 Svovalsyre. Fosfor- og Garvesyre. Citronsyre. Æblesyre, Ravsyre.
- 2) I det saltsure Udtræk fandtes:
 Oxalsyre. Fosfor- og Garvesyre. Citronsyre. Æble- og Ravsyre, mindre Mængder.
 Ved Glødning af Kalciumoxalatet fandtes 1,38 % Ca O .
- 3) Kalkfældende Syrer, som havde været til Stede i alkalibunden eller fri Tilstand.
 Svovalsyre. Fosfor- og Garvesyre. Citron- og Æblesyre, mindre Mængder.
 Ravsyre, ret rigelig Mængde.
- 4) Vand 6,86 %. Aske 5,53 %. I Saltsyre uopløselig Rest af Aske 0,20 %.
 Ca O 3,00 %. Alt i lufttørret Stof.
 Den til Oxalsyre bundne Mængde Ca O udgjorde 1,38 %. Resten 1,62 %, har fortrinsvis været til Stede som Citrat, Malat og Succinat.
 54,0 % af Ca O -Mængden har ikke været bundet til Oxalsyre.

Rhamnus Frangula.

Figurerne 9 a og b og 9 c viser Yderbark af et Aarsskud og en 4-aarig Gren med en Slimcelle og primære Bastceller; Fig. 9 d viser Inderbarken af en 6-aarig Gren med et enkelt Lag sekundære Bastceller. Yderbarkens Krystalstjerner er ofte større end Inderbarkens.

Tilstedeværelsen af Krystalstjerner og Enkeltkrystaller er almindelig beskrevet i Litteraturen, og Saltet angives at være Kalciumoxalat.

Kemisk Undersøgelse.

- a) Droege. Anvendt 15 Grm. lufttørret Stof.
- 1) I det vandige Udtræk fandtes:

Svovlsyre. Fosfor- og Garvesyre. Æble- og Ravsyre, ret rigelig Mængde.

2) I det saltsure Udtræk fandtes:

Oxalsyre. Citronsyre, ringe Mængde. Æble- og Ravsyre, ringe Mængder.

Ved Glødning af Kalciumoxalatet fandtes 1,27 % CaO .

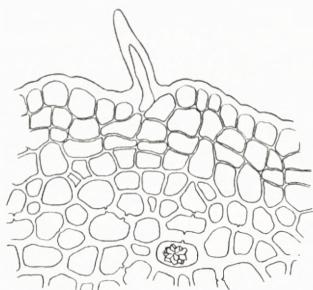


Fig. 9 a.

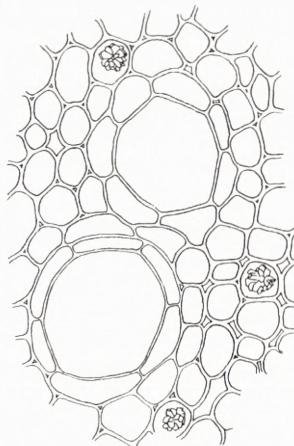


Fig. 9 b.

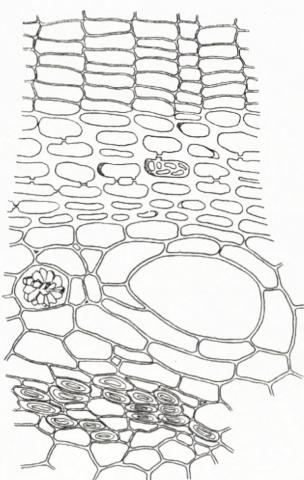


Fig. 9 c.

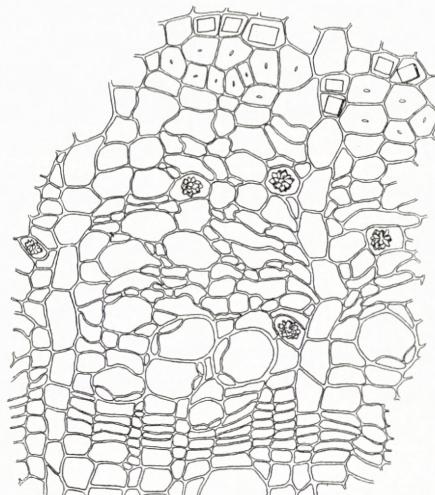


Fig. 9 d.

- 3) Kalkfældende Syrer, som havde været til Stede i alkalibunden eller fri Tilstand:
 - Svovlsyre. Æble- og Ravsyre, ret rigelig Mængde.
- 4) Vand 8,07 %. Aske 4,65 %. I Saltsyre uopløselig Rest af Aske 0,10 %.
 CaO 3,17 %. Svovlsyre 0,80 %. Alt i lufttørret Stof.

Den til Oxalsyre bundne Mængde CaO udgjorde 1,27 %. Resten, 1,90 %, har fortrinsvis været til Stede som Malat, Succinat og Citrat.

59,94 % af CaO -Mængden har ikke været bundet til Oxalsyre.

- b) Bark af unge Grene med Udeladelse af Aarsskudet. Materialet indsamlede jeg i Juli. Den strax aftagne Bark tørredes og anvendtes senere til Undersøgelsen. Anvendt 15 Grm. lufttørret Stof.

1) I det vandige Udtræk fandtes:

Svovalsyre. Fosfor- og Garvesyre. Citronsyre, ringe Mængde. Æble- og Ravsyre, ret rigelige Mængder.

2) I det saltsure Udtræk fandtes:

Oxalsyre. Citronsyre, ringe Mængde. Æble- og Ravsyre. Ved Glødning af Kalciumoxalatet fandtes 0,57 % CaO .

3) Kalkfaldende Syrer, som havde været til Stede i alkalibunden eller fri Tilstand.

Svovalsyre, Æblesyre. Ravsyre.

4) Vand 7,20 %. Aske 3,64 %. I Saltsyre uopløselig Rest af Aske 0,10 %. CaO 1,65 %. Alt i lufttørret Stof.

Den til Oxalsyre bundne Mængde CaO udgjorde 0,57 %. Resten, 1,08 %, har fortrinsvis været til Stede som Malat, Succinat og Citrat.

65,45 % af CaO -Mængden har ikke været bundet til Oxalsyre.

Althaea officinalis.

Roden indeholder Krystalstjerner saa vel i Bark som i Ved, som Regel en enkelt i hver Celle, Fig. 10 a. De Celler, som indeholder Krystalstjernerne, er hyppigt ordnede

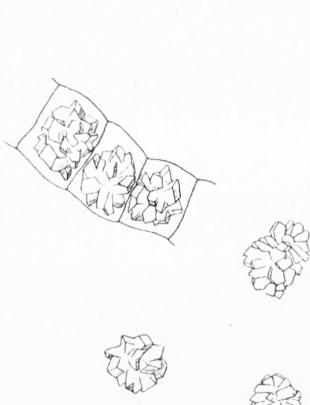


Fig. 10 a.

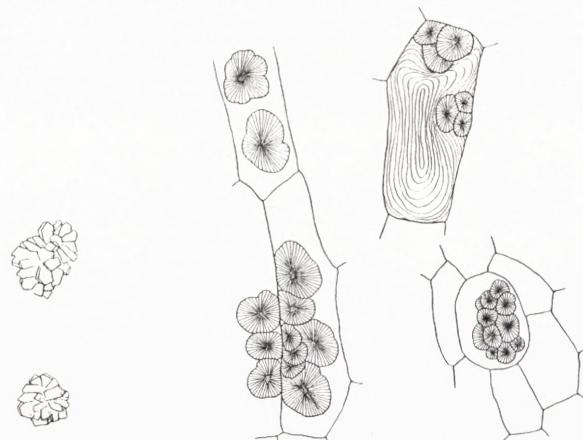


Fig. 10 b.

i korte lodrette Rækker. Forekomsten er almindelig angivet i Litteraturen, og Saltet betegnes som Kalciumoxalat: Flückiger³⁵), Pag. 374; Arthur Meyer³²), Bd. I, Pag. 230;

Jos. Moeller²⁸⁾, Pag. 365; Tschirch³³⁾, Pag. 127; Hartwich³⁶⁾, Bd. I, Pag. 476; Planchon & Collin³⁰⁾, Bd. VI, Pag. 703. — Gilg³⁴⁾, Pag. 210, angiver: Oxalatdruser i Bark- og Vedparenkym, af Krystaller forekommer kun Oxalatdruser.

Jeg har desuden paavist Sfærokrystaller, som i Regelen er ordnet i Grupper og altid aflejret i Slimcellerne, Fig. 10 b. Sfærerne er opløselige i Vand; de kan iagttaes i Snit, som indlægges i Vinaand eller Glycerin og Vinaand. Tages Snittene af Droege, som har henstaaet nogle Dage i Vinaand eller fortyndet Vinaand, kan man til de i fortyndet Vinaand indlagte Snit sætte Vand, hvorved Slimen opløses, medens Sfærerne en Tid bliver uopløste. Snit af Spiritus-Materiale taaler endog Indlægning i Kloral ($5 + 2 Aq$), uden at Sfærerne strax opløses. Ved Tilsætning af Svovalsyre dannes talrige Gipsnaale.

Det var mig paafaldende, at Tschirch, som har beskrevet Slimcellerne udviklingshistorisk, ikke har set Sfærerne, uagtet han ved disse Undersøgelser har maattet anvende Vinaand som Indlægningsmedium. Jeg antager, at Forklaringen kan søges i følgende Forhold. Medens Sfærernes Forekomst i de dyrkede Planters kødede Rødder er saa rigelig og almindelig, at jeg ikke mindes at have set nogen Slimcelle, som ikke indeholdt dem, er Forekomsten i ikke-kødede Rødder sparsom. I Materiale fra den henværende botaniske Have kunde jeg vel paavise Tilstede-værelsen, men ikke almindeligt.

Kemisk Undersøgelse. Anvendt 15 Grm. Pulver, som udrørtes med Vand og behandledes i Dialysator. De fremstillede Dialysater koncentreredes paa Vandbad, og Kalksaltene udfældedes ved Tilsætning af Vinaand.

- 1) I det vandige Udtræk fandtes:
Svovalsyre. Fosforsyre. Citronsyre, ringe Mængde. Æble- og Ravsyre, rigelige Mængder.
- 2) I det saltsure Udtræk fandtes:
Oxalsyre, Citronsyre, ret rigelig Mængde. Æble- og Ravsyre.
Ved Glødning af Kalciumpoxalatet fandtes 0,14 % $Ca O$.
- 3) Kalkfældende Syrer, som havde været til Stede i alkalibunden eller fri Tilstand.
Svovalsyre. Citronsyre, ret rigelig Mængde. Æblesyre, rigelig Mængde.
Ravsyre, ret rigelig Mængde.
Ved Bestemmelsen af Æblesyrens Ækvivalenttal fandtes dette at være 68,0.
- 4) Vand 10,33 %. Aske 5,70 %. I Saltsyre uopløselig Rest af Aske 0,39 %. $Ca O$ 1,07 %. (Ved en Bestemmelse, som foretages uden Udfældning af Fosforsyre og Jern fandtes nøjagtigt samme Tal). Svovalsyre 1,48 %. Alt i lufttørret Stof.
Den til Oxalsyre bundne Mængde $Ca O$ udgjorde 0,14 %. Resten, 0,93 %, har fortrinsvis været til Stede som Citrat, Malat og Succinat.
86,92 % af $Ca O$ -Mængden har ikke været bundet til Oxalsyre.

Exogonium Purga. (*Tuber Jalapae*).

Rodknoldens Bark- og Vedparenkym indeholder Krystalstjerner, Fig. 11. Ofte er Cellerne, som indeholder Kalksaltet, ordnet i lodrette Rækker. Krystalstjernerne er almindelig kendt og beskrevet som Kalciumpoxalat. Ved Behandling af Snit med Klorammoniumopløsning (20 %) opløses Krystalstjernerne langsomt.



Fig. 11.

Kemisk Undersøgelse. Anvendt 20 Grm. lufttørret Stof, som befriedes fra begge Former af Harpix ved Perkolering med Vin-aand og Æter.

1) I det vandige Udtræk fandtes:

Sfovlsyre. Fosfor- og Garvesyre. Citronsyre, ringe Mængde. Æblesyre, rigelig Mængde. Ravsyre, ret rigelig Mængde.

2) I det saltsure Udtræk fandtes:

Oxalsyre. Fosfor- og Garvesyre. Citronsyre, ret rigelig Mængde. Æble- og Ravsyre, mindre Mængder.

Ved Glødning af Kalciumpoxalatet fandtes 0,15 % CaO .

3) Kalkfældende Syrer, som havde været til Stede i alkalibunden eller fri Tilstand:

Sfovlsyre. Fosfor- og Garvesyre. Citronsyre, ringe Mængde. Æblesyre, rigelig Mængde. Ravsyre, ret rigelig Mængde.

Ved Bestemmelsen af Æblesyrens Ækvivalenttal fandtes dette at være 69,0.

4) Vand 9,05 %. Aske 3,59 %. I Saltsyre uopløselig Rest af Aske 0,09 %. CaO 1,39 %. Sfovlsyre 0,61 %. Alt i lufttørret Stof.

Den til Oxalsyre bundne Mængde CaO udgjorde 0,15 %. Resten, 1,24 %, har fortrinsvis været til Stede som Citrat, Malat og Succinat.

87,05 % af CaO -Mængden har ikke været bundet til Oxalsyre.

Rheum species. (*Rhizoma Rhei*).

Fig. 12 gengiver Krystalstjerner af Rabarber. Saltet er almindelig angivet at være Kalciumpoxalat. I Snit, som henlægges i Klorammoniumopløsning (20 %), kan man selv efter længere Tids Indvirkning ikke iagttagte nogen Opløsning af Krystalstjernerne.

Flückiger³⁵⁾, Pag. 403, angiver Indholdet af Aske i ved 100° tørret Stof til 13,87 %. Asken bestod overvejende af Kalciumpoxalat, samt lidt Lerjord (1 %) og Magnesium. I en Rabarber med 12,9 % Aske bestemte F. ved direkte Titrering med Kaliumpermanganatopløsning Oxalatmængden til 7,33 %, og beregner heraf, at under Halvdelen af Kalciumpoxalatet var bundet til Oxalsyre. Det er denne Analyse, som har dannet Forbilledet for Kraus' Forsøgsrække.

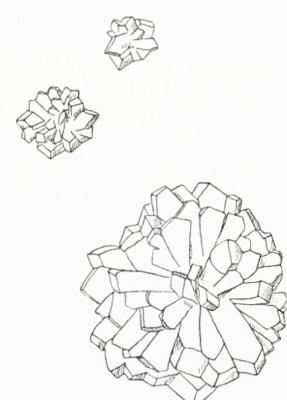


Fig. 12.

At Mængden af Kalciumoxalat vexler stærkt i Rabarber, er et Forhold, som længe har været kendt. Farmakopeerne forlanger som Regel en oxalatrig Droege (den skal knase ved Tygning).

Askemængden angives i³⁶⁾ Bd. X, Pag. 629 for Shensi-Rabarber til 19,4 %, for Kanton-R. til 7,92 % og for Szechuen-R. til 4,17 %. Pag. 630 angives Indhold af Kalciumoxalat og Æblesyre.

Kemisk Undersøgelse.

a) Kanton-Rabarber.

Saltsurt Udtræk: Ved Glødning af Kalciumoxalatet fandtes 0,39 % Ca O . De kalkfældende Syrer af det vandige Udtræk var Æble- og Ravsyre. Ved Bestemmelsen af Æblesyrens Ækvivalenttal fandtes dette at være 66,0 Vand 9,25 %. Aske 3,67 %. I Saltsyre uopløselig Rest af Aske 0,10 %. Ca O 0,73 %. Svovalsyre 0,40 %. Alt i lufttørret Stof. Den til Oxalsyre bundne Mængde Ca O udgjorde 0,39 %. Resten, 0,34 %, har fortrinsvis været til Stede som Malat og Succinat. (Citronsyre forekom mig at være til Stede i det saltsure Udtræk, men Stahres Reaktion forløb ikke utvivlsomt). 46,58 % af Ca O -Mængden har ikke været bundet til Oxalsyre.

b) Shensi-Rabarber.

Saltsurt Udtræk: Ved Glødning af Kalciumoxalatet fandtes 8,90 % Ca O . Vand 5,73 %. Aske 14,92 %. I Saltsyre uopløselig Rest af Aske 0,09 %. Ca O 10,45 %. Den til Oxalsyre bundne Mængde Ca O udgjorde 8,90 %. Resten, 1,55 %, har fortrinsvis været til Stede som Malat og Succinat. 14,83 % af Ca O -Mængden har ikke været bundet til Oxalsyre.

Dahlia species.

Rodknolden indeholder Kalksalt, som har Form af Sfæriter.

Kemisk Undersøgelse.

Saltsurt Udtræk: Ved Glødning af Kalciumoxalatet fandtes 0,11 % Ca O i oprindeligt Stof, svarende til 0,43 % i Tørstoffet.

Vandigt Udtræk: Af kalkfældende Syrer paavistes i rigelig Mængde Æblesyre, samt Ravsyre.

Ved Bestemmelsen af Æblesyrens Ækvivalenttal fandtes dette at være 66,0. Vand 76,73 %. Aske 1,52 %. I Saltsyre uopløselig Rest af Aske 0,14 %. Ca O 0,41 %. Svovalsyre 0,20 %.

Beregnet paa Tørstof faas følgende Tal:

Aske 6,55 %. I Saltsyre uopløselig Rest af Aske 0,61 %. Ca O 1,75 %. Svovalsyre 0,77 %.

Den til Oxalsyre bundne Mængde Ca O udgjorde 0,11 % (= 0,43 % paa

Tørstof). Resten 0,30 % (= 1,32 % paa Tørstof) har fortrinsvis været til Stede som Malat og Succinat.

73,04 % af Ca O-Mængden har ikke været bundet til Oxalsyre.

Quillaja saponaria.

Barken indeholder talrige store, prismatiske Enkeltkrystaller, Fig. 13 a. De findes almindelig omtalt i Litteraturen og angives at være Kalciumoxalat. HOLMES⁴⁴⁾, 1906 I, Pag. 315, beskriver en falsk Kvillajabark, der ligesom Barken af *Q. saponaria*

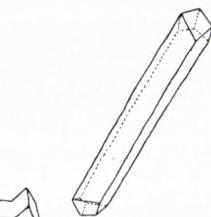
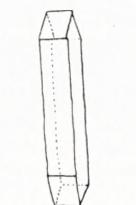


Fig. 13 a.

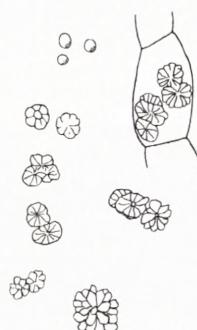


Fig. 13 b.

indeholder prismatiske Krystaller af Kalciumsulfat. Antagelig kan denne Angivelse føres tilbage til OTTO BERG, som⁴⁵⁾ og⁴⁶⁾, angiver, at Krystallerne i *Q. saponaria*, *Guajacum officinale* m. fl. er Kalciumsulfat. Flückiger³⁵⁾, Pag. 615, har Indholdet af Kalciumoxalat (med lidt Tartrat) andrager 11,5%; Aske-mængden over 13 %. WIESNER¹⁷⁾, Bd. I, Pag. 765, har ordret Flückigers Angivelse. Foruden Prismen angives der af Jos. Moeller (*)³⁶⁾. Bd. X, 1908, Pag. 539: sjældnere Romboedre, Druser eller Krystal-sand.

Jeg har paavist Krystalstjerner

og Sfæriter, Fig. 13 b, i mindre Antal end de store Enkeltkrystaller. De to første Former er opløselige i Klorammonium.

Kemisk Undersøgelse.

Saltsurt Udræk: Ved Glødning af Kalciumoxalatet fandtes 11,80 % Ca O.

Vand 7,82 %. Aske 20,08 %. I Saltsyre uopløselig Rest af Aske 0,63 %. Ca O 15,68 %. Svoevlsyre 1,07 %. Alt i lufttørret Stof.

Den til Oxalsyre bundne Mængde Ca O udgjorde 11,80 %. Resten, 3,88 %, har været til Stede som Salte af andre organiske, kalkfældende Syrer, jeg har paavist og identificeret Ravssyre, medens det kan anses som sandsynligt, at Sfæriterne er Malat og en Del af Stjerne Citrat.

32,88 % af Ca O-Mængden har ikke været bundet til Oxalsyre.

Begonia argyrostigma.

Jeg skal endelig anføre Resultatet af Undersøgelser, som jeg har foretaget af Begonieblade. Det fremgaar af Litteraturen, se bl. a. Solereder³¹⁾, Pag. 453, og jeg

* Artiklen er ikke forsynet med Autormærke og skyldes vel Redaktøren.

har fundet det bekræftet ved egne Undersøgelser, at Kalksaltet findes udskilt i forskellig Form inden for *Begoniaceae*. Snart er det som Enkeltkrystaller, snart som Konglomerater, som Stjerner eller Blandinger af alle Former. Mængden af udskilt Kalksalt fandt jeg meget vekslende. Til kemisk Undersøgelse er anvendt *B. argyrostigma*, hvoraf Hr. Slotsgartner PALUDAN stillede to Exemplarer til min Raadighed.

Bladene af det første Exemplar vejede i frisk Tilstand 61 Grm., efter Tørring ved 100° c. 5 Grm., altsaa med et Vandindhold af c. 92 %. I Bladenes Tørstof foretages følgende Bestemmelser: Aske 9,87 %. I Saltsyre uopløselig Rest af Aske 0,22 %. $Ca O$ 2,90 %.

Det fremgik iøvrigt af Undersøgelsen, at Bladene maatte indeholde en forholdsvis rigelig Mængde let opløseligt Oxalat. Med det andet Eksemplar, hvis Blade i frisk Tilstand vejede 66 Grm., foretages Undersøgelsen derfor paa den Maade, at de friske Blade først blev udtrukket med Vinaand 2 Gange (hver Gang med Anvendelse af c. 400 Cem.). De udtrukne Blade tørredes og pulveriseredes. I en Portion paa 0,876 Grm. bestemtes Tørstofmængden til 0,858 Grm., og, beregnet paa Tørstof, Aske 12,82 %. I Saltsyre uopløselig Rest af Aske 0,12 %. $Ca O$ 5,36 %. Svosvlsyre 1,96 %.

Resten af de tørrede Blade blev udtrukket med fortyndet Vinaand ($2 + 1 Aq$). De samlede vinaandige Udtræk behandledes paa Vandbad og til den vandige, eddike-sure Opløsning sattes Kalciumacetat, hvorved der fremkom et rigeligt Bundfald af Kalciumoxalat.

I det saltsure Udtræk af Bladene fandtes ved Glødning af Kalciumoxalatet 4,02 % $Ca O$ (paa Tørstof).

Den til Oxalsyre bundne Mængde $Ca O$ udgjorde 4,02 %. Resten, 1,34 %, har været til Stede som Salte af andre kalkfældende, organiske Syrer, hvoraf jeg har identificeret Ravsyre og mener at have paavist Citronsyre.

24,97 % af $Ca O$ -Mængden har ikke været bundet til Oxalsyre.

III. Bemærkninger til tidlige og egne Undersøgelser.

Som det fremgaar af de ovenfor meddelte Undersøgelser, har jeg i en Række Droger af over- og underjordiske Organer, saa vel som i nogle friske Planteorganer, paavist en ganske almindelig Forekomst af kalkfældende organiske Syrer. Efter de ved Undersøgelsen fundne Forhold er Syrerne til Stede dels i alkalibunden eller fri Tilstand, dels som Kalk- og i mindre Grad som Magnesiasalte (første Aars Blade af *Hyoscyamus niger* indeholder dog en rigelig Mængde Magnesiasalte, hvad der fremgik af den seje Beskaffenhed af Bundfaldet, som fremkom ved Tilsætning af Vinaand til det vandige Udtræk af Bladene, lige som det vil ses af den kvantitative Bestemmelse af samlet $Ca O$ og $Mg O$). Medens Oxalsyre i flere Tilfælde slet ikke

fandtes til Stede, paavistes den i andre Tilfælde i forskellig stor Mængde. I alle Tilfælde indeholdt Stofferne — uanset om Oxalsyre var til Stede eller ej — andre kalkfældende organiske Syrer, som Citron- Æble- og Ravsyre, til Dels som Kalksalte. Naar Tilstedeværelsen af disse Kalksalte i Drogerne er undgaaet saa mange Iagttageres Opmærksomhed, saaledes som det vil fremgaa af den ved de enkelte Undersøgelser citerede Litteratur, har dette sin Grund i forskellige Forhold, som et af de væsenligste maa anføres, at man, som Pfeffer træffende siger, i alt for overvejende Grad har havt Opmærksomheden henvendt paa Oxalsyren, idet man har betegnet det Kalksalt, som ikke hurtigt opløstes i Eddikesyre, som Kalciumpoxalat. Jeg ser herved bort fra ældre Forfatteres For vexling af Kalciumpoxalat med -sulfat (Model, Otto Berg o. fl.).

Størkest udpræget fremgaar dette af Analyserne af Altæa- og Jalaperod, hvis Krystalstjerner ganske almindeligt er antaget at være Kalciumpoxalat, skønt de kun for en meget ringe Del bestaar af dette Salt. Tilsvarende, om end mindre udpræget, er Forholdet ved de fleste af de andre undersøgte Droger, f. Ex. Krystalstjernerne i Granat- og Tørstetræbark. I mange Tilfælde tør det vel endog antages, at Krystalstjerneformen netop fremkommer som en Følge af forskelligartede Saltes UdkrySTALLisation. Om end Antallet af de undersøgte Plantedele har maattet begrænses, vil det være tilstrækkeligt stort til at vise, at den af Pfeffer fremsatte Antagelse, efter hvilken Kalciumpoxalat kun undtagelsesvis findes udkrystalliseret i Planterne, ikke er rigtig. Jeg maa iøvrigt her tilføje, at mikroskopiske og mikrokemiske Undersøgelser, som jeg har foretaget af en Række andre Droger, staar i Samklang med de anførte udførlige Analyser. Lettere opløselige Kalksalte forekommer herefter, alene eller sammen med Kalciumpoxalat, i Blade af andre Mentha-Arter, *Rosmarinus off.*, *Cnicus benedictus*, i Rødder af *Cichorium Intybus*, *Taraxacum off.*, i Stængelen af *Solanum dulcamara* m. fl. Det maa da tvært imod antages, at Citratet hyppigt forekommer udkrystalliseret og sikkert ogsaa sammen med lettere opløselige Kalksalte: Malat og Succinat. Det drejer sig jo i saa Henseende kun om de paagældende Organers eller Cellers Vandholdighed. At de lettere opløselige Kalksalte i andre Tilfælde forekommer i opløst Tilstand i de friske Organer, er sikkert. Ved Undersøgelse af friske Blade af *Tussilago Farfarus*, Mentha-Arter, *Cnicus benedictus* fandt jeg ikke Kalksalt udskilt; derimod dannedes der Gipsnaale med Svovalsyre, og efter Tørring eller Indlægning i Vinaand viste Snit, som indlagdes i Glycerin + Vinaand, udkrystalliseret Kalksalt. Det viste sig tillige ved disse Forsøg, at Tørring i Luften og Indlægning af det friske Materiale i Vinaand har Indflydelse paa den Form, i hvilken Kalksaltet udkrystalliserer. Blade af Mentha-Arter viste saaledes Kalksaltet udskilt som Sfærer i de lufttørrede Blade, medens det i Spiritus-Materiale var udskilt som løse Stjerner. Ved Undersøgelse af friske Fingerbølblade har jeg fundet løst byggede Krystalstjerner i Svampparenkymet, medens Sfærerne ikke var udskilt.

I Anledning af Schimpers og Wehmers modstridende Angivelser om Opløseligheden af det i forskellige Blade indeholdte Kalciumpoxalat skal jeg bemærke, at

Krystalstjernerne i Crataegusbladet, som det vil ses af min Analyse ikke eller kun til Dels bestaar af Kalciumoxalat. Det har været mig paafaldende, at man har turdet udtale noget Skøn om hvorvidt Crataegusbladets Krystalstjerner undergaar en Formindskelse i Antal eller ej. Det er meget vanskeligt at se Krystalstjernerne i dette Blad, vel særlig paa Grund af Hudens Slimindhold. Det ses da ogsaa, at Wehmer har følt sig besværet af dette Forhold, som han søger at afhjælpe ved forudgaaende Behandling med Svovlsyrling. Hvor let der kan indsnige sig Iagttagelsesfejl ved denne Art Undersøgelser, vil følgende Forhold vise. Ved Indlægning af Snit af Crataegusblade -- unge og gamle -- i Kloral ($5 + 2 Aq$) iagttog jeg, at der efter nogen Tids Forløb dannedes Gipsnaale. Ved yderligere Forsøg fandt jeg, at dette sker overalt, hvor man anvender Materiale, som indeholder lettere opløseligt Kalksalt. Forklaringen er den, at der opløses Kalksalt, som omsætter sig med Kaliumsulfat under Dannelse af Gipsnaale. Der foregaar altsaa en Opløsning af Kalksalt, som Schimper og Wehmer slet ikke har iagttaget ved deres Undersøgelser, som var rettet mod de Forandringer, Kalksaltet eventuelt undergik.

De af Kraus anstillede Forsøg, ved hvilke han paa Grundlag af kvantitative Bestemmelser mener at have bevist, at Kalciumoxalatet ved Væxtperiodens Indtræden genoptages i Stofskiftet i saa betydelig Grad, at han vil have paavist en Formindskelse af indtil ca 60 % af Oxalatet, imødegaas af Czapek, der betragter de formentlige Mindreindhold af Kalciumoxalat som Resultater af ledsagende sekundære Fænomener af de livligt foregaaende Omsætninger i Organerne. Det er mig ikke klart, hvilke Fænomener C. har for Øje, og under Hensyn til, at C. andet Steds bestemt udtaler, at de paa mikroskopiske og mikrokemiske Iagttagelser grundede Forsøg bør støttes ved kvantitative Bestemmelser, synes det mig ikke konsekvent at ville afkræfte Kraus' Resultater ved en Henvisning til Wehmers paa et Skøn hvilende Iagttagelser. Noget andet er, at Kraus' formentlige Beviser i Virkeligheden er saa svagt begrundede, at det — uagtet Arbejdsmetoden er ganske mangelfuld angivet — kan ses, at Resultaterne af hans anselige Forsøgsrække ikke kan være rigtige.

Da der er angivet Tal, kan der ses bort fra de besynderlige Angivelser i Volumen af det anvendte Stofs Mængde, af Tørstoffet og af Oxalatet. Ved de sammenlignende Bestemmelser er der imidlertid strax et Forhold, som er iøjnefaldende. K. gaar ud fra, at to lige store Rodstokke af *Rumex obtusifolius* eller to lige store Axedele af Træer indeholder samme Mængde Kalciumoxalat. Det er en Forudsætning, som sikkert er uholdbar, og hvis Indflydelse paa Resultaterne er uberegnet. Den anvendte Arbejdsmetode er — som anført — ikke nærmere angivet og navnlig gælder dette Detailler vedrørende Bestemmelsen af Kalciumoxalatet, om hvilken der kun anføres, at den er foretaget ved Titrering med Kaliumpermanganat. Forudsætningen for denne Metodes Anwendelighed er, at Kaliumoxalatet foreligger i ren Tilstand, men denne Fordring er sikkert ikke fyldestgjort ved Kraus' Forsøg, hvad der bl. a. kan sluttes deraf, at den oprindelig paatænkte Anwendung af Rabarber som Forsøgsmateriale maatte opgives, fordi det paa Grund af Rabarberens andre

Indholdsstoffer var umuligt at vinde Oxalatet i saa ren Tilstand, som nødvendigt for dets Titrering. Andet Materiale fandtes da bedre anvendeligt. Det kan ikke ses, om K. har foretaget Titreringerne direkte i det saltsure Udtræk eller med Anvendelse af et af disse Udtræk fremstillet Raa-Oxalat. En Renfremstilling, f. Ex. gennem Blysaltet, har ikke fundet Sted. Det benyttede Oxalat har altsaa været urent, det har indeholdt „organisk Stof“ og sandsynligvis Kalksalte af Citron-, Æble- og Ravsyre, som alle med Undtagelse af Succinatet affarver Kaliumpermanganat efter Væxtperiodens Indtræden, kan dette muligvis tale for, at der er foregaaet en Opløsning og et Forbrug af Citrat og Malat, men som Bevis for Kalciumoxalatets Genoptagelse i Stofskiftet er Forsøgsrækken ikke skikket. De mærkelige Spring i Udslagene, som flere af Forsøgene udviser, peger mod Metodens primitive Art.

De mikroskopiske Reaktioners Paalidelighed som Identifikationsmidler over for forskellige Kalksalte er bestridt af Wehmer, der er af den Anskuelse, at Kalciumoxalatets mikroskopiske Karakteristik hyppig er vanskelig, og at andet Kalksalt ikke sjældent uden tilstrækkelig Grund er betegnet som Kalciumoxalat. Wehmers Opmærksomhed er særlig rettet mod For vexling med Citrat, han gaar endog saa vidt, at han udtaler som sin Anskuelse, at Fanerogamers Sfærokrystaller og Rafider bestaar af Kalciumcitat. Wehmers Tvivl om den mikrokemiske Karakteristiks Paalidelighed begrundes ved hans Erkendelse af, at Kalciumcitat ikke kan ansees som let opløseligt i Eddikesyre og under Forudsætning af at der foreligger krystallinsk (og ikke for smaa-krystallinsk) Kalciumcitat, er denne Opfattelse jo korrekt.

Om Kalciumoxalatets Forhold over for Kaliumhydroxyd er Angivelserne ligeledes uoverensstemmende. Efter den almindelige Opfattelse af Forholdet er Saltet uopløseligt i Kaliumhydroxydopløsning. Sanio³⁾) har imidlertid iagttaget og først angivet, at Kalciumoxalatkrystaller ved Behandling under Dækglas med Kaliumhydroxydopløsning først blev uforandret, men efter nogen Tids Forløb — ofte Timer — pludselig opløstes, i det der i Vædsken dannedes ny Krystaller, der havde Form som seksidede Tavler, men hvis Sammensætning endnu ikke er oplyst. Denne ganske objektive Fremstilling er af Kohl¹¹⁾ tydet paa højst ejendommelig Maade. For den rette Forstaaelse maa Kohls Karakteristik af Kalciumoxalatets Reaktioner, Pag. 98, gengives i sin Helhed. „Kalciumoxalatet omdannes ved Glødning til Karbonat, det er uopløseligt i Eddikesyre, let opløseligt i Saltsyre, Saltpetersyre, Svovlsyre og Klorzinkjod (som altid indeholder Saltsyre). Kalciummalat er opløseligt i Vand, -tartrat og -citat i Eddikesyre. En For vexling med disse Salte er derfor ikke mulig. Druesur Kalk har størst Lighed med Oxalat, begge er uopløselige i Vand og Eddikesyre, opløselige i Mineralsyrer og Kaliumhydroxydopløsning, men ved Kalciumoxalatets Opløsning i Kaliumhydroxyd udskilles der i karakteristiske Former krystallinsk Kalium-Kalciumdobbelt salt, medens det druesure Kalium-Kalcium-salt forbliver i Opløsning“!

Ved mine Undersøgelser har jeg, som allerede anført, bestandig sammenholdt Resultaterne af den kemiske og mikroskopiske Analyse og bl. a. ogsaa prøvet de

forskellige Kalksaltes Forhold over for Kaliumhydroxyd. Et som Kalciumcitrat bestemt Salt viste ved Indlægning i Kaliumhydroxydopløsning det af Sanio for Oxalat angivne Forhold; efter nogen Tids Forløb opløstes Citratet, og der udskiltes hurtigt Krystaller, der for største Delen havde Form som sexsidede Tayler, Fig. 14 a og b. Ganske det samme Forhold paaviste jeg derefter ved tilsvarende Behandling af Kalciummalat og -oxalat. Naar der til saadanne Präparater sattes Eddikesyre, opløstes Krystallerne under Kulsyreudvikling. Det kunde heraf skønnes, at der

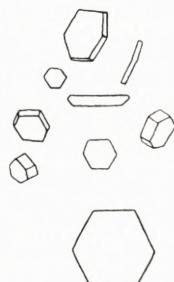


Fig. 14 a.

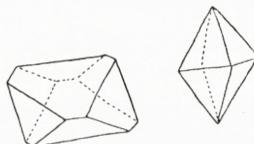


Fig. 14 b.



Fig. 15.

foregik en Dobbelt-Dekomposition under Dannelse af Kaliumcitrat, -malat og -oxalat, og Kalciumhydroxyd, som efter Indsugning af Luftens Kulsyre udskiltes som Karbonat. For nærmere at prøve dette Forhold, foretages nedennævnte Forsøg.

- 1) Kornet-krystallinsk Kalciumoxalat, fremstillet ved Tilsætning af opløst Kalciumacetat til en kogende Opløsning af Kalciumoxalat. Det udvadskede Bundfald tørredes ved 100° .

0,203 Grm. Oxalat bragtes i en fladbundet Glasskaal og overhældtes med 50 Cem. af en 5 %'s KOH-Opløsning. Efter $1\frac{1}{2}$ Døgns Henstand udførtes følgende Bestemmelser: Vædsken frafiltreredes, Skaal og Filter udvadskedes med kogende Vand. Filtratet overmættedes med Eddikesyre, og til den kogende Vædske sattes Kalciumacetat, hvorved der fremkom et rigeligt Bundfald. Efter Henstand til næste Dag bestemtes Mængden af CaO . Der fandtes 0,074 Grm. CaO . 0,203 Grm. $CaC_2O_4 + 1 Aq$ giver teoretisk 0,07785 Grm. CaO .

Det i Skaalen og paa Filtret tilbageblevne Karbonat behandles med fortyndet Eddikesyre (Kulseyreudvikling) og udvadskedes. Til det kogende Filtrat sattes Ammoniumoxalatopløsning. Efter Henstand frafiltreredes Bundfaldet, udvadskedes, og Mængden af CaO bestemtes. Der fandtes 0,072 Grm. CaO .

- 2) Krystallinsk Kalciumoxalat, fremstillet af ovennævnte kornet-krystallinske Salt, som opløstes i fortyndet Saltsyre og genudfældedes af den kogende Opløsning ved lidt efter lidt at tilsette en kogende Opløsning af Natriumacetat. Det saaledes fremstillede Kalciumoxalat er vist i Fig. 15.

0,218 Grm. ved 100° tørret Kalciumoxalat overhældtes med 50 Cem. 5 %'s KOH-Opløsning. Efter Henstand udførtes paa ovennævnte Maade Bestem-

melser af CaO -Mængden i Kalciumoxalaterne, der fremstilles af Kaliumoxalatopløsningen og det udskilte Kalciumkarbonat.

Der fandtes henholdsvis 0,084 og 0,082 Grm. CaO .

0,218 Grm. $\text{CaC}_2\text{O}_4 + 1 \text{ Aq}$ giver teoretisk 0,0836 Grm. CaO .

- 3) Krystallinsk Kalciumcitrat fremstillet af Citronsyre ved at mætte en Opløsning med Kaliumkarbonat og til denne Opløsning at sætte Kalciumacetat og



Fig. 16.

Ammoniak. Ved Kogning udskiltes Kalciumcitratet, som frafiltreredes og udvadskedes med kogende Vand. Af det lufttørrede Kalciumcitrat, Fig. 16, afvejedes 0,253 Grm., som efter 2 Døgns Henstand i Exsikkator viste uforandret Vægt. Citratet behandles med KOH -Opløsning, som anført, og CaO -Mængden bestemmes i Kalciumoxalatet, der fremstilles af det udskilte Kalciumkarbonat.

Der fandtes 0,073 Grm. $\text{CaO} = 0,0521$ Grm. Ca .

0,253 Grm. Kalciumcitrat + 4 Aq giver teoretisk 0,0533 Grm. Ca .

Ved et gentaget Forsøg med Kalciumcitrat tørredes en vejet Mængde ved 100° . Efter at Saltet havde henstaaet henholdsvis 3 og 4 T. i Tørrekassen, vejedes det, og det kunde da skønnes, at Saltet tabte Krystalvand. Ved 2 Døgns Henstand under Glasklokke tog det til i Vægt, uden helt at naa den oprindelige Vægt af det lufttørrede Stof.

Vægt af lufttørret Citrat 0,213 Grm.; efter Tørring i 3 T. 0,192, efter 4 T. 0,191, efter Henstand i 2 Døgn under Glasklokke 0,207.

Citratet behandles med KOH -Opløsning, og CaO -Mængden bestemmes i Kalciumoxalatet, som fremstilles af det udskilte Karbonat.

Der fandtes 0,062 Grm. $\text{CaO} = 0,0443$ Grm. Ca .

0,0207 Grm. Kalciumcitrat + 4 Aq giver teoretisk 0,0436 Grm. Ca , altsaa et lidt lavere Tal, som skyldes Tabet af Krystalvand. Beregnes Ca -Mængden af den oprindelige lufttørrede Stofmængde, 0,213 Grm., faas 0,0448 Grm. Ca .

Dekompositionen kan altsaa foregaa kvantitativt, og Forsøgene viser, hvor blottet for Grund Kohls ovennævnte Angivelser er. Forsøgene forklarer paa lignende Maade Iagttagelser, jeg tidligere havde gjort ved Undersøgelser af Bulmeurthblades og andre kalciumoxalatholdige Drogers Forhold over for Kaliumhydroxyd. Indlægges Snit af Bladet under Dækglas i Kaliumhydroxydopløsning opløses (dekomponeres) Oxalatet, og Kalciumkarbonatet udskilles hyppigst uden for Snittet. Ved Indlægning af c. 1 Kvadratcm. store Stykker af Bladet i Opløsningen, hvorved jeg benyttede smaa Glasskaale, foregik Dekompositionen ligeledes i 1 à 2 Døgn. Disse og andre Erfaringer, som jeg har gjort ved nærværende Arbejde, har bibragt mig Overbevisningen om, at den exakte Adskillelse af Kalksaltene ikke kan foretages mikrokemisk. Denne Opfattelse ændres ikke ved Behrens' udførlige Vejledning til mikrokemiske Analyser⁴⁸⁾, der er udarbejdet bl. a. paa Grundlag af Barfoeds organiske Analyse. Behrens angiver bl. a. Metode til at adskille minimale Mængder

kalkfældende Syrer ad kombineret kemisk og mikroskopisk Vej. Saa vidt jeg efter sammenlignende Forsøg har kunnet se, er Metoden (og hele Vejledningen) udarbejdet paa Grundlag af Prøver, som har været anstillet med de kemisk rene Stoffer. Under saadanne Forhold kan Metoden maaske være vejledende, medens den ikke har Betydning ved Undersøgelsen af Plantestoffer.

Paa Foranledning af Wehmers Paavisning af Sandsynligheden for Forvexling af Oxalat med Citrat ved Forsøg paa at adskille Kalksaltene gennem Forholdet over for Eddikesyre, fremsætter Benecke⁴⁹⁾, Ønsket om, at der angives Metode for en paalidelig mikrokemisk Adskillelse af disse Salte, idet han gaar ud fra, at Fler-tallet i modsat Tilfælde — med Ret eller Uret — vil anse Kalksalt-Krystaller, som modstaar Indvirkning af Eddikesyre ud over minutlang Iagttagelse, som Oxalat. I Overensstemmelse med det ovenfor anførte, skal jeg hertil bemærke, at man heller ikke ved Eddikesyre kan adskille Kalksaltene mikrokemisk. Kalciumcitrat vil i langt længere Tid kunne modstaa Indvirkning af Eddikesyre, og det samme gælder sandsynligvis under visse Forhold (Droger) Kalciummalat. Man kan da, om man vil være paa den sikre Side, nøjes med at anføre Tilstedeværelsen af Kalksalt, uden nærmere Betegnelse, eller man kan skønne, om der foreligger Kalciumoxalat eller lettere opløseligt Kalksalt: Citrat, Malat, Succinat. Hertil kan man benytte sig af Forholdet over for Klorammoniumopløsning, idet man i Glasskaal henlægger Snit i Opløsningen, hvis Styrke bør være ca. 20 %. Opløses Krystallerne i Løbet af nogle Timer, kan man slutte, at der ikke foreligger Kalciumoxalat. Drejer det sig om Krystalstjerner, kan disse, som mine Undersøgelser viser, være sammensat af Oxalat og lettere opløseligt Kalksalt. At amorf Kalciumcitrat er opløseligt i Klorammonium er almindeligt angivet, derimod er det krystallinske Salts Forhold angivet forskelligt. Rigtigt er det, at Kalciumcitrat, som er opløst i Klorammonium, udskilles krystallinsk ved Kogning. Ved sammenlignende Forsøg har jeg fundet, at krystallinsk Salt ogsaa kan opløses, og jeg anser dette Forhold som en noget paalideligere Prøve end Forholdet over for Eddikesyre. Forsøgene har jeg foretaget med Anvendelse af krystallinsk Kalciumcitrat og Klorammoniumopløsninger, hvis Styrke var 5, 10 og 20 %. Stof og Vædske bragtes i Erlenmeyerske Kolber og hensattes ovenpaa en Varmtvandskasse, i hvilken Vandets Temperatur var 65°. Citratet opløstes fuldstændigt i den 20 %'s, meget vanskeligt i den 10 %'s og ikke eller ganske ufuldstændigt i den 5 %'s Klorammoniumopløsning.

De af Kraus anstillede Forsøg, ved hvilke han paaviser Kalciumoxalatets delvise Opløselighed i svagere organiske Syrer, bringer jo i og for sig ikke noget Nyt.

Om Kalciumoxalatet er opløseligt i den levende Celle, som man almindelig finder det angivet, er et Spørgsmaal, som har ligget uden for min Opgave. Der er, som tidligere anført, af forskellige Forfattere fremsat Paastand herom, bl. a. af Czapek, som dog i sin Biokemi tager Afstand fra disse Iagttagelser, af hvilke man — efter C. — har draget for vidgaaende Slutninger. Af mine Undersøgelser over Fennikelfrugter fremgaar det, at man er gaaet ud fra fejle Forudsætninger, idet det indeholdte Kalksalt er Malat og Succinat; og min Analyse af Begonieblade

viser, at lignende Forhold har været til Stede her. Hvor vidt Kalciumoxalatet er opløseligt i den levende Celle og ud over den ringe Opløselighed, som er mulig i sur Vædske, er derfor et Spørgsmaal, som staar aabent. De hidtil fremsatte Iagttagelser herom afgiver intet Bevis for dette Spørgsmaal.

Man plejer, siden Schleidens bekendte Undersøgelse over Kalciumoxalat i Kaktusplanter, at finde disse Undersøgelser omtalt og kommenteret i Arbejder, der vedrører Kalksalte i Planterne. Ved mine Undersøgelser har jeg ogsaa medtaget en Type for denne Familie, men jeg fandt herved Forhold, som nødvendiggør yderligere Undersøgelser, om hvilke jeg ved senere Lejlighed haaber at kunne give Meddelelse.

IV. Sammenstilling af fundne Resultater.

I det foreliggende Arbejde er der tilsiget ved sammenlignende kemisk og mikroskopisk Undersøgelse at tilvejebringe et Materiale, som kunde tjene til Belysning af Forhold vedrørende Planternes Indhold af Kalksalt. Paa Grundlag af mikrokemiske Iagttagelser havde jeg forud dels havt Grund til at antage, at meget som Kalciumoxalat angivet Salt helt eller delvis bestod af andet Kalksalt og dels paavist, at Angivelserne i Litteraturen, efter hvilke forskellige Droger (f. Ex. Blade af *Digitalis* og *Mentha*-Arter) ikke skulde indeholde Kalksalt, maatte være urigtige, idet jeg ved Tilsætning af Svovlsyre fandt, at der dannedes et mere eller mindre rigeligt Antal Gipsnaale. Samtidig ønskede jeg saa vidt mulig at tilvejebringe Forklaring paa de væsentlige Uoverensstemmelser mellem tidligere Arbejdernes Angivelser vedrørende Kalciumoxalatets Opløselighedsforhold over for Reagentier og over for dets Genoptagelse i Stofskiftet, saa vidt dette kunde oplyses gennem den anvendte kemiske og mikroskopiske Undersøgelsesmetode.

Som Undersøgelsesobjekter er anvendt: Blade af *Tussilago Farfarus*, *Mentha piperita*, *Pilocarpus spec.*, *Digitalis purpurea*, *Crataegus monogyna*, *Thea sinensis*, *Hyoscyamus niger*, *Datura Stramonium* og *Begonia argyrostigma*; Griffelgrene af *Crocus sativus*; Bark af *Punica Granatum*, *Rhamnus Frangula* og *Quillaja saponaria*; Rødder og Rodstokke af *Althaea officinalis*, *Exogonium Purga*, *Dahlia* og *Rheum*.

Der er ved Undersøgelsen af disse Droger paavist:

1) En almindelig Forekomst af organiske kalkfældende Syrer; i en Del Tilfælde fandtes Oxalsyre, i andre ikke; i alle Tilfælde paavistes andre organiske Syrer: Citron-, Æble- og Ravsyre. Paafaldende er den ganske almindelige Forekomst af Ravsyre, hvis Tilstedeværelse i Materiale, som det undersøgte, forholdsvis sjældent er paavist. Grunden hertil kan mulig søges i Succinaternes Letopløselighed og den regelmæssige samtidige Forekomst af Æblesyre. Vinsyre er ikke paavist i noget Tilfælde. I omstaaende Tabel er der givet en Oversigt, der viser de enkelte Analyzers Hovedresultater.

2) Syrerne forekommer dels i alkalibunden eller fri Tilstand, dels som Kalcium- (og Magnium-) Salte.

3) Af den sammenlignende mikroskopiske og kemiske Undersøgelses Resultater fremgaar det, at de indeholdte lettere opløselige Kalksalte i de friske Organer forekommer saavel i opløst Tilstand, som udkrystalliseret. Forholdet maa være betinget af Organets eller de kalksaltførende Cellers Vandindhold. Krystalstjernerne er i mangfoldige Tilfælde sammensat af forskelligartet Kalksalt.

4) De mikrokemiske Reaktioner tillader ikke at karakterisere Kalksaltene paa saadan Maade, at Sondringen mellem Saltene er mulig ad denne Vej. Eddikesyrens Betydning som diagnostisk Hjælpemiddel er — som Wehmer allerede har fremhævet — overvurderet. Ved Behandling af Kalksaltene med Kaliumhydroxydopløsning af passende Styrke (5 %), dekomponeres de under Dannelse af Syrerne Kalisalte og Kalciumhydroxyd, som efter Indsugning af Luftens Kulsyre udskilles som Karbonat, der har Form af — oftest — sexsidede Tavler, naar Reaktionen anstilles under Dækglas, af sammenhobede Sfærer (som Kolostrumdanlæser), naar den anstilles i Skaal. Denne Dekomposition er — uden at være tydet — for Kalciumoxalatets Vedkommende først iagttaget af Sanio. Forholdet har bidraget til væsentlige Uoverensstemmelser i Kalksaltenes mikrokemiske Karakteristik. Den af Kohl givne Tydning, saavel som hans Karakteristik af Kalksaltenes Reaktioner er ganske urigtig. Ved Indlægning af Materiale, som indeholder lettere opløselige Kalksalte, i Kloral, foregaar der en Dobbelt-Dekomposition, hvorefter der udskilles Gipsnaale. Med Anvendelse af mikrokemiske Reaktioner kan der kun opnaas et Skøn over Arten af foreliggende Kalksalt, man kan bedst benytte sig af Forholdet over for Klorammoniumopløsning. Den exakte Adskillelse er kun mulig paa Grundlag af den kemiske Analyse.

5) De af en Række Forfattere fremsatte Angivelser, som gaar ud paa mikroskopisk at godtgøre Kalciumoxalatets Genoptagelse i Stofskiftet maa antages at skyldes Iagttagelsesfejl, hidrørende fra Forvexling af Kalciumoxalat med andre Kalksalte. Kraus' Forsøg paa gennem kvantitative Bestemmelser af Kalciumoxalatet før og efter Væxtperiodens Indtræden at bevise dets Genoptagelse i Stofskiftet er ufyldestgørende, idet der maa have foreligget Kalciumoxalat sammen med andre Stoffer, som reducerer Kaliumpermanganat.

6) Om Muligheden af Kalciumoxalatets Opløselighed i den levende Celle foreligger der hidtil intet Bevis. De Iagttagelser, som af forskellige Forfattere er fremsat til Støtte for denne Paastand, gaar ud fra fejlagtige Forudsætninger.

For den Understøttelse, som har været tilstaaet mig af Carlsberg Fondet til Fremme af dette Arbejde, bringer jeg min ærbødige Tak.

Art af undersøgt Materiale	Vand	Aske og i <i>HCl</i> uopløselig Rest af Aske	Total <i>CaO</i>	<i>CaO</i> , som havde været bundet til Oxalsyre	<i>CaO</i> , som havde været bundet til andre kalkfæl- dende Syrer	Paaiste kalkfældende Syrer
	pCt.	pCt.	pCt.	pCt.	pCt.	
Folia Farfari.....	7,13	15,08 1,37	3,01	0,04	2,97	Svovlsyre, Oxalsyre, Citronsyre, Æblesyre, Ravsyre.
Folia Menthae piperitae	8,95	15,40 5,73	3,08	0	3,08	Svovlsyre, Citronsyre, Æblesyre, Ravsyre.
Folia Jaborandi	7,54	9,95 2,27	3,45	0,48	2,97	Svovlsyre, Oxalsyre, Citronsyre, Æblesyre, Ravsyre.
Folia Digitalis	10,90	8,34 0,39	1,13	0	1,13	Svovlsyre, Citronsyre, Æblesyre, Ravsyre.
Folia Crataegi, Juni-Blade	8,27	5,50 0,24	1,95	0,59	1,36	Svovlsyre, Oxalsyre, Citronsyre, Æblesyre, Ravsyre.
Folia Crataegi, Oktober- Blade	8,38	10,47 0,48	5,04	1,54	3,50	Svovlsyre, Oxalsyre, Citronsyre, Æblesyre, Ravsyre.
Folia Theae.....	7,28	8,83 2,75	0,84	0,21	0,63	Svovlsyre, Oxalsyre, Citronsyre, Æblesyre, Ravsyre.
Folia Hyoscyami, første Aars Grundblade	8,33	20,89 2,14	2,19	1,30	0,89	Svovlsyre, Oxalsyre, Citronsyre, Æblesyre, Ravsyre.
Folia Hyoscyami, andet Aars siddende Bladé ..	10,84	14,58 1,08	3,45	2,88	0,57	Svovlsyre, Oxalsyre, Citronsyre, Æblesyre, Ravsyre.
Folia Stramonii	6,15	14,15 1,22	4,03	3,00	1,03	Svovlsyre, Oxalsyre, Citronsyre, Æblesyre, Ravsyre.
Stigmata Croci	9,11	4,84 0,58	0,72	0	0,72	Svovlsyre, Citronsyre, Æblesyre, Ravsyre.
Cortex Granati, Handels- vare, Stammebark....	8,34	17,70 1,63	9,07	5,67	3,40	Svovlsyre, Oxalsyre, Citronsyre Æblesyre, Ravsyre.
Cortex Granati, af unge, indtil 4-aarige Grené ..	6,86	5,53	3,00	1,38	1,62	Svovlsyre, Oxalsyre, Citronsyre, Æblesyre, Ravsyre.
Cortex Frangulae, Han- delsvare	8,07	4,65 0,10	3,17	1,27	1,90	Svovlsyre, Oxalsyre, Citronsyre, Æblesyre, Ravsyre.
Cortex Frangulae, af unge, indtil 6-aarige Grené uden Aarsskudet	7,20	3,64 0,10	1,65	0,57	1,08	Svovlsyre, Oxalsyre, Citronsyre, Æblesyre, Ravsyre.
Radix Althaea	10,33	5,70 0,39	1,07	0,14	0,93	Svovlsyre, Oxalsyre, Citronsyre, Æblesyre, Ravsyre.
Tuber Jalapae	9,05	3,59 0,09	1,39	0,15	1,24	Svovlsyre, Oxalsyre, Citronsyre, Æblesyre, Ravsyre.

Art af undersøgt Materiale	Vand	Aske og i <i>HCl</i> uopløselig Rest af Aske	Total <i>CaO</i>	<i>CaO</i> , som havde været bundet til Oxalsyre	<i>CaO</i> , som havde været bundet til andre kalkfældende Syrer	Paaviste kalkfældende Syrer
	pCt.	pCt.	pCt.	pCt.	pCt.	
Rhizoma Rhei, Kanton . .	9,25	3,67 0,10	0,73	0,39	0,34	Svovlsyre, Oxalsyre, Citronsyre(?), Æblesyre, Ravsyre.
Rhizoma Rhei, Shansi . .	5,73	14,92 0,09	10,45	8,90	1,55	Svovlsyre, Oxalsyre, Æblesyre, Ravsyre.
Tuber Dahliae	76,73	1,52, 0,14 = 6,55, 0,61 i Tørstof	0,41 = 1,75 i Tørstof	0,11 = 0,43 i Tørstof	0,30 = 1,32 i Tørstof	Svovlsyre, Oxalsyre, Æblesyre, Ravsyre.
Cortex Quillajae	7,82	20,08 0,63	15,68	11,80	3,88	Svovlsyre, Oxalsyre, Ci- tronsyre (?), Æblesyre (?), Ravsyre.

Litteraturfortegnelse.

1. a. SCHEELE: Chemische Annalen, 1775, Pag. 19, og
b. FLÜCKIGER: Zur Erinnerung an Scheele, Archiv der Pharmacie, 1886, Pag. 390.
2. LIEBIG: Agrikulturkemi eller Kemien anvendt paa Agerdyrkning og Fysiologi, Aalborg 1846, Pag. 173, 175 og 177. (Anonym Oversætter).
3. SANIO: Ueber die in der Rinde dikot. Holzgewächse vorkommenden krystall. Niederschläge und deren anatom. Verbreitung, Monatsberichte der Berliner Akademie der Wissensch., 1857.
4. HOLZNER: Ueber die physiologische Bedeutung des oxalsauren Kalkes, Flora, 1857.
5. SACHS: Lehrbuch der Botanik, 1870, Pag. 594.
6. EMMERLING: Beiträge zur Kenntnis der chemischen Vorgänge in der Pflanze, Landwirtsch. Versuchsstat., Bd. 30, 1884.
7. DE VRIES: Ueber die Bedeutung der Kalkablagerungen in den Pflanzen, Landw. Jahrbücher, 1881.
8. AÈ: Ueber die physiologische Bedeutung der in den Pflanzen vorkommenden oxalsauren Kalks, Flora, 1869, Pag. 177.
9. A. BEIER: Mittheilungen über das Saftsteigen in den Bäumen zur Frühjahrszeit, Archiv der Pharmacie, 1868.
10. SCHIMPER: Botanische Zeitung, 1888.
11. KOHL: Kalksalze und Kieselsäure in der Pflanze, 1889.
12. HANSEN: Flora, 1890.
13. WEHMER: Das Verhalten des oxalsauren Kalkes in den Blättern von *Symporicarpus*, *Alnus* und *Crataegus*, Bot. Zeit., 1889, Pag. 141.
14. WEHMER: Die Oxalatabscheidung im Verlauf der Sprossentwicklung von *Symporicarpus racemosus*, Bot. Zeit., 1891.
15. G. KRAUS: Ueber das Verhalten des Kalkoxalats beim Wachsen der Organe, Flora, 1897, Pag. 54.
16. AMAR: Ann. sc. nat., Tome XIX, 1904, Pag. 195.
17. BERTHELOT & ANDRÉ: Sur la formation de l'acide oxalique dans la vegetation, Comptes rendus, T. 102.
18. PFEFFER: Untersuchungen über die Proteinkörper und die Bedeutung des Asparagins beim Keimen der Samen, Pringsheims Jahrb. f. wissenschaftl. Bot., Bd. VIII, 1872, Pag. 429.

19. TSCHIRCH: Justs Bot. Jahresbericht, 1887, 15. Jahrg., 1. Abth., Pag. 189, 2. Abth., Pag. 330 og Pag. 558.
(Alle Steder væsentlig samme Ref.).
 20. CZAPEK: Milchsaftsystem der Convolvulaceen, Sitzungsberichte der Wiener Akademie 1894, Pag. 87.
 21. JÖNSSON: Lunds Universitets Aarsskrift, Bd. 88, Afd. 2, 1902.
 22. BILLE GRAM: Om Proteinkornene hos oliegivende Frø. Det kgl. danske Vidensk. Selsk. Skr., 6. Raekke, naturv. og mathem. Afd. IX, 1901, og Landw. Versuchsstat., 1902, Pag. 257.
 23. PFEFFER: Pflanzenphysiologie, 1897, Erster Band.
 24. JOST: Vorlesungen über Pflanzenphysiologie, 1904.
 25. CZAPEK: Biochemie der Pflanzen, 1905, Zweiter Band.
 26. EUG. WARMING og W. JOHANNSEN: Den almindelige Botanik, 1900.
 27. BARFOED: De organiske Stoffers kvalitative Analyse, 1878, Pag. 111.
 28. JOS. MOELLER: Lehrbuch der Pharmacognosie, 1906.
 29. JOS. MOELLER: Leitt. z. mikroskopisch-pharmakogn. Übungen, 1901.
 30. PLANCHON & COLLIN: Les Drogues simples d'origine végétale, 1896.
 31. SOLEREDER: Systematische Anatomie der Dikotyledonen, 1899.
 32. ARTHUR MEYER: Wissenschaftliche Drogenkunde, 1891.
 33. TSCHIRCH & OESTERLE: Anatomischer Atlas der Pharmacognosie und Nahrungsmittelkunde, 1893.
 34. GILG: Lehrbuch der Pharmacognosie, 1905.
 35. FLÜCKIGER: Pharmacognosie des Pflanzenreiches, 1891.
 36. Real-Encyklopädie der gesamten Pharmacie, Zweite Aufl.
 37. OTTO: Haandbog i Pharmakognosien, 1840.
 38. WIGGERS: Handbuch der Pharmacognosie, 1864.
 39. SIIM: Beiträge zur botan. und pharmakognostischen Kenntnis von *Hyoscyamus niger*, Bibliotheca botan., 1901.
 40. MITLACHER: Toxikologisch oder forensisch wichtige Pflanzen und vegetabilische Drogen, 1904.
 41. VOGL: Die wichtigsten vegetabilischen Nahrungs- und Genussmittel, 1899.
 42. MOLISCH: Grundriss einer Histochemie der pflanzlichen Genussmittel, 1891.
 43. RUD. MÜLLER: Ueber die vermeintlichen Oxalatkristalle im Safran, Zeitschr. des allgem. oesterreich. Apotekervereins, 1903, Pag. 823.
 44. HOLMES: Pharmaceutical Journal, 1906, I, Pag. 315.
 45. OTTO BERG: Archiv der Pharmacie, 1859, Pag. 155.
 46. OTTO BERG: Bot. Zeit., 1861, Pag. 140.
 47. WIESNER: Die Rohstoffe des Pflanzenreiches, 1900.
 48. BEHRENS: Anleitung zur mikrochemischen Analyse der wichtigsten organischen Verbindungen, 1895.
 49. BENECKE: Kleine Mitteilungen über Oxalsäurebildung in Pflanzen, Bot. Zeit., 1907.
 50. SCHLEIDEN: Mém. Ac. St. Petersb., VI. Sér. T. IV, 1839.
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FERSKVANDSAALENES (*ANGUILLA*) UDBREDNING I VERDEN

I. DET ATLANTISKE OCEAN OG TILGRÆNSEnde
OMRAADER

EN BIO-GEOGRAFISK STUDIE

AF

JOHS. SCHMIDT

MED 1 KORT

D. KGL. DANSKE VIDENSK. SELSK. SKRIFTER, 7. RÆKKE, NATURVIDENSK. OG MATH. AFD. VIII. 3



KØBENHAVN

BIANCO LUNOS BOGTRYKKERI

1909

I. INDLEDNING.

Ved de Undersøgelser, som jeg i Aarene 1904—1905 udførte med det danske Havundersøgelsesskib „Thor“ i Atlanterhavet udfor Nord- og Vesteuropa for at fastslaa Udbredningen af den alm. Ferskvandsaals Larver og denne Fisks Yngleomraade, kom jeg til det Resultat, at Aalen for at kunne forplante sig kræver visse ydre Beitingelser, saaledes navnlig store Dybder med høje Temperaturer af Vandet (se SCHMIDT, 1906, p. 256). Som jeg i det citerede Arbejde har gjort Rede for, viste denne Betragtning sig at stemme ganske for det undersøgte Havomraade, nemlig den nordøstligste Del af Atlanterhavet og Nordhavet. Men dette Omraade udgør kun en lille Del af det, hvor Ferskvandsaal (*Slægten Anguilla*) forekommer, og den Tanke opstod da ogsaa strax hos mig, at det maatte være af stor Interesse at prøve Gyldigheden af nævnte Betragtning ogsaa for andre Havomraader i Verden og derved eventuelt vinde yderligere Bekræftelse herpaa.

Allerede ved de allerførste forberedende Undersøgelser blev det mig dog klart, at det her drejede sig om et Arbejde, der krævede Aar for at kunne gennemføres, for det første fordi *Anguilla*-Slægtens Systematik befinner sig i den mest komplette Uorden og Forvirring, og for det andet fordi vor Viden om Udbredningsforholdene er meget mangelfuld, hvad der ogsaa gælder om de hydrografiske Forhold, som er af Betydning i denne Sammenhæng. Da Publikationen af det ovenfor nævnte Arbejde ikke kunde opsættes, idet det udgjorde en Del af de for de internationale Havundersøgelser udførte Arbejder, maatte jeg altsaa opgive dér at medtage en Undersøgelse af Ferskvandsaals videre Udbredningsforhold. Men jeg begyndte allerede dengang, for fire Aar siden, at samle paa Materiale i denne Retning og har fortsat hermed i saa stor en Udstrækning, som Tiden har tilladt mig det. Det har herunder været min Tanke, dels at søge at bringe Orden i *Anguilla*-Slægtens Systematik, dels at komme til Forstaaelse af denne Slægts Udbredning over Jorden og de ydre Beitingelser, hvoraf Udbredningen er afhængig. Endnu er denne store Opgave langtfra fuldført, men Bearbejdelsen er dog paa nogle Punkter saa vidt fremskreden, at jeg anser det for rigtigst at forelægge Offentligheden den Del, som allerede er fuldendt.

Af rent praktiske Grunde vil jeg opsætte Offentliggørelsen af den systematiske Undersøgelse til senere og hvad Artsadskillelsen angaaer, her nøjes med at gøre Adskillelse mellem 1) ensfarvede *Anguilla*-Arter som den europæisk-nordafrikanske

Anguilla vulgaris TURT. og den amerikanske *Anguilla chrysypa* RAF. (se om disse SCHMIDT, 1906, p. 239) og 2) brogede eller marmorerede *Anguilla*-Arter som den indiske *Anguilla bengalensis* HAM. BUCH. Denne Adskillelse er fuldstændig tilstrækkelig for den her foreliggende Del af Arbejdet, som kun beskæftiger sig med Udbredningsforholdene, særlig da der i det atlantiske Ocean kun forekommer de to ensfarvede *A. vulgaris* og *A. chrysypa*, hvis indbyrdes Forhold jeg allerede har gjort til Genstand for Omtale (l. c., p. 239 ff.).

I det indiske og pacifiske Omraade forekommer der i Modsætning til det atlantiske baade ensfarvede og brogede *Anguilla*-Arter, og jeg har saaledes undersøgt Hundreder af Exemplarer fra Java, Japan og New Zealand; men om dette skal jeg her indskräんke mig til at udtale, at Resultatet i høj Grad gaar ud paa en Reduktion af Antallet af de opstillede Arter, hvorfaf mange øjensynligt kun er baserede paa Undersøgelsen af et enkelt Exemplar, og ved hvis Beskrivelse og Begrundelse man har maattet gaa ganske ukritisk frem uden at vide noget om den systematiske Værdi af de anvendte Karakterer.

Saalænge som disse Aaleformers Forhold til de forholdsvis vel undersøgte atlantiske Aaleformer (*A. vulgaris* & *chrysypa*) ikke engang i systematisk Henseende er klarlagt, vil det naturligvis være ørkesløst at diskutere deres Biologi udfra vort Kendskab til de sidstes. Hertil kommer ogsaa, at de hydrografiske Forhold i det pacifiske Ocean kun er mangelfuld kendte over store Strækninger. Disse Forhold er Grunden, til at jeg her foreløbig kun beskæftiger mig med Atlanterhavet og de tilgrænsende Farvande.

Hvad det for dette Arbejde for det første gjaldt om, var at oplyse, hvor i Verden Ferskvandsaal findes, og, hvad der her er af ikke mindre Viglighed, hvor de ikke findes. I den Anledning maatte talrige Værker omhandlende de forskellige Egnes Fiskefauna raadspørges, hvad der har været meget tidsrøvende for mig, som ikke var fortrolig med oversøiske Landes ichthyologiske Litteratur, der naturligvis findes spredt i Smaaafhandlinger og Lister i de mest forskellige Tidsskrifter. Men endvidere klæber der den Mangel ved at maatte støtte sig til saadanne Afhandlinger, der ofte kun er baserede paa en Expeditions eller en Samlers korte Besøg i vedkommende Egn, at man ikke faar mindste Underretning om Aalen dér har været en af de almindeligste Fisk, eller om der tværtimod maaske kun en enkelt Gang har været taget et enkelt Exemplar; om dens Faatallighed i Samlingerne skyldes, at den virkelig dér er en sjælden Art eller blot, at man har savnet brugelige Redskaber til Fangst af denne Fisk. Kort sagt, de sædvanlige Samlingslister giver i Reglen slet ingen Forestilling om Mængden af de paa Stedet forekommende Aal eller den Rolle, de dér spiller i Fiskefaunaen, og hvad værre er, man kan af den tilsyneladende Mangel paa Aal efter Listerne ikke altid være sikker paa, at dette svarer til Virkeligheden. Det er derfor kun i saadanne Tilfælde, hvor man i flere forskellige Beretninger finder samme Resultat, at man tør stole paa Mangelen af Aal, eller hvor Beretninger fra andre nærliggende Egne udviser det samme. For i saa høj Grad, som det for Tiden er muligt at komme ud

over de herved foraarsagede Vanskeligheder, har jeg, som man ofte vil se af det følgende, ved brevlig Forespørgsel henvendt mig til saadanne Institutioner eller Personer i de forskellige Egne af Jorden, hvorfra bedre Oplysning end Litteraturen kunde give, var ønskelig, og, som man ogsaa vil se, har jeg ofte modtaget særdeles oplysende og værdifulde Svar. Navnlig er der Grund til at fremhæve den af de danske Konsuler rundt om i Verden ydede Understøttelse; dette vil fremgaa med den største Tydelighed ved Læsningen af det følgende Afsnit. En Meddelelse om der det eller det Sted foregaar et Fiskeri af Aal, er saaledes naturligvis af største Betydning i denne Sammenhæng, i langt højere Grad end Forekomsten af en eller anden efter Beskrivelsen mere eller mindre genkendelig, nyopstillet *Anguilla*-Art i en Liste over paa Stedet, maaske tilfældigt indsamlede Fiskearter. At man herved faar et ganske anderledes fast Holdepunkt for Bedømmelsen af, i hvilken Mængde Aalen forekommer, er saaledes tydeligt nok; men selv en negativ Oplysning, gaaende ud paa, at man ikke paa Stedet fisker Aal eller at Befolkningen ikke kender den eller ikke har Navn paa den, kan saaledes være af stor Vigtskab, og Underretning herom har jeg derfor ogsaa stedse udbedt mig ved mine Forespørgsler. Det er da ved en Kombination af de foreliggende videnskabelige Faunalister og de hos Institutioner eller Personer bosiddende i vedkommende Egne indhentede Oplysninger, at jeg er naaet til efterfølgende Oversigt over Ferskvandsaalens Udbredning, men forøvrigt vil man i de enkelte Tilfælde altid kunne se, hvorfra jeg har mine Oplysninger:

Efter at Raamaterialet til en Beskrivelse af Udbredningen var samlet, var Opgaven at søge at forstaa denne, det vil sige, ved Studiet af de ydre Forhold at paavise, hvorfor Aalene netop findes dér, men mangler dér. Denne Side af Sagen, den interessanteste unægteligt, vil man finde behandlet i det tredje Afsnit.

Jeg skal inden jeg gaar over til at beskrive Aalenes Udbredningsforhold i de forskellige Dele af det Omraade, hvormed vi her vil beskæftige os, bemærke, at der ved denne Lejlighed væsentlig kun vil blive Tale om Forekomsten i de i Nærheden af Kysterne beliggende Egne, altsaa saadanne, til hvilke Aalene har direkte Adgang fra Havet. Der foreligger ganske vist en meget interessant og lærerig Opgave i at undersøge, hvor langt Aalene de forskellige Steder trænger ind i Landet gennem de store i Havet udmundende Ferskvandssystemer, men jeg har, for ikke at gøre Udviklingen altfor lang, valgt at opsætte Behandlingen af denne Side af Sagen til en senere Lejlighed. Jeg skal derfor her indskrænke mig til om dette Forhold at bemærke, at intet er bedre skikket til øjeblikkelig at illustrere, at Ferskvandsaalene yngler i og stammer fra Havet end en Fremstilling paa et Verdenskaart af, hvor langt de forekommer ind i det ferske Vand; man ser øjeblikkelig heraf, hvorledes de aftager i Mængde, jo længere man fjærner sig fra Havet, indtil de tilsidst ganske hører op. Et fortræffeligt Exempel herpaa yder Nordamerika, hvor Aale-Tæthedens i de forskellige Stater er meget ulige stor, hvad jeg har forsøgt i store Træk at fremstille paa Side 128 i nærværende Arbejde.

II. BESKRIVELSE AF FERSKVANDSAALENES UDBREDNING.

A. Vestlige Del af Omraadet.

Grønland.

Ifølge FABRICIUS (1780, p. 137) forekommer der, omend sjældent, Aal i de sydlige Strømme og Sører i Grønland. Denne Angivelse er for nylig blevet bekræftet, idet Zool. Museum i Kjøbenhavn har erhvervet et blankt Exemplar af den grønlandske Aal. Om dette har cand. mag. Ad. JENSEN, Zool. Museum, Kjøbenhavn, godhedsfuldt meddelt mig følgende:

"Aalen nedsendtes i Efteraaret 1903 af Kolonibestyrer Brummerstedt. Den var samme Aar stanget med et Pilejern paa Stage af Eskimoen Elisa, i en Fjordarm ved Bopladsen Igdlukasik, omtr. 4 danske Mil S. f. Nanortalik ved den sydlige Del af Grønlands Vestkyst. Den maalte 603 mm.; Afstanden fra Snudespidsen til Rygfinnen 195 mm.; Afstanden mellem Forenden af Analfinnen og do af Dorsalfinnen 61 mm. Hovedets Længde 69 mm. Af Totallængden udgør følgelig det første Maal 32,5 %, det andet 10,1 % og herefter at dømme tilhører den altsaa ikke den europæiske *A. vulgaris* Turt., men den amerikanske *A. chrysypa* Raf. (Jfr. JORDAN og EVERMANN, 1896 a, p. 349), hvad man iøvrigt ogsaa efter disses Udbredning var berettiget til at vente".

Dette interessante Fund bekræfter altsaa FABRICIUS' længe ubekræftede Angivelse om at der lever enkelte Aal i den sydlige Del af Grønlands Vestkyst; men at det kun drejer sig om ganske faa Exemplarer er ligesaa sikkert.

Ved den nordlige Del af Vestkysten og ved Østkysten findes den ikke (Ad. JENSEN, 1904), hvad man selvfølgelig heller ikke kunde vente sig i Betragtning af de yderst ugunstige Forhold, der hersker baade for Tilførselen af Yngel og for dens Trivsel i disse arktiske, isbelagte Egne.

Det samme gælder utvivlsomt ogsaa for den nordligste Del af det amerikanske Kontinent (Davis-Strædets vestlige Kyster), hvor Naturforholdene vel er om muligt endnu ugunstigere for Aalens Forekomst; men nogen sikker Underretning har jeg ikke, førend vi kommer saa langt sydpaa som til Labrador og Newfoundland.

Labrador; Newfoundland.

Paa Forespørgsel meddeler den danske Konsul i St. Johns', Newfoundland, Mr. JOHN BROWNING i Brev af 30. April 1908 følgende Underretning, der skyldes "the Deputy Minister of the Department of Marine and Fisheries", W. B. PAYN:

"Fresh water eels are found in mostly all our lakes and rivers, but not in great numbers. They are also found on Labrador. There is no eel fishery of any importance in this country. They are only caught now and again by trouters except on the West Coast where they are caught with traps".

Hertil føjer Mr. BROWNING følgende Bemærkninger:

"I have made several inquiries but cannot obtain further information than is contained in reply from Marine and Fisheries Department excepting that the eels are not of a large run; an occasional large one is caught".

Om Maengden af de i Newfoundland fangede Aal kan intet oplyses.

Ifølge "Annual Report of the Department of Marine and Fisheries, Newfoundland for the year 1906", St. Johns' 1907, p. 33 udførtes der i Aaret 1906 fra Kolonien 53 Tønder Aal til en samlet Værdi af 465 Dollars.

Heraf kan vi altsaa drage den Slutning, at Aalen forekommer i Labrador og at den i Newfoundland maa være en almindelig forekommende Fisk, eftersom den paa Vestkysten er Genstand for et Fiskeri med Ruser, og eftersom der finder en, omend beskeden, Export af den Sted.

Canada.

Gennem Danmarks Fiskeriagent i London, Capt. A. SØLLING har jeg modtaget følgende Oplysninger fra Professor E. E. PRINCE, "Commissioner of Fisheries for Canada" (i Brev af 20. Feb. 1906):

"Only one species is recognized in this country; it is called *Anguilla chrysypa*, Raf., sometimes *Anguilla rostrata*. It occurs in most rivers from Prince Edward Island, Cape Breton and Nova Scotia on the east to Lake Ontario and adjacent lakes on the west, an area of over 300000 square miles. Some of the places where eels are obtained in very considerable quantities are: the rivers of Prince Edward Island especially Cardigan, Morell and Durk Rivers, also Cape Breton especially the Grand River and Mira River. In New Brunswick the chief eel rivers are the St. John — and the Nepisiguit —, in Quebec the Three Rivers and the Richelieu River. From all these nine rivers and twenty or thirty more rivers frozen eels are shipped to New York and London.

The elvers ascend from the sea in July and August. Unfortunately there is no literature on the eels in Canada. They are not eaten generally here as we have such quantities of salmon, trout, *Coregonus* or whitefish and the finer qualities of seafish; hence eels are despised by our people generally".

Gennem den danske Generalkonsul i Montreal, Mr. H. H. WOLFF har jeg modtaget følgende interessante Oplysninger meddelte af "Office of the Minister of Marine and Fisheries of Canada" og undertegnede L. P. BRODEUR:

"I may say that eels are more or less plentiful from the Maritime Provinces, even as far west as Lake Ontario. The following is a statement of the quantities and value of eels caught in the different Provinces in which they are taken, during 1904:

	Lbs.	Value (\$)
Prince Edward Island	270,000	13,500
Nova Scotia	554,000	27,720
New Brunswick	649,200	32,460
Quebec	897,800	53,534
Ontario	45,500	2,730

In the Province of Quebec, eels are caught all along the St. Lawrence River from Lake St. Francis to the Gulf, as well as in all the main tributaries, and notably in the Richelieu River, from which eighty to ninety thousand pounds are annually taken.

In the southwestern portion of Quebec eels are caught towards the end of June, after the high water has receded, when they start to descend to the Gulf, and their capture continues throughout the summer and even late into the fall in the eastern portion of the Province".

De nævnte Beretninger godtgør tilfulde, at meget store Mængder Aal forekommer i Canadas atlantiske Provinser, og af de i de forskellige Provinser indfangede Mængder Aal faar man et ganske bestemt Indtryk af, at Aalen i Mængde aftager, naar man fra de i mest Berøring med Havet liggende Dele som Nova Scotia, Prince Edward Island og New Brunswick, bevæger sig i vestlig Retning til Quebec og Ontario.

(Smlgn. saaledes de i New Brunswick fangede c. 650,000 lbs. med de i den mangfoldige Gange større, men vestligere eller fjernere fra Havet beliggende Provins Quebec fangede c. 900,000 lbs., eller hvad der er endnu mere iøjnefaldende, Prince Edward Island (270,000 lbs.) med den store Provins Ontario (45,000 lbs.), som ligger længst fra Atlanterhavet af de af Dominion of Canada's Provinser, hvor Aal overhovedet forekommer).

Med Hensyn til Arten af de i Canada forekommende Aal kan jeg henvise til mit tidligere Arbejde (SCHMIDT, 1906, p. 240), hvor henimod 100 store Aal fra St. Lawrence Floden er nærmere undersøgt og fundet at afvige betydeligt fra den europæiske Ferskvandsaal ved forskellige anatomiske og morfologiske Forhold, saaledes navnlig Hvirveltallet, der hos de undersøgte Exemplarer overalt var lavere end hos de europæiske Aal.

Forenede Stater.

JORDAN & EVERMANN (1896, p. 269) omtaler Aalens (*Anguilla chrysypa* Raf.) Forekomst:

"Atlantic Coast of the U. S.; very abundant from Maine to Mexico, ascending all rivers S. of Canada and E. of the Rocky Mountains and resident throughout the Mississippi Valley".

Foruden denne summariske Angivelse af JORDAN og EVERMANN af Aalens Udbredning vil man finde dens Forekomst omtalt i adskillige af de lokale Fiske-Faunaer, paa hvilke den nordamerikanske Litteratur er saa rig. Noget Indtryk af den forskellige Hyppighed („Tæthed“), hvormed den forekommer i de forskellige Dele af dette mægtige Omraade, faar man dog ikke gennem disse. Da det ikke desto mindre i denne Sammenhæng var af stor Interesse at vide noget herom, har jeg gennem Fiskeristatistikken søgt at tilvejebringe et brugeligt Grundlag i saa Henseende.

Materialet har jeg gennem den danske Generalkonsul i New York, Hr. J. CLAN, modtaget fra "the Commissioner of Fisheries" i Washington, Mr. GEO. M. BOWERS, i Form af en Fortegnelse over "yield of eels (*Anguilla chrysypa*) in the United States", hvori Udbyttet for de enkelte Stater var angivet. Indholdet af denne Fortegnelse er gengivet i Tabellen paa næste Side.

For den biologiske Betragtning, vi her vil gøre gældende, kan vi inddøle de Forenede Stater i tre Omraader, nemlig:

- 1) Øst-Omraadet eller de Stater, hvis Floder løber ud i Atlanterhavet nord for Florida¹, altsaa i Hovedsagen Omraadet øst for Alleghany Bjergene.
- 2) Central- eller Golf-Omraadet, d. v. s. det (vest for Florida beliggende) Omraade, hvis Floder løber ud i den mexikanske Golf, og som mod Vest begraen ses af Montana—Wyoming—Colorado—New Mexico².
- 3) Vest-Omraadet, d. v. s. det Omraade, der har Afløb til det pacifiske Ocean, og som er beliggende vest for Montana—Wyoming—Colorado—New Mexico², altsaa i Hovedsagen det vest for Rocky Mountains etc. beliggende Omraade.

Af denne Inddeling følger, at de Aal, der findes i Øst-Omraadet maa være trængte op gennem Floder, der løber ud i det atlantiske Ocean øst for Florida, medens Central-Omraadets Aalebestand maa komme fra den mexikanske Golf (vest for Florida).

Inden jeg anfører Resultaterne af Sammenstillingen, skal jeg udtrykkelig fremhæve, at denne Fremgangsmaade selvfølgelig ikke kan give os et nøjagtigt Billede af Aale-Tæthedens i de forskellige Stater. Der er jo ingen Tvivl om, at de i de forskellige Stater forhaandenværende Aalebestande ikke overalt efterstræbes med samme Iver eller med lige højt udviklet Fangst-Teknik, og tænkes kan det jo ogsaa, at de Angivelser af Udbyttet, der ligger til Grund for Statistiken, ikke overalt sker paa samme Maade³.

Der klæber saaledes store Mangler ved denne Metode. Naar jeg tiltrods for disse alligevel mener, at der kan drages vigtige Slutninger af Sammenstillingen, er det fordi Resultaterne er saa overordentlig tydelige og slaaende, at der ikke kan være nogen Tvivl, om at de i store Træk giver et rigtigt Billede af de faktiske Forhold.

¹ Naar Florida er valgt som Grænsen mellem de to første Omraader, saa at den ikke er regnet med til nogen af dem, er det dels fordi denne Stat ved sin Form danner en naturlig Adskillelse mellem de to Have, (Atlanterhavet og den mexikanske Golf) hvorfra Aaleyngel kan stige op i de ferske Vande og befolke disse, dels fordi Statistiken ikke omtaler noget Aalefiskeri i Florida, skønt der ikke kan være nogen Tvivl om, at ikke faa Aal maa findes her, eftersom der fiskes af denne Fisk i begge de omgivende Stater.

² Som adskillende mellem Central- og Vest-Omraadet regnes Montana—Wyoming—Colorado—New Mexico ikke med til noget af dem.

³ Saaledes er jeg tilbejelig til at tro, at der maa leve forholdsvis flere Aal i saadanne Stater som f. Ex. Louisiana og Mississippi, end det synes at fremgaa af Statistiken.

Tabel visende Udbytte af Aalefiskeriene (*Anguilla chrysypa*)
i de Forenede Stater, i Pund (lbs.)¹.

I. Øst-Omraadet		II. Central-Omraadet		III. Vest-Omraadet	
	lbs.		lbs.		lbs.
Maine	255,150	Alabama	1,045	Washington	0
N. Hampshire	800	Mississippi	3,930	Idaho	0
Vermont	4,100	Louisiana	1,670	Oregon	0
Massachusetts	541,945	Texas	484	California	0
Rhode Island	290,195	W. Virginia	100	Nevada	0
Connecticut	178,197	Tennessee	8,787	Utah	0
New York	807,157	Arkansas	5,240	Arizona	0
Pennsylvania	60,650	Kentucky	150		
N. Jersey	407,609	Indian Territory	?		
Delaware	268,255	Oklahoma	?		
Maryland	326,465	Kansas	600		
Virginia	86,350	Missouri	6,555		
N. Carolina	507,111	Illinois	20,813		
S. Carolina	?	Indiana	1,550		
Georgia	5,300	Ohio	618		
Michigan ²	1,211	Wisconsin	2,487		
		Iowa	21,978		
		Minnesota	5,632		
		Nebraska	300		
		S. Dakota }	ubetydeligt		
		N. Dakota }			
Ialt...	3740,395	Ialt...	81,939	Ialt...	0
eller 97,90 %		eller 2,10 %		eller 0 %	

Af det samlede Udbytte af Staternes Aalefiskeri, nemlig 3822,434 lbs. fiskedes altsaa 3740,395 lbs. i Østomraadet, 81,939 i Central-Omraadet, og slet intet i Vest-Omraadet. Udtrykt i % falder saaledes 97,90 % paa Øst-Omraadet og kun 2,10 % paa Central-Omraadet, skønt dette sidste har et Areal, der er mellem 3 og 4 Gange saa stort som Øst-Omraadets, og skønt det for en stor Del bestaar af flodrigt Lavland, der er meget velegnet til Aalens Trivsel.

Der kan efter dette ingen Tvivl være om at der stiger overordentlig mange flere Aal op fra Atlanterhavet end fra den mexikanske Golf, men paa den anden Side er det overraskende at se, hvor højt op Aalene formaar at trænge i Floder som Mississippi og Bifloder. Det vil i denne Sammenhæng have sin Interesse at se lidt

¹ "The above figures are compiled from statistics of the New England States for 1905, Middle Atlantic States for 1904, South Atlantic States for 1902, Great Lakes and Mississippi River and tributaries for 1903, Gulf States for 1899, and the interior waters of Texas for 1900, and those of New York and Vermont for 1902". (Bemærkning til den fra the Commissioner of Fisheries, Washington modtagne Liste).

² Michigan regnes her med til Øst-Omraadet, da de her fangede Aal stammer fra de Store Sører, som har Forbindelse med Atlanterhavet (se Tabellen paa næste Side og S. 130).

nærmere paa Udbyttet af Aalefiskerierne i saadanne fjærnt fra Havet beliggende Stater. Jeg gengiver i den Anledning efter den amerikanske Statistik (U. S., 1902, p. 667) Udbyttet af Aalefiskerierne i 1899 i Mississippi-Floden og Bifloder.

Tabel visende Udbyttet af Åalefiskerierne i Mississippi-Floden
og Bifloder i Aaret 1899 (U. S., 1902, p. 667).

Stater	Aal, lbs.	Stater	Aal, lbs.
Alabama.....	8,040	Mississippi	3,930
Arkansas	3,702	Missouri	7,811
Illinois	29,263	Nebraska	300
Indiana	5,078	Ohio	618
Iowa	10,943	South Dakota	"
Kansas	1,070	Tennessee.....	14,180
Kentucky	3,900	West Virginia.....	755
Louisiana.....	1,670	Wisconsin	1,745
Minnesota	900		
		Ialt...	93,905

Vi ser heraf, at naar der i en Stat som for Exempel Wisconsin fiskes Aal i de ferske Vande, der staar i Forbindelse med Mississippi, som jo strømmer ud i den mexikanske Golf, saa følger det deraf, at disse Aal maa være traengt ikke mindre end over 1000 miles op i Landet, regnet fra Mississipis Munding. Det er saaledes kolossale Vejlængder, Aalen kan tilbagelægge, og altsaa ogsaa efter at den er kommen ind i det ferske Vand.

Der er nu det interessante Forhold, at i flere af de ovenanførte Stater, som yder Bidrag til Aalefiskeriet i Mississippi-Omraadet, finder der, ifølge den amerikanske Statistik, ogsaa et Fiskeri Sted af Aal, som maa have en anden Oprindelse end de, der i samme Stat fiskedes i Mississippi-Omraadet. Dette Fiskeri foregaar i de Store Søer, hvor Aalene maa være komne ind gennem St. Lawrence-Floden fra det atlantiske Ocean. Det vil have sin Interesse efter den officielle Statistik først at give en Oversigt over Udbyttet af de Aalefiskerier, der finder Sted i de Store Søer fra de Forenede Staters Side (U. S., 1905, p. 580):

Tabel visende Udbyttet af Aalefiskerierne i de Store Søer i 1899.

Sø	Aal, lbs.	Sø	Aal, lbs.
Ontario.....	123,840	Michigan	484
Erie.....	849	Superior.....	"
Huron.....	861		
		Ialt...	125,590

Vi ser af denne Sammenstilling, at Udbyttet af Aalefiskeriet i Ontario Søen langt overgaard de andre Søers Udbytte. Et Blik paa Landkortet giver os imidlertid Forklaringen paa dette Forhold. Ontario Søen er nærmest Havet, hvorfra Aalene kommer, og for at komme ind i de andre Søer herfra maa de passere Niagara. Den Vanskelighed, der herved møder den fremtrængende Aaleyngel, maa rimeligvis være Hovedaarsagen til den paafaldende store Forskel mellem Ontarios og de øvrige Søers Udbytte, idet de fleste Aal maa antages at blive standsede i Ontario Søen uden at naa videre frem til de øvrige Søer.

Fordelt efter Staterne tager de Store Søers Aalefiskeri i 1899 sig saaledes ud (U. S., 1902):

Stater	Ontario-Søen	Erie-Søen	Michigan-Søen	Huron-Søen
	lbs.	lbs.	lbs.	lbs.
New-York	123,840	200	"	"
Pennsylvania	"	"	"	"
Ohio	"	99	"	"
Michigan	"	550	100	861
Illinois	"	"	300	"
Indiana	"	"	84	"
Wisconsin	"	"	"	"
Ialt	123,840	849	484	861

Jeg skal herefter efter den officielle Statistik (U. S., 1902) anføre Udbytet af Aalefiskerierne i de Stater, der omgiver de Store Søer, saaledes at der for hver Stats Vedkommende gøres Adskillelse mellem den Del af Udbytet, der stammer fra de Store Søer, og den Del, der har sin Oprindelse fra Mississipis Flodomraade. Udbytet er angivet i lbs.

Tabel visende for de til de Store Søer grænsende Stater Udbyttet af Aalefiskerierne henholdsvis i Mississipi-Omraadet og i de Store Søer, i 1899.

	New York	Michigan	Ohio	Indiana	Illinois	Wisconsin	Minnesota
Mississipi-Omraadet	"	"	618	5,078	29,263	1,745	900
Store Søers Omraade	124,040	1,511	99	84	300	"	"

Tabellen viser, at i Staterne Ohio, Indiana, Illinois, Wisconsin og Minnesota stammer den største Del af de dér fiskede Aal fra det Flodsystem, der har sit Udløb i den mexikanske Golf, medens langt færre af dem er komne ind gennem St. Lawrence Floden. Tager man nu i Betragtning, at der i den sidstnævnte Flods Omraade fiskes store Mængder Aal (baade i de Forenede Stater og i Canada), saavel nedenfor Ontario Søen som i selve denne Sø, med andre Ord ikke langt fra de anførte 5 Stater, saa synes der i det, at disse Stater ikke desto mindre fisker deres fleste Aal i Mississipi-Omraadet, at ligge en ny Tilkendegivelse af, at det kun kan være forholdsvis meget faa Aal, som fra Ontario Søen slipper ind i de andre Store Søer.

Vort Hovedresultat med Hensyn til Aaletæthedens i De Forenede Stater er da, at medens denne Fisk mangler i det vestlige Omraade, findes den baade i det østlige og det centrale Omraade. Her er den dog meget ulige fordelt, idet der i det første, som er 3—4 Gange mindre end det sidste, ikke desto mindre findes mange Gange flere Aal (i Øst-Omraadet **97,90 %**, i Central-Omraadet kun **2,10 %** af det samlede Udbytte af Fiskeriet).

Efter saa godt som det lod sig gøre for mig at have forsøgt at karakterisere Aalens Udbredning og Hyppighed i de forskellige Dele af de Forenede Stater, skal jeg, inden jeg forlader dette Rige, anføre nogle Hvirveltællinger, jeg har foretaget paa Aale-Yngel fra to forskellige Steder af Atlanterhavskysten. Materialet skylder jeg velvillig Imødekommnenhed af "United States National Museum", Washington, D. C.

Smaa-Aal fra Wilmington, N. Carolina (talte af JOHS. SCHMIDT).

Stærkt pigmenterede, meget tynde, rimeligvis ved den omtrentlige Minimallængde i Stad. VI.

1)	Længde	45 ^{1/2} mm	Vert.	43 + 65 = 108
2)	—	48	- (krum)	43 + 64 = 107
3)	—	c. 48	-	42 + 67 = 109
4)	—	c. 52	-	43 + 66 = 109
5)	—	c. 53	-	43 + 66 = 109

Smaa-Aal fra Woods Hole, Mass., 1 Marts 1872 (talte af JOHS. SCHMIDT).

Fra U. S. Nat. Mus. 13592.

	1) Længde	c. 55 mm	Vert.	43 + 65 = 108	Antal Hvirvler	Antal Explr.
2)	—	c. 57	-	43 + 66 = 109	112	○
3)	—	c. 53	-	43 + 65 = 108	111	
4)	—	c. 54	-	42 + 64 = 106	110	○ ○ ○
5)	—	c. 52	-	43 + 66 = 109	109	○ ○ ○ ○ ○ ○
6)	—	c. 52	-	43 + 64 = 107	108	○ ○ ○ ○ ○ ○ ○
7)	—	c. 58	-	43 + 67 = 110	107	○ ○
8)	—	c. 58	-	43 + 64 = 107	106	○
9)	—	c. 52	-	43 + 65 = 108	105	
10)	—	c. 57	-	43 + 67 = 110		
11)	—	c. 60	-	45 + 67 = 112		
12)	—	c. 59	-	42 + 66 = 108		
13)	—	c. 55	-	43 + 66 = 109		
14)	—	c. 55	-	44 + 66 = 110		
15)	—	?	-	43 + 65 = 108		
16)	—	c. 63	-	44 + 65 = 109		
17)	—	c. 57	-	43 + 66 = 109		
18)	—	c. 60	-	44 + x { Glasaaal med flere sammenvoxede Vert.		
19)	—	c. 63	-	43 + 65 = 108		
20)	—	c. 70	-	43 + 66 = 109		
Ældre Aaleunger:						
	...					
	...					
	...					

Disse Aale-Unger, hvis Maal er anført i "Contrib. to the Life-History of the Eel" p. 244. Anm. (Maalene dér er bedre end de her anførte paa Xylol-Explr. tagne) er lidet pigmenterede, i 5te Stadium ("Glasaal"), undtagen de paa 70 eller derover, som er meget tykkere og et Aar ældre. Glasaalene her synes da at have en Længde af omkring 5—6 Cm.

Mexico.

Den danske Konsul i Mexico, Herr H. L. WIECHERS, meddeler paa Forespørgsel følgende i Brev af 2den Juni 1908:

"I nogle af de til Golfen tributære Floder fanges lejlighedsvis smaa (indtil fodlange) Aal; man antager i Alm., at disse er unge Aal, som fra Havet vandrer op i Floderne og — efterat de har opnaaet en vis Størrelse eller Udvikling — igen vandrer tilbage til Havet. Disse Dyr findes stadig i større Mængde sammen i Floderne".

MEEK (1904, p. 91) omtaler i sit Værk om Mexicos Fiske Forholdet og siger, at den amerikanske Aal (*A. chrysypa*) er almindelig i Mexicos Floder nord for Tampico.

REGAN (1905) giver en Liste over Fisk fra det sydlige Mexico; men Aalen mangler i denne. Desuden meddeler Mr. C. TATE REGAN fra British Museum mig i et Brev af 13de April 1908:

"On the continent of America *Anguilla* does not appear to extend further south than Tamaulipas, but in the islands it ranges southwards to St. Croix, St. Vincent, Dominica, Grenada etc. There are specimens from these islands — — —".

I sit bekendte Værk om "the apodal fish" omtaler KAUP (1850, p. 44) et Exemplar af *Anguilla* fra Vera Cruz i Mexico, det sydligste Sted i dette Land, hvorfra sikker Underretning om denne Slægts Forekomst haves.

Vort Hovedresultat bliver da, at Aalen forekommer i Mængde i den nordligere Del af Mexico, men at den aftager i Mængde sydefter, saa at den synes at mangle eller i hvert Fald at være sjælden i den sydligste Del. Dette stemmer tilsyneladende godt med Forholdet i de tilgrænsende Lande: de Forenede Stater og de centralamerikanske Republikker.

Central-amerikanske Smaastater.

GÜNTHER (1869, p. 377—494) giver i sin "Account of the Fishes of the States of Central America etc." en Liste over de Arter, der kendes fra Centralamerika. Grænsen for Omraadet angives ved følgende: N. Grænse: "Political boundary of Guatemala", S. Grænse: "Isthmus of Darien". Det fremhæves, at Halvøen Yucatan er saa at sige ukendt i ichthyologisk Henseende. GÜNTHER's Liste indeholder 303 Arter, men ingen *Anguilla*¹.

Paa Forespørgsel meddeler Mr. H. B. WALCOTT, "Acting Colonial Secretary" for Kolonien British Honduras mig i Brev dateret Belize 9de Juni 1908:

¹ Af Fisk, der gaar under Navn "Aal", anføres kun *Symbranchus marmoratus* fra den atlantiske og *S. immaculatus* fra den pacifiske Del af Guatemala.

"In reply to your letter asking whether the common fresh water Eel occurs in the waters of this Colony, I have the honour to inform you that I have made enquiries and find that it does not appear to do so".

I denne Sammenhæng skal jeg ogsaa gentage den bedste Kender af Centralamerikas Fiske, C. TATE REGAN's Udtalelse (jfr. forrige Side):

"On the Continent of America *Anguilla* does not appear to extend further south than Tamaulipas (Mexico)".

Alle de foreliggende Beretninger gaar da ud paa, Aalen mangler i de centralamerikanske Vande. Da disse delvis er daalrligt undersøgte, kan man vel ikke være vis paa, at ikke ganske enkelte Exemplarer vilde kunne anträffes, men det synes dog i hvert Fald sikkert, at den i det højeste kun kan være sjælden.

Heller ikke i EVERMANN & GOLDSBOROUGH's (1902, p. 137—59) Lister paa 56 Arter fra Centralamerika forekommer *Anguilla*, (men *Symbranchus marmoratus*).

Vestindien.

Aal kendes fra mange Steder i det vestindiske Archipelag; det er i denne Sammenhæng ikke nødvendigt at nævne dem alle, og jeg skal derfor indskräenke mig til nogle Exempler.

Dansk Vestindien. Jeg har haft Lejlighed til at undersøge endel Montée taget paa St. Croix i en lille Bæk ved "Envy" 14de Februar 1906 af Dr. Th. MORTENSEN, der velvilligst har stillet dem til min Disposition. De er dels i det 6te Stadium (SCHMIDT, 1906, p. 169), dels endnu videre fremme i Udvikling, og de maaler i Millimeter 49, 49, 51 $\frac{1}{2}$, 57, 57, 73. Efter at have klaret dem i Xylol talte jeg Hvirvler paa dem og fandt følgende Tal: 108, 107, 106, 109, 107, 111. De viste sig, efter hvad jeg tidligere har oplyst, altsaa at tilhøre den amerikanske Aal (*Anguilla chrysypa*). Iovrigt skal jeg for at give et Begreb om Mængden af her forekommende Aal anføre følgende Udtalelser af Dr. Th. MORTENSEN, der dengang befandt sig paa en Undersøgelsesrejse i Dansk Vestindien:

"Her er Aal, men meget faa; de tælles enkeltvis. Kun eet Sted, Salt River, St. Croix, synes der at være noget videre af Aal, og en derværende Fisker mente at kunne samle en 100 Stk. i Løbet af ca. 14 Dage".

POEY (1876, p. 192) angiver Aalen at forekomme paa **Cuba**. Han henfører de cubanske Aal til den gamle KAUP'ske Art *A. (Muraena) cubana* med den Motivering, at KAUP's Exemplarer var fra Cuba. Foruden sin *A. cubana* har POEY en *Anguilla sp.*; men han oplyser intetsomhelst om den Mængde, hvori Aalen findes paa Cuba.

Heller ikke af EIGENMANN siges noget om Hyppigheden af Aalen paa Cuba. Han indskräenker sig til i sit Værk om Cubas Ferskvandsfiske (1904, p. 222) at anføre, at *Anguilla chrysypa* er taget ved San Juan og ved Paso Real.

Om Forekomsten paa **Portorico** berettes af EVERMANN & MARSH (1900, p. 68) blandt andet følgende:

"It (i. e. *Anguilla chrysypa*) is caught in considerable numbers in Portorico in the small bamboo traps or "nasas" set in the small rivers".

Om **Jamaica** meddeler Mr. W. FAWCETT, fhv. Direktør for den botaniske Have i Kingston mig følgende i Brev af 2den November 1908:

"There are fresh water eels in Jamaica, which Dr. BOULENGER of the British Museum (Natural History) assures me are *Anguilla chrysypa*. Eels are caught and eaten, but the fishing is not of much importance. They are locally called eels".

Mr. C. TATE REGAN fra British Museum, London meddeler mig i Brev af 13de April 1908 følgende:

"On the continent of America *Anguilla* does not appear to extend further south than Tamaulipas, but in the islands it ranges southwards to **St. Croix**, **St. Vincent**, **Dominica**, **Grenada**, etc. There are specimens from these islands in our collection, but none from Trinidad from which island we have a fine series of fresh-water fishes".

Om Forholdet paa den mellem Cuba og Florida beliggende Ø **Key West** betræffer JORDAN (1884, p. 111) følgende:

"A single extremely young eel was taken in a seine in Enteromorpha. The species seems to be entirely unknown to the Key West Fishermen; nor did I find any one who had ever heard the word eel".

Columbia.

STEINDACHNER har givet adskillige vigtige Bidrag til Columbias Ferskvandsfiske, saaledes (1878, p. 76) og (1880, p. 90). I sidstnævnte Arbejde findes en "Uebersicht der bisher aus dem Stromgebiete des Magdalena-Stromes bekannten Fische", og der opføres i denne 70 Arter (deriblandt *Symbranchus marmoratus*), men ingen *Anguilla* eller anden Murænoid.

Venezuela.

I sine talrige "Beiträge zur Kenntniss der Flussfische Südamerikas", saaledes i (1879, p. 151—71) omtaler STEINDACHNER Ferskvandsfiske fra Orinoco-Floden. *Anguilla* mangler overalt. Det samme gælder om PETERS's Liste over venezuelanske Fiske (1879, p. 469), hvor der opføres 43 Arter og mellem disse *Symbranchus marmoratus* ("calabozo") og *Gymnotus electricus* ("temblador").

Britisk Guiana.

T. SIDNEY HARGREAVES siger i sin Bog "The Fishes of British Guiana", p. 13, Demerara 1904:

"There is a species of Conger Eel (*Leptocephalus conger*), and one or two species of true Eel to be met with: but these are never to be seen in the market as the creoles object to eat them, probably on account of their snakelike appearance, although throughout the West Indies the common Eel is highly valued as a food fish".

Nærmere Underretning fra Forfatteren om de her omtalte Aal har jeg modtaget gennem et Brev fra "the Director of Science and Agriculture Department, British Guiana", Mr. J. B. HARRISON, dateret Georgetown 27. Marts 1908, idet Mr. HARGREAVES meddeler at:

"there are two species of *Anguilla* found in fresh water trenches. These are *Anguilla chrysypa* and *Anguilla sp.*".

Hollandsk Guiana.

PALACKY (1891, p. 216) refererer en mig ubekendt Afhandling af KEPPLER (KAPPLER?) om Ferskvandsfiskene i Surinam, af hvilke han angiver ikke mindre end 70 Arter. Blandt disse nævnes foruden *Sybranchus marmoratus* og *Gymnotus electricus* ogsaa to Aal. Dr. J. BOEKE i Leiden, der som bekendt har foretaget omfattende Undersøgelser over Fiskeriforholdene paa den hollandsk-vestindiske Ø Curaçao, meddeler mig i Brev godhedsfuldt følgende:

"As far as I could gather when I was in Surinam, the fresh water eels are rather common there, but I have not seen them myself (I stayed there only a few days)".

Fransk Guiana.

I sin "Contribution à l'étude de la faune ichthyologique de la Guyane française et du contesté franco-brésilien" (1900, p. 123—136) opfører VAILLANT en Liste paa 40 Arter Ferskvandsfisk fra Guianas Floder og Sører. I denne Liste mangler *Anguilla* ganske.

Brasilien.

E. A. GOELDI (1898, p. 443—488) giver i sin "Primeira contribuição para o conhecimento dos Peixes do valle do Amazonas e das Guyanas" en meget udførlig Liste over de i Amazonfloden forekommende Fiske. Den indeholder 114 Arter, deriblandt *Sybranchus marmoratus*, men *Anguilla* mangler ganske.

EIGENMANN (1907, p. 659—667) giver i sin Afhandling om Amazonflodens Fiske en Liste paa ca. 46 Arter. Listen omhandler den Del af Amazonfloden, som ligger mellem Para' og Manaos. *Anguilla* mangler ganske.

Paa Forespørgsel meddeler Chefen for den zoologiske Sektion af "Museu Goeldi" i Para' i det nordlige Brasilien, Dr. E. SNETHLAGE i Brev af 6te Maj 1908:

"Es ist mir ueber das Vorkommen von *Anguilla* in brasilianischen Gewaessern, speciell im Staate Para', nie etwas zu Ohren gekommen. Wir haben in unserer ziemlich umfangsreichen Sammlung wohl Meeraale (*Muraena*); aber der Suesswasseraal scheint absolut zu fehlen".

I sin paa omfattende danske Indsamlinger baserede Afhandling "Velhas Flodens Fiske" giver LÜTKEN (1875, p. 123—252) en Liste paa 55 Arter, hvorimellem *Anguilla* ikke findes. Velhas Floden er en Biflod til Rio S. Francisco faldende i denne 2° N. for Lagoa Santa i Staten Minas Geraes.

Paa Forespørgsel meddeler det danske Generalkonsulat i Rio Janeiro i Brev af 16. Juni 1908 følgende:

"Generalkonsulatet henvendte sig i Anledning af Deres Anmodning om Oplysning hvorvidt den almindelige Ferskvandsaal (*Anguilla*) forekommer i Brasilien, til Herr Professor Macedo de Mendonça, Rio de Janeiro. Fra denne har man erholdt det Svar, at i de brasilianske Vande fandtes ikke, saavidt bekendt, denne Fisk".

Paa Grundlag af ovennævnte samstemmende Beretninger maa vi slutte, at Aalen (*Anguilla*) mangler i Brasilien.

Argentina og Uruguay.

GÜNTHER giver i sin "Contribution to the knowledge of the Fish-fauna of the Rio de la Plata" (1880, p. 9—13) en Liste paa 59 Arter, hvorimellem *Anguilla* mangler.

BERG giver i sin "Enumeracion sistematica y sinonímica de los peces de las costas argentina y uruguaya" (1895, p. 1—120) og i sin "Sobre peces de agua dulce nuevos ó poco conocidos de la República Argentina" (1895 a, p. 121—165) meget omfattende Lister, hvori *Anguilla* mangler.

EIGENMANN & KENDALL giver i deres "Notes on a Collection of Fishes from Argentina" (1907, p. 67—108) en Liste indeholdende 52 Arter. I denne Liste nævnes en Conger (*Leptocephalus*) Art; men *Anguilla* mangler.

Paa Forespørgsel meddeler den danske Generalkonsul i Buenos Aires, Dr. E. H. LUND følgende i Brev af 15de Maj 1906:

"Jeg skal herved tillade mig at meddele, at jeg ved personlig Henvendelse til Chefen for det herværende Fiskerivæsen, Dr. LAHILLE, har bragt i Erfaring, at Ferskvandsaalen mangler her, og at den eneste Ferskvandsfisk, som kendes i Argentina, under Navnet "anguila" (d. v. s. Aal paa spansk) er *Symbranchus marmoratus*".

SMITT har (1901) offentliggjort en Afhandling "Poissons d'eau douce de la Patagonie etc."; den indeholder ikke *Anguilla*.

Paa Grundlag af ovennævnte Oplysninger er man utvivlsomt berettiget til at slutte, at Aalen ganske mangler i Argentina.

Endelig skal jeg nævne et Arbejde af CARL H. EIGENMANN & ROSA S. EIGENMANN (1892, p. 1—81) betitlet "A Catalogue of the Fresh-Water Fishes of South America". Heri anføres ikke mindre end 1134 Arter overalt fra Sydamerika, men *Anguilla* mangler ganske.

Vi ser altsaa, at *Anguilla* mangler ved Størstedelen af Sydamerikas Østkyst. Der er Grund til at fremhæve, at den aaleformede *Symbranchus marmoratus* forekommer overalt i de foreliggende Lister og at den hos ikke kyndige kan give Anledning til Forvexlinger.

Skønt jeg først ved en senere Lejlighed kommer til at omtale Forholdet ved Stillehavet, skal jeg dog allerede i denne Sammenhæng omtale Amerikas pacifiske Kyster og begynder da med Chile.

Chile.

Paa Forespørgsel meddeler den danske Generalkonsul i Valparaiso Dr. JEAN H. THIERRY følgende:

"Da jeg aldrig selv har set eller hørt om Ferskvandsaal herfra, henvendte jeg mig til Herr CARLOS E. PORTER, Direktør for det herværende zoologiske Museum. Herr PORTER meddelte mig, at der til Dato ikke var fundet Aal i Floder og Søer i Chile".

DELFIN (1898—1900) omitaler i sit "Catálogo de los Peces de Chile" heller ikke *Anguilla*.

Peru.

Den danske Vice-Konsul i Callao, Herr HANS HANSEN meddeler i Brev af 12. April 1906 følgende:

"Den almindelige Ferskvandsaal forekommer ikke her i Peru. En anden Aaleart (*Muraena Helena*) forefindes her i Oceanet, men er dog sjælden Genstand for Fiskeri".

ABBOTT (1899) giver en Liste paa 101 Arter fra Peru, hvoriblandt ingen *Anguilla* findes.

Peru og Ecuador.

STEINDACHNER (1879) giver i sine "Beiträge zur Kenntniss der Flussfische Südamerikas" Lister over peruanske Ferskvandsfiske. *Anguilla* mangler i disse.

STARKS (1906) giver en Liste paa 92 Arter af Ferskvandsfiske fra Peru og Ecuador. *Anguilla* mangler i denne.

STEINDACHNER (1880) anfører en Liste over 12 Arter af Fisk stammende fra Floder og Brakvand omkring Guayaquil. *Anguilla* mangler i denne.

Her kan ogsaa nævnes en Liste paa 184 Arter af "shore-fishes" fra Revillagigedo, Clipperton, Cocos & Galapagos Islands, forfattet af SNODGRASS & HELLER (1905), hvor *Anguilla* ogsaa mangler.

Endelig skal jeg erindre om den Liste paa 1134 Arter af Ferskvandsfisk stammende fra alle Steder i Sydamerika, som gives af EIGENMANN & EIGENMANN (1892), og hvori *Anguilla* ganske mangler, hvad der udtrykkelig bemærkes af Forfatterne.

Centralamerika.

Med Hensyn til den pacifiske Kyst af de centralamerikanske Smaastater henvises til GÜNTHER (1869, p. 377—494). I den 303 Arter store Liste, som her gives, og som baade indeholder Fersk- og Saltvandsarter, mangler *Anguilla* ganske.

De Forenede Stater.

JORDAN & EVERMANN (1896) siger i deres "Fishes of North and Middle America", p. 348 om Ferskvandsaalen "Not found in the Pacific". Se ogsaa Tabellen S. 128.

Yderligere kan gengives følgende Oplysninger modtagne gennem den danske Konsul i San Francisco, Herr H. H. BIRKHOLM i Brev af 22de Marts 1906: Professor DAVID S. JORDAN, Stanford Universitetet, Californien, meddeler:

"There are no true Eels on this coast. They are plentiful all along the Atlantic coast, in the waters of Japan, and through the South Sea except about Hawaii".

Canada.

Ifølge velvillig Meddelelse fra den danske Konsul i Vancouver, Hr. O. MARSTRAND mangler Ferskvandsaal her. I de tidlige citerede Angivelser (S. 125—26) fra officiel canadisk Side siges det ogsaa, at det kun er i Canadas østlige Provinser, at Aalen forekommer, og dette fremgaar ligeledes af den officielle Fiskeriberetnings statistiske Angivelser (Dominion of Canada, 1908—09), saaledes som det kan ses af følgende Uddrag.

Udbyttet af Canadas Aalefiskerier i Aaret 1907.

Provins	Værdi	Mængde	
		Dollars	Ibs.
Pr. Edward Island	7,380	"	738
New Brunswick	32,870	"	3,287
Nova Scotia	28,160	"	2,816
Quebec	45,068	729,800	128
Ontario	3,000	50,000	"
Manitoba	"	"	"
Saskatchewan	"	"	"
Alberta	"	"	"
British Columbia	"	"	"

Det Hovedresultat, som vi nu er naaet til for det amerikanske Kontinents Vedkommende, kan i Korthed udtrykkes saaledes. Langs de atlantiske Kyster træffer vi først Aalen ved Labrador. I størst Mængde findes den i Canada og de Forenede Stater, men ogsaa i den nordlige Del af Mexico opträder den i Mængde, hvad der delvis ogsaa gælder om Størstedelen af det vestindiske Archipelag. I den sydlige Del af Mexico bliver den sjældnere, og i Centralamerika synes den at mangle, hvad der efter de foreliggende Oplysninger ogsaa er Tilfældet i Columbia og Venezuela. Det eneste Sted paa Sydamerikas Fastland, hvorfra den med Sikkerhed er kendt, er Guiana. Derimod mangler den ganske i Brasiliens og Argentinas store Flodsystemer, hvilket i ganske særlig Grad fortjener at fremhæves og bemærkes, og ligeledes mangler den fuldstændigt paa hele den store amerikanske Stillehavskyst, baade i Sydamerika og i Nordamerika, hvad der ogsaa er meget paafaldende. Iøvrigt henviser jeg til Kortet, der paa engang giver en fortræffelig Oversigt over hvad vi veed.

B. Atlantiske Øer.**Spitzbergen.**

KNIPOWITSCH (1901, p. 57) giver en Liste over Spitzbergens Fiske. Aalen mangler heri.

Island.

Som jeg tidligere har oplyst (SCHMIDT, 1906, p. 207), forekommer Aalen paa Island, i størst Antal paa Syd- og Sydvestlandet, men ogsaa paa Vest- og den vestlige Del af Nordlandet, hvorimod den mangler paa Østlandet og den østlige Del af

Nordlandet. Jeg har talt Hvirvler paa et større Antal og fundet, at de alle uden Undtagelse tilhørte den europæiske *Anguilla vulgaris*.

Færøerne.

Aalen forekommer ret almindeligt paa de fleste Øer. I størst Mængde synes den at findes paa den sydligste af Øerne, Syderø, hvor jeg selv har taget halvblanke Aal i September Maaned i Vaagfjord mellem "Aalegræs" (*Zostera*) i ret betydeligt Antal. Aalefaring har jeg gennem Hr. Etatsraad O. FINSEN's Velvilje modtaget i Mængde fra Thorshavn, taget i April Maaned. De af mig undersøgte færøske Aal var typiske *Anguilla vulgaris*.

Azorerne.

GÜNTHER (Cat. 1870, p. 30) omtaler Exemplarer af *A. vulgaris* fra Azorerne, opbevarede i British Museum.

Gennem et Brev af 21de Sept. 1908 fra Danmarks Vicekonsul i San Miguel, Senhor V. de SEQUEIRA, har jeg modtaget følgende Underretning fra Professor, Lieutenant Coronel CHAVES:

"Ferskvandsaalen er hyppig i Smaafloder paa alle Øerne, men er ikke Genstand for et Fiskeri af større Betydning. Den kaldes her "iróz", ikke "eiro" som paa Madeira. Denne Aal ansaa man tidligere for at være en for Azorerne, Madeira og Canarerne ejendommelig Art, men den vides nu at være identisk med den paa det europæiske Kontinent levende *Anguilla*".

Det forekom mig nu at være af betydelig Interesse at faa nærmere Rede paa den systematiske Stilling af de paa Azorerne levende Ferskvandsaal. Man kunde jo tanke sig, at der paa disse i Oceanet saa langt mod Vest fremskudte Øer forekom Overgangsformer mellem *Anguilla vulgaris* og *Anguilla chrysypa*. Jeg henvendte mig derfor til Hr. Konsul V. de SEQUEIRA, der med den største Imødekommnenhed tog sig af Sagen og i Løbet af kort Tid sendte mig en Samling Smaa-Aal fra Azorerne, fortræffeligt konserverede i Formol. Samlingen der var tilvejebragt i Maj 1909 ved Ponta Delgada, indeholdt 34 Exemplarer, der i Længde varierede mellem 56 og 141 mm. Med Undtagelse af 8 Stk. (Længde: 141, 117, 106, 103, 97, 77, 70, 66 mm.), der tilhørte ældre Aargange, bestod Samlingen af nylig forvandlet Aalefaring eller "montée" (6te Stadium) varierende i Længde mellem 56 og 74 mm., saaledes som det kan ses af hosstaaende Tabel.

Undersøgelsen af disse Smaa-Aal fra Azorerne bestod dels i Hvirveltælling, dels i Bestemmelsen af Afstandene mellem Snudespids og henholdsvis Ryg- og Gatfinnens forreste Punkt. Ved tidligere Undersøgelser (SCHMIDT, 1906, p. 240) havde jeg fundet, at Hvirveltallet ydede en god Karakter til Adskillelse mellem den europæiske og amerikanske Aal, medens af ydre Karakterer navnlig Afstanden mellem Ryg- og Gatfinnens forreste Punkter udtrykt i Procent af Totallængden i Almindelighed ogsaa kunde anvendes til Adskillelse.

Resultatet af Undersøgelsen, som foretages af cand. mag. A. STRUBBERG, kan ses af følgende:

Ferskvandsaal fra Ponta Delgada, Maj 1909.

„Montée“ (6te Stadium).

Længde i mm	Antal Exemplarer
74	○
72	○
70	○
68	○
66	○ ○
64	○ ○ ○
62	○ ○
60	○ ○
58	○ ○ ○ ○ ○
56	○

„Montée“ (6te Stadium).

Hvirvelantal. ¹	
Antal Hvirvler	Antal Exemplarer
117	○ ○ ○
116	○ ○ ○ ○ ○ ○
115	○ ○ ○ ○ ○ ○ ○ ○
114	○ ○
113	○

For samtlige 34 undersøgte Exemplarer (56—141 mm.) fandtes Afstanden mellem Begyndelsespunkterne af Ryg- og Gatfinnerne udtrykt i % af Totallængden at variere mellem 9,9 og 13,1. Gennemsnitlig var den 11,5 %, og kun for 2 af de undersøgte Individer fandtes Værdier under 10 %, nemlig 9,9 og 9,9.

Som Hovedresultat af Undersøgelserne kan det siges, at samtlige Aal fra Azorerne viste sig at være typiske *Anguilla vulgaris* baade i Henseende til Hvirveltal og til de øvrige undersøgte Karakterer (Jfr. SCHMIDT, 1906, p. 239—43).

Bermudas Øerne.

Af forskellige Grunde, som vil fremgaa af det følgende, maatte jeg nære Tvivl, om at Mangelen af *Anguilla* i den eneste mig foreliggende Liste over Bermudas Fiske af GÜNTHER (1880, Challenger) var i Overensstemmelse med de virkelige Forhold. Jeg henvendte mig derfor til den danske Konsul i St. George's, Bermuda, Mr. JOHN S. DARRELL med Forespørgsel og modtog derefter i Brev af 9de Juli 1908 følgende Oplysninger fra Mr. LOUIS L. MOWBRAY ved "the Bermuda Biological Institution and Aquarium":

"*Anguilla chrysypa* is taken in almost all of the inland marshes, harbors, bays, and inlets, and frequently among the reefs. In September 1906 I secured a larval form at St. George's. It was thrown ashore during a strong north-east breeze".

¹ Naar der gjordes Adskillelse mellem Krop- og Halehvirvler, fandtes følgende Tal: 43 + 71; 44 + 70; 3 (44 + 71); 2 (44 + 73); 45 + 68; 3 (45 + 70); 4 (45 + 71); 46 + 69; 2 (46 + 70); 46 + 71; 47 + 68.

Madeira.

I sin Synopsis over Madeiras Fiske omtaler LOWE (1841, p. 191) Forekomsten af Aalen paa denne Ø. Han henfører den til *Anguilla latirostris* Yarrel, der, som bekendt, henhører til den europæiske Aal, *Anguilla vulgaris*. Det Navn, den gaar under paa Madeira, er "Eiro", og den synes at forekomme i Mængde. LOWE siger:

"Eels are the only indigenous fresh-water fish of the island. They abound in the torrents, up to the height of about 500 feet above the sea. There are more species or varieties; but I am not sufficiently acquainted with them at present to attempt their classification".

Denne Mængdeforekomst af Aal paa den langt ude i Oceanet beliggende Ø, hvor denne Fisk ifølge LOWE er den eneste "indigenous fresh-water fish", er af meget betydelig Interesse for nærværende Undersøgelse, som det klart vil fremgaa af den almindelige Del.

Canariske Øer.

Ifølge brevlig Meddelelse fra den danske Konsul i Sta Cruz de Tenerife, Sr. FILIBERTO LALLIER (dateret 19de Februar 1908) er Aalen almindelig paa de canariske Øer. Sr. LALLIER udtales følgende:

"Ferskvandsaalen ("anguila de agua dulce") forekommer paa Tenerife, Palma, Gomera og Canaria; det er tvivlsomt, om den findes paa Øen Hierro, og den forekommer ikke paa Lanzarote og Fuerteventura. Det Sted, hvor der er mest af den, er Tenerife og særligt i den Del af "la Laguna" (kaldet saaledes, fordi der tidligere fandtes en Lagune her ved Siden af Byen), som er nærmest ved Byen, samt i "Las Montañas", hvor den findes i Maengde i de Vandpytter ("charcos"), som dannes i de Klofter ("barrancos"), hvor Elvene løber. Bønderne lægger saakaldet "leche de cardon", Saften af *Euphorbia canariensis*, i Vandet for at bedøve dem og kunne fange dem".

I det pragtfulde Værk om Canarerne Naturhistorie, udgivet af BARKER-WEBB & BERTHELOT (1836—44) omtaler VALENCIENNES p. 88—89 den canariske Aal, som han kalder *Anguilla canariensis* Val.; men som efter den Beskrivelse og Afbildning, han giver af den, utvivlsomt ikke er andet end den almindelige *Anguilla vulgaris*. Om dens Forekomst meddeler VALENCIENNES følgende:

"On trouve plus particulièrement ces Anguilles dans les mares d'eau laissées là et là par les ruisseaux qui serpentent au fond des barrancos ou ravins profonds de Téneriffe. Ces ruisseaux, au temps des pluies deviennent des torrents formidables, mais qui se dessèchent quand les eaux manquent dans les bas-fonds. Ces Anguilles restent alors à sec, et on peut les prendre en les piquant avec des dards. On en mange communément aux Canaries".

Jeg har fremhævet sidstnævnte Sætning, fordi den, i Forbindelse med den danske Konsuls interessante Meddelelse om den ejendommelige Maade, hvorpaa de canariske Bønder fanger Aalen, utvivlsomt viser, at der her maa findes meget af denne Fisk.

Cap Verdiske Øer.

Den danske Vice-Konsul i San Vicente, Shnr. MANOEL DA SILVA PINTO FERRO, meddeler paa Forespørgsel følgende i Brev af 27. Februar 1908:

"I Besvarelse af Deres Brev tillader jeg mig at meddele, at Ferskvandsaalen ikke findes i Cabo Verde, hvor der ikke existerer Ferskvandssøer. I Floderne i det nordlige Portugal forekommer den i store Mængder".

TROSCHEL (1866) anfører en Liste paa 42 Arter, deriblandt *Muraena helena*, men ingen *Anguilla*.

Herefter synes Aalen altsaa at mangle paa de Cap Verdiske Øer.

St. Helena.

Den danske Konsul paa St. Helena, Mr. H. W. SOLOMON, meddeler paa Fore-spørgsel følgende i Brev af 22de Maj 1908:

"I have the honour to acknowledge the receipt of your letter of the 8th ultimo asking for certain information re fresh water Eels, and in reply have to inform you that there are no fresh water fish at all in this Colony".

C. Østlige Del af Omraadet.

(*Nordasien, Vesteuropa, Middelhavet, Vestafrika*).

Den alm. Aal (*Anguilla vulgaris*) forekommer overalt ved de atlantiske Kyster af Europa. Dette er saa almindeligt bekendt, at jeg ikke behøver at nævne hvert enkelt Land, men skal indskrænke mig til at henvise til den Beskrivelse af Aale-yngelens Indvandring, som jeg tidligere har givet (SCHMIDT, 1906, p. 196—213). Tilbage bliver at omtale Nordhavet, Ishavet og Middelhavet.

Nordhavet og Ishavet.

Aalen er almindelig i det sydlige og vestlige Norge, men findes ogsaa i det nordlige Norge, hvor den overskrider Polarkredsen og gaar længere mod Nord end noget andetsteds i Verden. Om dens Udbredning i Norge giver COLLETT (1905, p. 39) Besked i sin Bog om Norges Fiske. Han meddeler her, at den nord for Trondhjem utvivlsomt er mindre talrig end længere sydpaa, men at den dog er funden f. Ex. ved Tromsø og Magerø, ja endog i Varangerfjord i Finmarken.

KNIPOWITSCH (1898, p. 1—11) beretter om det Hvide Hav og Murmankystens Fiske. Han inddeler Omraadet i 4 Arealer: I) Varanger Fjord og Murmankysten til Wostotschnaja-Liza, II) derfra til Kanin-Nos og til Indgangen af det Hvide Hav, III) Østlige Halvdel af Murmanhavet og IV) Hvide Havet. — Kun for det vestligste Areal (I) angives *Anguilla* og kun med Tvivl, medens den mangler i de 3 øvrige længere mod Øst beliggende Arealer.

Der er altsaa ingen Tvivl om at Forholdet er det, at Aalen er meget sjælden østen for Nordkap, omend der muligvis i de vestligste Dele af den russiske Ishavskyst undertiden kan træffes enkelte Exemplarer.

I Sibirien mangler Aalen ifølge PALLAS (*Zoogeographia rosso-asiatica*, vol. III, p. 71, 1831).

Spanien.

Middelhavet.

Hvad angaar de spanske Atlanterhavskyster, da har jeg tidligere oplyst (SCHMIDT, 1906, p. 196 og 205) om den Opgang af Aaleyingel, som her finder Sted. (I Portugal findes der naturligvis ogsaa Aal, jfr. S. 142, og BRITO CAPELLO's Værk om Portugals Fiske (Cat. Peix. Portug.).

Med Hensyn til Spaniens Middelhavskyst er det nok at henvise til det Aalefiskeri, der finder Sted i den store Albúfera-Lagune i Nærheden af Valencia (BELLINI, 1907, p. 1).

Paa de baleariske Øer findes Aalen ogsaa, skønt der ingen andre Ferskvandsfiske forekommer (ifølge PALACKY, 1891, p. 175).

Italien.

At der i Italien findes store Aalefiskerier, er en alm. bekendt Sag. Størst Betydning har de meget bekendte Fiskerier ved Comacchio ved Adriaterhavet syd for Venedig. (Se f. Ex. JACOBY, 1880 og BELLINI, 1907).

Balkanhalvøen.

Ifølge mundtlig Meddelelse fra Hans Majestæt Kong GEORG af Grækenland forekommer der Aal i Grækenland, men de er ikke Genstand for noget større Fiskeri, da de ikke værdsættes videre meget af Befolkningen.

BELLINI (1907, p. 1) meddeler, at der finder et Aalefiskeri Sted i Herzegovina og i Buru Søen i det europæiske Tyrki.

GÜNTHER (Cat., 1870, p. 31) omtaler et voxent Exemplar af *Anguilla vulgaris* fra Marmarahavet.

Derimod er man efterhaanden enig om den paafaldende Kendsgerning, at Aal mangler i Sortehavsområdet (i det caspiske Hav mangler den ogsaa, men derved er der intet mærkeligt, eftersom dette er en indelukket Brakvandssø). Angaaende det Sorte Hav kan jeg ikke gøre bedre end at citere von SIEBOLD (1863, p. 345—48), der i sit fortræffelige Arbejde om Mellemeuropas Ferskvandsfiske har underkastet dette Spørgsmaalet en indgaaende Prøvelse. Han siger herom bl. a.:

“Die geographische Verbreitung des Aals in Mitteleuropa ist eine höchst eigenthümliche. Er wird in allen denjenigen Flüssen und stehenden Gewässern angetroffen, welche mit der Ost- und Nordsee, mit dem atlantischen, mit dem Mittel- und adriatischen Meere zusammenhängen, fehlt aber in denjenigen Seen und Flüssen, welche ihr Wasser dem schwarzen Meere zusenden. Daher findet sich der Aal nirgends im Flussgebiete der Donau, und fehlt derselbe auch im Dnestr, Bug, Dnjepyr und Don. PALLAS¹ machte bereits auf die Abwesenheit des Aals in den dem kaspischen und schwarzen Meere zufließenden Gewässern aufmerksam: auch EICHWALD² und NORDMANN³ lassen den Aal in ihren Faunen des Caucasus und Pontus unerwähnt. Hiermit stimmen auch die Forschungen des CZERNAY⁴, TCHIHATCHEFF⁵ und KESSLER⁶ überein welche in keinem der südrussischen Flüsse Aale antrafen”.

¹ Zoographia rosso-asiatica (vol. III, edit. 1831, p. 71). ² Fauna Caspio-Caucasia, 1841. ³ Observations sur la Faune pontique, 1840. ⁴ Bull. Soc. Imp. Nat. Moscou Tom. 23, 1850, p. 627. ⁵ C. R., Tom. 42, 1856, p. 442. ⁶ Bull. Soc. Imp. Nat. Moscou, Tom. 29, 1856, p. 442.

Derefter gaar v. SIEBOLD over til at gennemgaa de forskellige Angivelser om Forekomst af Aal i Donau og kommer til det Resultat, at de alle beroer paa Fejtagelser eller Misforstaelser. Dette er ogsaa alm. anerkendt af senere Forfattere; men i senere Aar har man indplantet Aaleyngel i Mængde i Donau fra Italien og Frankrig, og den synes at trives godt, selvom den naturligvis ikke kan forplante sig. BADE (1902, p. 83) har fornlyig omtalt Sagen og udtaler:

“Ursprünglich im Gebiete des Kaspischen und Schwarzen Meeres fehlend, ist der Aal in neuerer Zeit in die Donau, besonders innerhalb Deutschland durch Einsetzung von Aalbrut eingebürgert”.

Se endvidere Side 162, hvor Aarsagerne til Mangelen af Aal i det Sorte Hav omtales.

Asien.

Palæstina.

Ifølge GÜNTHER (Cat., 1870, p. 31) findes Aalen (*Ang. vulgaris*) i Palæstina (Bahr el Kelb).

I Cilicien omtaler PALACKY (1891, p. 183) Forekomsten af Aal.

Ægypten.

GÜNTHER (PETHERICK, 1869) omtaler i “The Fishes of the Nile” Aalens Forekomst her ligesom ogsaa *Anguilla vulgaris* hos GÜNTHER (Cat., 1870, p. 31) angives at forekomme i den nedre Nil. Hvor højt den trænger op i Nilen, véd jeg ikke; men at den ikke er fundet i dens øverste Del, ses af de S. 149 omtalte Arbejder af BOULENGER. Der forekommer store Mængder Aal i Nilen, hvorfra Export endog finder Sted til Tyskland og London (meddelt af Aalefirmaet Salomonsen & Co. London).

Tunis.

VINCIGUERRA (1884, p. 52) omtaler Aalens (*A. vulgaris* Turt.) Forekomst i Tunis og siger, at den er:

“.... frequentissima specialmente nel lago di Tunisi”

Algier.

GERVAIS (1853, p. 16—17) siger om Aalens Forekomst i Algier:

“On vend au marché de Bône et dans d'autres lieux de l'Algérie des Anguilles prises, soit dans les eaux douces, soit dans les eaux saumâtres et littorales de ce pays”.

Den forekommer i saa stort Antal i Algier, at Export af den finder Sted, saaledes til London (meddelt af Firmaet Salomonsen & Co., London).

Den algierske Aal, hvorfaf jeg har haft Lejlighed til at undersøge adskillige Exemplarer, afviger ikke fra den alm. *Anguilla vulgaris*. Den er i sin Tid af GUI-CHENOT opført som en særlig Art, *Anguilla callensis* Guich., men allerede GERVAIS gør i 1853 l. c. opmærksom paa, at der ikke foreligger nogen Grund til at opføre den som en særlig Art.

BOULENGER (1905, p. 50) anfører i sin store og meget vigtige Liste over Afrikas Ferskvandsfiske for Nordafrika kun *Anguilla vulgaris* Turt.

Atlanterhavet (Vestafrika). Marocco.

Den danske Vice-Konsul i Saffi, Mr. GEORGE P. HUNOT, meddeler paa Fore-spørgsel følgende i Brev af 14. Sept. 1908:

"The fresh water eel is found in the rivers and lakes, and also in the underground aqueducts where it is sometimes caught. The natives do not give it great importance although it is much appreciated by them as food. They call it "noon".

Selv har jeg i Februar 1909 taget Glasaal i Havet tæt ved Cap Spartel fra det danske Havundersøgelsesskib "Thor".

Senegal og Gambia.

STEINDACHNER (1870, p. 580—82) giver en Liste over samtlige (50) Ferskvands-fiske fra Senegal. Heri mangler *Anguilla*.

BOULENGER (1900, p. 511 ff.) beretter om de store Samlinger fra Gambia Floden, som er tilvejebragte af I. S. BUDGETT. Der opføres 40 Arter, men ingen *Anguilla*.

Prosecutor AUG. BRINKMANN, Kgl. Landbohøjskole, København, der i Febr. og Marts 1906 opholdt sig i Gambia, anstillede paa min Opfordring Undersøgelser over Aalens Forekomst i Gambia Floden. Han meddeler følgende herom:

"I Gambia har jeg gentagne Gange paa Fisketorvet i Bathurst samt overalt opad Floden søgt Oplysninger, stadig med negativt Resultat!".

I den 336 Arter store Liste af ROCHEBRUNE over Senegambiens Fiske mangler *Anguilla*.

Angaaende de Cap Verdiske Øer se S. 141—42.

Liberia.

STEINDACHNER (1894, p. 1—96) opfører en Liste paa 96 Arter; for denne Liste ligger meget betydelige Undersøgelser af Herr BüTTIKOFER til Grund. Den indeholder ikke *Anguilla*.

HUBRECHT (1881, p. 66—71) beretter om en Samling Fiske fra St. Paul's Floden i Liberia. Den indeholder ikke *Anguilla*.

Elfenbenskysten.

SAUVAGE (1882, p. 313—25) omtaler en Samling Fisk paa 13 Arter fra Terri-toire d'Assinie (Assinee) samlede af Maurice Chaper. *Anguilla* mangler.

Guldkysten.

GÜNTHER (1867, p. 110 ff.) giver en mindre Liste, hvori *Anguilla* mangler, og senere (GÜNTHER 1899, p. 716 ff. samt GÜNTHER 1902, p. 330 ff.) en stor Liste over

de af Mr. R. B. N. WALKER paa Guldkysten samlede Fisk. Ogsaa i de sidste mangler *Anguilla*.

Nigeria.

GÜNTHER (1896, p. 261 ff.) omtaler de af Miss M. H. KINGSLEY i Old Calabar samlede Fisk, hvorimellem *Anguilla* ikke findes.

BOULENGER (1901 a, p. 4 ff.) og (1902, p. 324 ff.) omtaler de af Dr. W. J. ANSORGE i Niger Delta'et samlede Fisk. Der omtales ikke mindre end 80 Arter, men ingen *Anguilla*.

Camerun.

PETERS (1876, p. 244) omtaler de af Prof. Dr. REINHOLD BUCHHOLZ mest i Victoria Floden, men ogsaa i Camerun, samlede Fisk, ialt 79 Arter, hvorimellem *Anguilla* mangler.

LÖNNBERG (1895, p. 179) omtaler de af Herr Y. SJÖSTEDT i Camerun samlede Ferskvandsfisk: Ingen *Anguilla*.

Fransk Congo.

SAUVAGE (1880—81, p. 19) giver en stor Liste over alle de Ferskvandsfisk, som kendes paa Strækningen “depuis l'embouchure du Sénégal jusqu'à l'embouchure du Congo”. *Anguilla* mangler.

GÜNTHER (1896, p. 261 ff.) omtaler i sin Afhandling om de af Miss M. H. KINGSLEY i Ogowe Floden samlede Fisk, at der fra denne Flod kendes 51 Arter, derimellem ikke *Anguilla*.

Congo.

I BOULENGER's store Værk: “Les Poissons du Bassin du Congo” (1901) opføres og beskrives 221 Arter Ferskvandsfisk, men mellem dem hverken *Anguilla* eller nogen anden Murænoid. Da dette Værk er baseret paa meget betydelige Indsamlinger og Beretninger om Fisk og Fiskeri i Congo, er der ingen Tvivl om, at Aalen virkelig mangler her¹.

Angola.

BOULENGER nævner i sit anførte Værk om Congos Fiske ogsaa Arter fra Angola, men ingen *Anguilla*. Heller ikke findes denne Slægt omtalt hos GÜNTHER (1873, p. 142 ff.).

¹ Naar E. WILVERTH i sit Arbejde: “Les Poissons du Congo” (Soc. d’Études coloniales, Bruxelles, 1897) omtaler, at han paa en Rejse i 1896 “entre le Congo et la rivière N’ghiri par la Moboka et le lac Ibana” oplevede, at hans Folk “se mirent en quête de petites anguilles qui pullulaient dans tous les marigots . . .”, saa anfører BOULENGER l. c., at disse “petites anguilles” rimeligvis var Silurider af Slægten *Clarias*.

Paa samme Maade opfatter jeg en Meddeelse af en ikke Fagmand om Forekomsten af Aal i Congo-Floden; thi indenfor Slægterne *Clarias* o. a. findes der jo Arter, som er overordentlig langstrakte, næsten aaleformede; saaledes anfører BOULENGER, at Siluriden *Channallabes apus*, der er aaleformet, og som i Boma kaldes “Doango” og i Nedre Congo “Sanga Monteké”, skal være meget god at spise.

Tysk Sydvestafrika.

L. SCHULTZE (1906), der specielt har studeret Fiskeriforholdene i Tysk Sydvestafrika, omtaler ikke Aalen. Paa Forespørgsel meddeler Dr. L. SCHULTZE i Brev af 28. Feb. 1908 følgende:

"Den alm. Aal (*Anguilla*) findes hverken ved Kysten, i Floderne eller Flodmundingerne etc. i Sydvestafrika. De indfødte fanger i Floderne kun Silurider".

Sydafrika.

I Sydafrika træffer vi igen Ferskvandsaal af Slægten *Anguilla*. Dette fremgaar bl. a. af den af BOULENGER, den bedste Kender af Afrikas Ferskvandsfisk, forfattede kollektive Liste over alle de fra denne Verdensdel kendte Ferskvandsfisk, (BOULENGER, 1905). BOULENGER anfører her p. 50: *Anguilla Delalandii* Kaup fra Sydafrika og *Anguilla bengalensis* Ham. Buch. fra Natal. Den sidste er en af de brogede *Anguilla*-Arter.

Paa Forespørgsel har jeg gennem "the Agent General for the Cape of Good Hope", London, modtaget følgende Underretning om Kapkoloniens Ferskvandsaal i et Brev fra "the Acting Chief Clerk to Secretary for Agriculture", Mr. B. Mc. MILLAN, dateret "Office of the Secretary for Agriculture", Capetown, 19de Juni 1906:

"In reply to your letter on the above subject, I am directed to inform you that the undermentioned eels are known to occur in South Africa, viz.: *Ophichthys serpens*, *Anguilla delalandii*, *Anguilla labiata*, *Muraena flavomarginata*. Two specimens of *Leptocephalus* are also recorded from South African waters. There is no local literature on the South African Eel".

Den fungerende Konsul for Danmark i Capetown, Mr. W. THOMAS OLIVE, meddeler i Brev af 8de Maj 1906:

"I have the honour to inform you that through the good office of the Acting Director of the Cape Town Museum I have obtained the following information from Dr. GILCHRIST, the keeper of Marine Invertebrates and Fishes: The Eels in South Africa at present known are five in number: *Anguilla delalandii*, *Anguilla labiata*, *Muraena nebulosa*, *Muraena flavomarginata*, *Ophichthys serpens*. There are therefore only two true eels. There is here no trawling for eels, and no eel industry".

Hr. VALDEMAR JOHANSEN, fungerende Konsul for Danmark i Durban, Natal, meddeler paa Forespørgsel i Brev af 15de Januar 1908 følgende:

"Having made enquiries in the matter, I now beg to inform you that the fresh water eels are to be found abundantly in practically all rivers, estuaries and lakes of Natal.

As a matter of fact, I am told that only in the Mooi River, the eel is extinct owing to the water containing minerals. The size of eels in streams and rivulets runs from 18" to 2' in length, and in big rivers up to 5 and 6 feet. There are no Government restrictions as to fishing of eels, they are, however, caught only rarely by the farmers and hardly ever sold in the towns".

Med Hensyn til hvilken Aaleart de natalske Aal tilhører, da angiver BOULENGER i sin flere Gange citerede Liste over Afrikas Ferskvandsfisk p. 50, at *A. bengalensis* Ham. Buch. forekommer i Natal.

MARTENS (1869—73) angiver i sin Oversigt over de østafrikanske Ferskvandsfiske, at *Anguilla macrocephala* Rapp. findes i Natal.

Til sidst er det mig en Glæde her at kunne anføre en meget interessant Redegørelse for Udbredningen af Ferskvandsaalene i Sydafrika baseret paa personlige Iagttagelser af den velkendte Autoritet i sydafrikansk Ichthyologi, Dr. GILCHRIST, Capetown. Dr. GILCHRIST meddeler paa Forespørgsel følgende i et Brev af 29de December 1908 :

"The distribution of the fresh water eel in South Africa is very peculiar and I have been making enquiries about it for some time back. On a recent visit to Natal I found it occurred in abundance and was caught by Indians as food. The natives (Kaffirs) have a prejudice against fish of all sorts and especially against eels and there is no regular industry. Further south, towards and at Port Elizabeth they do not occur so abundantly. They are found at the south coast in all the rivers as far west as the Breede River where they are in fair abundance. Cape Agulhas or its neighbourhood seems to be the point where they disappear, and practically none occur in the rivers west of this nor on the west coast generally.

The eel however does seem to occur in these rivers but only now and again have specimens been found and then of exceptionally large size. Thus one was found in the Leerbeck a small stream flowing into Table Bay. One or two have been found in the Orange River. At Pretoria (the watershed between the Crocodile and Orange Rivers) one large specimen has been found in a stream which ultimately joins the Orange River, while they are abundant in the small streams not far off which join the Crocodile River flowing into the Indian Ocean".

Jeg skal her tilføje en Beskrivelse af Aalens Forekomst i det indiske Ocean i naturlig Tilslutning til Sydafrika, hvormed Omtalen af Atlanterhavet sluttede. Jeg begynder med at omtale Østafrika.

Østafrika.

Portugisisk Østafrika.

PETERS (1868), der noget efter Midten af forrige Aarhundrede foretog naturhistoriske Undersøgelsesrejser i Moçambique, omtaler p. 94—103 Ferskvandsaalene, af hvilke han opfører ikke mindre end 4 Arter. Disse er: *Anguilla labiata* PETERS, *A. macropthalma* PETERS, *A. mossambica* PETERS og *A. virescens* PETERS. Den første findes ved Zambezi og Licuare Floderne; de indfødte ved Tette (Zambezi) kalder den "mucúnga"; i Boror hedder den "licovóvo". *A. mossambica* er fundet i Molumbo Floden (15° S. Br.), *A. macropthalma* i Zambezi Floden ved Byen Tette (kaldes her ligesom *A. labiata* "mucúnga") og *A. virescens* i Licuare Floden (Boror). *A. labiata* er ogsaa funden i Pangani Floden (GÜNTHER & PLAYFAIR, 1866, p. 124—25).

Britisk og Tysk Østafrika.

PFEFFER (1892, p. 169) omtaler blandt de af Dr. F. STUHLMANN i 1888—1889 samlede Fiske *Anguilla labiata* PETERS fra en Dam ved Mhonda, Ungúu, og der udtales om den, at den spises. Endvidere anføres *Anguilla virescens* PETERS som taget i Zanzibar.

GÜNTHER (1894, p. 91) anfører i sin Beretning om de under Dr. J. W. GREGORY's Expedition til Mount Kenya indsamlede Fiske *A. bengalensis* GRAY fra Thika-thika, Athi, og Tana Floderne.

BOULENGER (1902, p. 224) anfører i sin Omtale af de af Mr. S. L. HINDE i Kenya Distriket samlede Fiske *A. bengalensis* GRAY, fra Mathoiya Floden med den Bemærkning, at *A. labiata* PETERS ikke kan adskilles fra denne Art.

Zanzibar. — PFEFFER (1892, p. 169) anfører *Anguilla virescens* fra Zanzibar.

BOULENGER (1906 a, p. 557—566) og PELLERIN (1905, p. 290—94) omtaler Fiske-samlinger fra Rudolf Søen i den centrale Del af Britisk Østafrika og BOULENGER (1906, p. 433—445) fra Victoria Søen. Ingen *Anguilla* anføres fra disse Vandomraader, som ikke har Afløb til Østkysten af Afrika. Det samme gælder om BOULENGER's (1902 a, p. 260—64) 39 Arter store Liste over Fisk samlede ved Gondokoro (øverste Nil, N. for Albert Nyanza Søen).

Somaliland.

VINCIGUERRA (1895, p. 27) omtaler en *Anguilla* fra Juba (Giuba)-Omraadet, som han mener maa henføres til *A. labiata* PETERS.

Rødehavets Kyster.

Djibuti. PELLEGRINI (1904, p. 543—45) omtaler de af M. Ch. Gravier ved Djibuti og Obok samlede Fisk. *Anguilla* mangler mellem disse.

Eritrea. Fra denne Koloni foreligger fra italiensk Side ret talrige Samlinger. GIGLIOLI (1888, p. 67—73) giver en Fortegnelse over Fisk fra Assab og Scioa. *Anguilla* mangler mellem disse.

DEL PRATO (1891) giver en Liste over de af den italienske Kaptajn V. Bottego i Eritrea samlede Fiske; men ingen *Anguilla* findes i denne ligesom ikke heller i BORSIERA's (1904, p. 187—220) Bidrag til Eritrea's Fiskefauna.

KLUNZINGER (1870—71) giver en paa meget omfattende Undersøgelser baseret Liste over det Røde Havs Fiske. *Anguilla* mangler i denne, hvor flere andre Mu-raenoider opføres.

Om de fleste af de her citerede Arbejder vedrørende det Røde Havs Kystlande gælder det, at de væsentlig beskæftiger sig med Fisk fra Salt- og Brakvand, hvorfor man maa være varsom med Slutninger angaaende Mangelen af Ferskvands-fisk paa Grundlag af de heri meddelte Oplysninger. Det bør forøvrigt ikke glemmes, at Betingelserne for Ferskvandsaalens Trivsel kun er slette i disse yderst vandfattige Egne ved det Røde Havs Kyster.

Til Slutning skal jeg kun gengive MARTENS's (1869—73) og BOULENGER's (1905) Lister over samtlige fra henholdsvis Østafrika og hele Afrika kendte *Anguilla*-Arter.

MARTENS (1869—73, p. 144) **Østafrika.** BOULENGER (1905, p. 50) **Hele Afrika.**

- | | |
|---|--|
| 1) <i>Anguilla labiata</i> PETERS: Pangani, Zambezi, Licuare. | 1) <i>Anguilla vulgaris</i> TURT, 1807: N. Afrika. |
| 2) — <i>Johannae</i> GÜNTHER: Johanna Øen. | 2) — <i>bengalensis</i> HAM. BUCH. 1822: Ø. Afrika. |
| 3) — <i>Mossambica</i> PETERS: Molumbo Floden (15° S. Br.). | 3) — <i>virescens</i> PETERS 1852: Ø. Afrika. |
| 4) — <i>macroptalma</i> PETERS: Zambezi. | 4) — <i>Delalandii</i> KAUP 1856: Madagascar, S. Afrika. |
| 5) — <i>virescens</i> PETERS: Licuare. | 5) — <i>amblodon</i> GÜNTHER 1866: Seychellerne. |
| 6) — <i>macrocephala</i> RAPP.: Natal. | 6) — <i>Hildebrandtii</i> SAUVAGE 1891: Madagascær. |
| 7) — <i>marmorata</i> QUOY & GAIMARD: Réunion. | |
| 8) — <i>amblodon</i> GÜNTHER: Seychellerne. | |

Oer i det indiske Ocean.

Seychellerne.

GÜNTHER i GÜNTHER & PLAYFAIR (1866, p. 124—125) beskriver en Aaleart, *Anguilla amblodon* fra Ferskvand paa Seychellerne. Det er en marmorereret Form opnaaende en betydelig Størrelse (Originalexemplaret var 2 Fod langt).

Comorerne.

GÜNTHER i GÜNTHER & PLAYFAIR (1866, p. 124—25) beskriver en Aaleart, *Anguilla Johannae* fra Øen Johanna. Det er en marmorereret Art.

Madagascar.

SAUVAGE (GRANDIDIER, 1891, p. 498) omtaler de madagassiske Aal paa følgende Maade:

“Les Malgaches appellent les Anguilles “Amalonā”. On distingue l’Amalombandanā (Anguille rayée), l’Amalondriatsa (Anguille noire), l’Amalonkorakā, l’Amalontsorondranō, l’Amalontserikā. Les Malgaches de l’Ouest (au Ménabé) leur donnent aussi le nom de “Henalava” (litt. viande longue), “Lamarankenā”, “Lonā”, “Sakamalonā” (les jeunes), “Voninamalonā” (litt. fleur d’Anguille ou le fretin) et les Hova celui de “Kirija”.”

Iøvrigt henfører SAUVAGE de madagassiske Aal til to Arter: *Anguilla Hildebrandti* SAUV., som er funden i den nordvestlige Del af Madagascar og desuden “sur le versant oriental de cette même île dans les hautes forêts”, og *Anguilla Delalandii* KAUP, om hvilken det meddeles, at den paa Østkysten bærer Navnet “Tona”.

Réunion.

MARTENS (1869—73, p. 144) anfører *Anguilla Marmorata* QUOY & GAIMARD som forekommende paa Réunion.

Mauritius.

PETERS (1876, p. 445) anfører *Anguilla labiata* PETERS blandt de af Prof., Dr. K. Möbius paa Mauritius samlede Fisk.

Asien.

Om der findes Aal i det sydlige Arabien, er mig ubekendt, ligesom overhovedet ichthyologisk Litteratur omhandlende disse Egne.

Den persiske Bugt.

Ifølge PALACKY (1891, p. 185) har den Chesney'ske Expedition fundet Aalen i Tigris Floden.

Britisk Indien.

DAY (1878, p. 659—660) henfører de indiske Aal til 2 Arter, nemlig:

1. *Anguilla bicolor*, med følgende Synonymer:

- Muraena anguilla* RUSSELL, Fish. Vizag., 8, p. 22, t. 31.
- A. bicolor* MC. CLELLAND, Calc. Journ. Nat. Hist., V, p. 178, t. 6, f. 1.
- A. mod* BLEEKER, Java, p. 22: KNER, Novara, Fische, p. 369.
- A. bicolor* and *mowa* BLEEKER, Muræn., 16, 17; KAUP, 51, 53, fig. 44; KNER, Novara, Fische, p. 368; GÜNTHER, Cat., VIII, 36.
- A. Malgumora*, *Celebensis*, *Bleekeri*, *Malabarica* and *Cantori*, KAUP, Apod. F., KNER, Novara, p. 367.
- M. moa*, *malgumora* and *sidat*, BLEEKER, Atl. ichthiol., IV, p. 10, 11. "Jee-tah-dah", Andamanese.

2. *Anguilla bengalensis*, med følgende Synonymer:

- M. anguilla* & *maculata*, HAM. BUCH., Fish. Ganges, p. 22, 23; DAY, Fish. Mal., p. 244 (in part).
- A. bengalensis*, GRAY & HARDW., Ill. Ind. Soc.; GÜNTHER, Cat. VIII, p. 27.
- A. Elphinstonei*, SYKES, Transact. Zool. Soc. London, II, 377, pl. 67; JERDON, M. J. L. and Sc., 1849, p. 346.
- A. Mauritaniana*, BENNETT, Proceed. Zool. Soc., 1831, p. 113; GÜNTHER, Cat., VIII, p. 25.
- A. labrosa*, RICHARDS., Voy. Erebus and Terror, Fishes, p. 113.
- A. brevirostris*, *variegata*, *nebulosa* and *Arracana*, MC. CLELLAND, Calc. Journ. Nat. Hist., V; BLEEKER Beng., p. 153.
- A. marmorata*, KAUP, Apodal Fish., p. 43 (not QUOY & GAIMARD).

Endvidere siger DAY l. c. p. 660:

"A. Mauritaniana BENNETT, A. labrosa RICHARDSON, M. maculata BLEEKER, A. Johannæ GÜNTHER, *Muraena marmorata* KNER, are terms employed for an Eel which appears to be a variety of this fish in which the origin of the dorsal fin is only about $\frac{1}{2}$ the length of the head before the vent".

I sit andet Hovedværk om Indiens Fiske omtaler DAY (1889, p. 86, 87) ligeledes de indiske Ferskvandsaal, som han ogsaa her henfører til to Arter: den marmorerede *Anguilla bengalensis* og den ensfarvede *A. bicolor*. Der synes efter DAY ikke at være nogen karakteristisk Forskel i Udbredningen af de to Arter; thi om den første udtales det, at den beboer "islands of the Indian Ocean, Continent of India and Burma" samt Andamanerne, medens den sidste siges at bebo "Coasts of India to the Andamans" etc.

Aalene synes ikke at spille nogen stor økonomisk Rolle, ialtfald ikke for Euro-pærne; DAY siger herom:

"Being seldom eaten except by the lower classes, there is but little demand for them".

DAY specificerer ikke sin Omtale af, hvor i Britisk Indien Aalen forekommer, men at den findes overalt i Kystegnene, fremgaar af mange andre Forfatteres Arbejder. Exemplarer omtales saaledes f. Ex. fra *Bombay* (*Ang. Cantori*, KAUP, 1856, p. 52), fra *Malabar-Kysten* (*A. dussumieri*, GÜNTHER, Cat., 1870, p. 37; *A. malabarica*, KAUP, 1856, p. 53), *Nilgherries*, *Ceylon*, *Madras* (*A. bengalensis*, GÜNTHER, Cat., 1870, p. 27); *Almorah* (*A. mauritiana*, GÜNTHER, Cat., 1870, p. 26); *Ganges* (*Muræna anguilla*, HAM. BUCH, Fish. Gang. p. 22) osv. osv.

VINCIGUERRA (1890, p. 358) angiver *A. bicolor* MC. CLELL. fra Rangoon i Burma. Han tilføjer, at det er sandsynligt, at *A. sidat* BLEEKER og *A. virescens* PETERS ikke er artsforskellige fra *A. bicolor*. Som ovenfor anført angiver DAY, at baade *A. bicolor* og *A. bengalensis* forekommer paa Andamanerne.

Ostindiske Archipelag.

Jeg skal her ikke komme ind paa de talrige Arbejder, der omtaler Forekomsten af Ferskvandsaal i de to ostindiske Archipelag, da dette rettelig henhører under Stillehavsområdet, som først ved en senere Lejlighed vil blive behandlet, og desuden fordi det vil være hensigtsmæssigt forinden at søge at udrede de i Ostindien forekommende Aals Systematik, hvortil jeg har fortrinlig Anledning efter fra Hr. Mag. sc. HJ. JENSEN paa Java at have modtaget nogle meget store Samlinger af udmærket konserverede Aal. Jeg skal derfor kun anføre to Arbejder her.

WEBER (1894, p. 428) anfører *Anguilla sidat* BLEEKER fra Manindjau (Sumatra) og oplyser, at denne Fisk i Tempe hedder "Bale Masapi".

BLEEKER (1864, p. 8) anfører følgende:

"Les Anguilles de l'Inde archipelagique pourraient remplir un rôle assez important comme nourriture des populations indigènes tant par leur chair exquise, que par leur nombre et par leurs dimensions, mais il ne paraît pas qu'on les mange partout, pas même à Java, où en général elles sont peu recherchées, si ce n'est que par les Européens et les Chinois".

Vi vil da nøjes med at konstattere, at Ferskvandsaal (og baade marmorerede og ensfarvede) forekommer i Mængde i det ostindiske Archipelag og hermed ved den østlige Rand af det indiske Ocean, saavel som ved den vestlige.

III. OM DE AARSAGER, SOM BETINGER FERSKVANDS-AALENES UDBREDNING.

Som Hovedresultat af vor Undersøgelse over Ferskvandsaalenes Udbredning fandt vi altsaa, at de forekom ved Nordamerikas atlantiske Kyster og i Vestindien, men manglede ved Sydamerikas Atlanterhavskyst (undtagen i Guiana) samt baade ved Sydamerikas og Nordamerikas Stillehavskyster. De fandtes paa næsten alle de atlantiske nord for Ækvator beliggende Øer, de manglede ved Ishavets Kyster i Sibirien og det nordlige Rusland, men fandtes lige fra Nordcap i det nordligste Norge og videre sydpaa ved alle det nordlige og vestlige Europas Kystlande. Fremdeles fandtes de ved alle Middelhavets Kyster undtagen det Sorte Havs, ved det nordvestligste Afrikas Kyst indtil de canariske Øer. Derimod manglede de omtrent fra Senegal og sydefter paa Afrikas Vestkyst, baade paa Guineakysten, i Nigeria Camerun, Congo, Angola og Tysk Sydvestafrika. Først i Kapkolonien træffer vi igen Ferskvandsaal, men derefter findes saadanne videre op langs hele Østkysten af Afrika (foruden paa Øerne ud for denne Kyst) ialtfald saa langt mod Nord som til Somaliland (om der findes Ferskvandsaal ved Kysterne af det røde Hav, kan ikke oplyses med Sikkerhed). Endelig er de tilstede paa Asiens Sydkyst i det mindste fra den persiske Bugt og videre østefter i Britisk Indien til den malayiske Halvø samt i det malayiske Archipelag.

Af denne Oversigt fremgaar det, at Ferskvandsaalene har en meget vid Udbredning. Tager vi saaledes *Anguilla vulgaris* og undersøger, hvor den forekommer, vil vi se, at den er udbredt fra Island og Nordcap (Norge) i Nord til Middelhavet, Nordvestafrika, Azorerne, Madeira og de canariske Øer i Syd, medens den amerikanske Ferskvandsaal (*Anguilla chrysypa*) forekommer lige fra Syd-Grønland og Labrador og sydefter til Vestindien og Guiana, altsaa baade i arktiske, tempererede og rent tropiske Egne. Dette er yderst ualmindeligt for en Ferskvandsfisk og lige saa ualmindeligt er det, at vi genfinder baade den europæiske og amerikanske *Anguilla* paa adskillige rent oceaniske Øer, den første saaledes paa Madeira og Azorerne, den anden paa Bermudas Øerne, skønt Ferskvandsfisk ellers mangler paa flere af de Øer, hvor Aalene forekommer. Men mest af alt er det dog ejendommeligt at se (jfr. Udbredningskortet), hvorledes Aalen, der f. Ex. paa den vestlige Side af Atlanterhavet gennemskrider baade den arktiske, tempererede

og en stor Del af den tropiske Zone, standser i det nordlige Sydamerika, saa at der i Størstedelen af Sydamerika ikke findes Aal, og noget lignende ser vi er Tilfældet ved den østlige Side af Atlanterhavet, selv om den her ikke naaer fuldt saa langt mod Syd som ved den vestlige. Vi skal nu i det følgende diskutere de forskellige mulige Aarsager til denne Aalenes ejendommelige Udbredning.

Inden denne Diskussion begyndes, skal jeg fremhæve to Forhold, som er af Betydning. 1) For det første at Ferskvandsaalene yngler i Havet. At dette er Tilfældet, tør vel nu tildags betragtes som endeligt fastslaaet (jfr. p. 165). Bevist er det i hvert Fald for baade den europæiske Aal (*A. vulgaris*) og den amerikanske (*A. chrysypa*), idet man af begge har fundet Larvestadierne (*Leptocephalus*) ude i Oceanerne fjærnt fra Land (jfr. SCHMIDT, 1906, p. 194—95, og EIGENMANN & KENNEDY, 1902, p. 84). For de andre *Anguilla*-Arter mangler Beviset endnu, men der er vel neppe nogen rimelig Grund til, at ikke ogsaa de skulde yngle i Havet. Forøvrigt vil vi her kun beskæftige os med den europæiske og amerikanske Aal, der i alle Forhold er de, som er bedst kendte. 2) For det andet, at Fiskene for at kunne udføre deres Forplantning ofte kræver ganske andre Vilkaar end dem, hvorunder deres Opvæxt og øvrige vegeterende Liv foregaar. Denne Sag har jeg ved flere tidligere Lejligheder nærmere udviklet (SCHMIDT, 1906, p. 234 ff., 1907, p. 11—12, 1909 a, p. 11—12) og behøver derfor ikke at komme ind paa den her. Men naar man som her søger at forstaa, hvorfor f. Ex. en Fisk mangler i en eller anden Egn, vil man indsee, at Spørgsmaalet derfor i Grunden opløser sig i to: om der paa det paagældende Sted ikke er Betingelser tilstede for, at Forplantning kan foregaa, eller om Grunden er, at Forholdene er saaledes, at de ikke er gunstige for Fisken i de andre Perioder af dens Liv, saaledes f. Ex. under Opvæxten. Hvor vigtigt det er at skelne imellem disse to Forhold, vil med stor Klarhed fremgaa af det følgende.

Naar en Fiske-Art, tilmed en Art, der lever i Ferskvand, kan have en saa overordentlig vid Udbredning som baade den amerikanske og den europæiske Aal, kan man ved at se paa Kortet ikke undlade at forundre sig over, at dens Udbredning mod Syd netop standser der, hvor den gør, thi i ganske særlig høj Grad har en Art som denne med dens Yngels enestaaende langvarige pelagiske Liv (jfr. SCHMIDT, 1906, p. 262) Betingelser for i Løbet af Artens Historie at udvide sit Forekomstomraade. Naar, som vi ser, Forholdet er saaledes, ligger det nær at begynde vore Betragtninger netop med at spørge, hvorfor ingen af dem har kunnet trænge længere sydpaa, saa at de mangler baade i Sydamerikas og Vestafrikas store Flodssystemer. Paa Forhaand kunde man tænke sig en eller flere af følgende Aarsager:

- 1) Ugunstige Temperaturforhold.
- 2) Mangel paa tilgængeligt Ferskvand.

- 3) Mangel paa passende Næring eller Vandets Uskikkethed til Aalenes Trivsel af kemiske Aarsager.
- 4) Mangel paa Tilgang af Yngel.

Om de under 1) nævnte Forhold kan det strax siges, at Aarsagen til Aalenes Mangel i Sydamerika og Vestafrika ikke kan være Mangel paa saadanne Vandtemperaturer, som er nødvendige for deres Trivsel, thi baade i Sydamerika og Vestafrika vil man genfinde de samme Temperaturforhold som dem, hvorunder de trives fortræffeligt f. Ex. i Nordamerika og i Vestindien. Om 2) kan det strax siges, at i Sydamerika og Vestafrika findes nogle af Jordens største og vigtigste Floder (f. Ex. Amazon- og La Plata-, Gambia-, Niger- og Congo-Floderne), hvorved denne Mulighed strax udelukkes¹. Heller ikke det under 3) nævnte Forhold har nogen Sandsynlighed for sig, thi begge de nævnte Omraader er fulde af fiskerige Floder, som derfor maa antages at indeholde Næring nok til, at Aalene kunde leve der, hvis der ellers var Betingelser herfor. At det paa mange Steder i Verden er lykkedes at indføre Ferskvandsfisk (f. Ex. Karper, Lax og Ørred), hvor saadanne tidligere ganske manglede, saaledes i Nordamerika fra de atlantiske Stater til Stillehavstaterne og fra Europa til flere af Øerne i det atlantiske og pacifiske Ocean, synes ogsaa at vise, at det ikke kan være Næringsmangel eller specielle kemiske Forhold i disse Egnes ferske Vande, der gør, at Aalene mangler der. Jeg skal her ogsaa minde om, at man i de Forenede Stater har forsøgt Transplantation af Ferskvandsaal fra Atlanterhavskysten til Stillehavskysten, hvor de jo mangler. Saa vidt jeg har kunnet faa Underretning herom, trivedes Aalene særlig godt, og det samme gælder dem, der utsattes i Donau Floden, hvor Aal jo ogsaa mangler, hvad der navnlig er af Interesse i denne Sammenhæng. (En anden Sag er det, at det naturligvis i ingen af Tilfældene lykkedes at faa Aalene til at forplante sig. Vil man indføre Aal saadanne Steder, hvor de ikke findes ved naturlig Tilgang, maa man være klar over, at der kun kan blive Tale om en Opdrætning af de oplantede Exemplarer, ikke om en Propagering af disse, se mere herom S. 165 ff.).

Vi er nu naaede saa vidt i vor Udvikling, at vi maa acceptere det under 4) nævnte Forhold, nemlig Mangel paa Tilgang af Yngel, som Forklaring paa Mangelen af Aal i Sydamerika og Vestafrika. Herved føres vi naturligt over til at spørge, hvorfor der er Mangel paa Tilgang af Yngel, og derved fremdeles til at beskæftige os med Ynglepladserne og de ydre Faktorer, som bestemmer disse. Herved er vi naaede til Sagens Kerne. I mit første Arbejde om Aalen (1906) havde jeg vist, at Aalene fra Landene ved den nordøstlige Del af Atlanterhavet yngler i Havet vest for Europa fjernet fra Kysterne, hvor Dybderne er mindst ca. 1000 Meter,

¹ Som en Forklaring paa Mangelen af Ferskvandsaal ved Amerikas Stillehavskyst har jeg set fremsat Mangelen paa store Floder. Dette kan neppe være Grund nok dertil, dersom der ellers havde været Aaleyngel nok i Havet udenfor; thi dersom det sidste var Tilfældet, skulde den nok vide at finde, hvad der var af Ferskvand. Saaledes har vi jo hørt, at der vrimlede af Aal paa de næsten ferskvandsløse Bermudas Øer (se S. 140), og i de vestindiske Øers en stor Del af Aaret udtrørrede Smaabække finder Aaleyngelen ogsaa med Lethed op.

men kun saadanne Steder, hvor Temperaturen i Dybet er høj, nemlig ca. 7° eller derover i 1000 Meters Dybde, saa at f. Ex. hele Nordhavet vest for Norge bliver udelukket som Yngleplads paa Grund af de lave Temperaturer, under 1° i 1000 M. Dybde.

Det laa nu nær at prøve, hvorvidt de dengang fundne Forhold ogsaa havde Gyldighed for de andre Egne af Jorden, hvor *Anguilla vulgaris* og den nærbeslægtede *A. chrysypa* forekommer, og jeg fik da ved velvillig Hjælp af Hydrografeerne Cand. mag. I. N. NIELSEN og Mag. Scient. H. HANSEN efter Challenger-, Valdivia- og andre Dybhavsexpeditioners hydrografiske Resultater indtegnet Temperaturkurverne for 1000 M. Dybde paa et Verdenskort, saaledes som det ses af Kortet Pl. I.¹. Betragter man disse for det atlantiske Ocean, forekommer det mig, at med eet bliver Mangelen af Aal i Sydamerika og Vestafrica forstaaelig. Vandet er her i Dybet for koldt til, at Aalens Forplantning kan finde Sted. Vi ser saaledes 6° og 5° Isothermerne forløbe fra Vestindien østefter over mod Cap Verde, saa at hele den store Del af Atlanterhavet Syd herfor har lavere Temperaturer i 1000 Meters Dybde. Ud for Størstedelen af Brasilien er Temperaturen endog kun mellem 3 og 4 Grader C., udfor Vestafrica lidt højere, for Størstedelen mellem 4 og 5 Grader, men ingen af Stederne altsaa naaende den Højde, som jeg ved Undersøgelserne med „Thor“ i 1904—1906 udfor Nord- og Vesteuropa havde fundet maatte være Minimumstemperaturen for Aalens Forplantning, nemlig ca. 7 Grader i 1000 Meters Dybde.

Ogsaa ved Stillehavskysten af Amerika er, som vi ser af Kortet, Temperaturerne i Dybet lave, idet de intetsteds naaer op til 7° i 1000 Meters Dybde, og i den største Del af Omraadet er de under 5 Grader. Derimod træffer vi Øst for Afrika i det indiske Ocean noget højere Temperaturer ligesom ogsaa Syd for Asien. Som det fremgaar af Kortet, genfinder vi ved disse Kyster Ferskvandsaal (jfr. ogsaa S. 147 ff.) omend ikke de samme Arter som i Atlanterhavsomraadet.

At Aalenes Udbredning sydefter ved Atlanterhavets Kyster er i meget god Overensstemmelse med Temperaturerne i Dybet, ses let af Kortet, og vi er da hermed komne saa vidt i vore Betragtninger, at vi kan udtale følgende uden nærmere Forklaring tilsyneladende paradoxale Sætning: I Sydamerika og Vestafrica, der jo indeholder nogle af Jordens hedeste Egne, er der ikke desmindre for koldt til, at Aalen, denne Fisk som i visse Stadier af sit Liv endog kan trives nord for Polarkredsen, kan existere, fordi den i en Periode af sit Liv, Forplantningstiden, forlanger højere Temperaturer, end der findes udfor disse Dele af Jorden paa saa store Dybder af Havet, som den kræver for at kunne forplante sig.

Det er nu paa Tide at undersøge, hvorvidt den her fremsatte Forklaring paa Aalenes Mangel i Sydamerika og Vestafrica ogsaa lader sig forene med disse Fiskes faktiske Udbredning indenfor den øvrige Del af det atlantiske Omraade.

For den østlige Del af Atlanterhavsomraadet (Vesteuropa og Nordvestafrika, Azorerne, Madeira og Canarerne) viser et Blik paa Kortet, at Forklaringen synes

¹ Det hos KRÜMMEL (1907, p. 429) givne Kort blev senere ogsaa benyttet.

at stemme godt nok; thi vi ser, at Aalen (*Anguilla vulgaris*) netop findes overalt i de Egne, som er beliggende ved Havomraader, hvor Temperaturen i 1000 Meters Dybde er fra ca. 7° og derover, d. v. s. de Temperaturer, hvorunder Forplantningen ifølge mine Undersøgelser med "Thor" foregaar. Saaledes er der Grund til at bemærke, at de aalerige oceaniske Øgrupper Azorerne, Madeira og Canarerne alle ligger i den Del af Atlanterhavet, hvor Temperaturen i Dybet er højest, nemlig over 8° i 1000 Meters Dybde. En lidt nærmere Betragtning af Kortet viser os dog strax, at Forholdet ikke overalt er saa enkelt, at Aalene udelukkende er indskrænkede til de Egne, udfor hvilke Havets Temperatur i 1000 Meters Dybde er over ca. 7° . Dette træder saaledes med Tydelighed frem ved det nordlige Europa (f. Ex. ved Norge), og det viser, at ogsaa andre Momenter maa være medvirkende. Med Hensyn til Nordeuropa har jeg allerede tidligere (SCHMIDT; 1906, p. 204—231) drøftet denne Sag og vist, hvorledes hele Vest- og Nordeuropa forsynes med Aaleyngel fra de store Produktionscenter, som ligger Vest for de britiske Øer og Frankrig, samt hvorledes den Mængde Yngel, et Sted modtager, i første Linie afhænger af Stedets Afstand fra disse Ynglepladser og af, i hvilken Grad de herskende Strømretninger begunstiger Yngelens passive og aktive Indvandring til Stedet. Vi fik derved en Forklaring paa, hvorfor Aalen aftager saa stærkt i Mængde indefter i Østersøen, og ligeledes paa, hvorfor den er saa almindelig i det sydlige og vestlige Norge, men bliver sjældnere og sjældnere nordpaa i dette Land, indtil den tilsidst helt hører op. Vi saa saaledes, at det var betydelige Distancer Aalen som Yngel kunde tilbagelægge og derved udstrække sit Forekomstomraade til langt fra Ynglepladserne bortfjernede Egne (jfr. Afstanden fra Havet V. for de britiske Øer til den indre Østersø), omend der selvfølgelig er Grænser herfor, idet en Egn naturligvis kan ligge saa fjernet fra Ynglepladserne, at der ikke er nogen Mulighed for, at Yngelen ved de passive og aktive Vandringer, den har i sin Magt at udføre, kan naa saa vidt¹⁾. Vi saa da ogsaa, at Aalen manglede eller var yderst sjælden Øst for Nordcap i det nordlige Norge, men alene det, at den kan naa saa langt som hertil og til den indre Østersø, giver os netop en udmarket Forestilling om de store Distancer, den kan tilbagelægge fra Ynglepladserne, et Faktum, det er af stor Betydning at have konstateret, naar det drejer sig om at forstaa Forholdet i andre af Jordens Omraader, specielt ved Amerikas Østkyst, saaledes som vi snart skal se.

Jeg skal derefter gaa over til at omtale Forholdet i den **vestlige** Del af Atlanterhavsomraadet, hvor det jo ikke længer drejer sig om *Anguilla vulgaris*, men om den nærbeslægtede *Anguilla chrysypa*. Vi mødes her af den Vanskelighed, at

¹⁾ I mit Arbejde over de nordatlantiske Gadoiders Ynglepladser (SCHMIDT, 1909 a, p. 156) har jeg udførligt omtalt, at der foregaar en storstilet Drift af pelagiske Organismer fra Atlanterhavet nord om de britiske Øer ind i Nordhavet og Nordsøen. Jeg vedfører herfra en Figur (S. 158), som viser Omfanget af denne Drift i Sommeren 1905, og hvorfra det tydeligt fremgaar, at Aaleyngelens østgaaende Vandring i høj Grad maa begunstiges af denne Drifts Aarsag. Som et direkte Bevis for, at Driften har Betydning for Aaleyngelens Transport, kan anføres, at ifølge velvillig Meddeelse fra Dr. HELLAND-HANSEN i Bergen fandtes i Oktober 1907 en delvis forvandlet Larve (i 3de Stadium, jfr. SCHMIDT, 1906, p. 168) af den alm. Aal i Skærgaarden ved Bergen.

vi har at gøre med en anden, omend nok saa nærstaaende Form, saa at det derfor ikke er berettiget uden videre at gaa ud fra, at den i sine biologiske Forhold er identisk med den europæiske Ferskvandsaal. Dog vil det følgende vise, at den efter al Sandsynlighed ligner denne saa meget, at dens Udbredning maa finde en lignende Forklaring.

Medens den europæiske Aals Ynglepladser er nogenlunde godt kendte ved

Fundet af mange Hundrede Larvestadier over en meget stor Strækning (se Kortet¹) har vi for den amerikanske Aals Vedkommende til Dato kun Fundet af tre Larver at støtte os til, naar det gælder at udfinde, hvor i Havet denne Arts Ynglepladser er beliggende. EIGENMANN & KENNEDY (1902, p. 84) beretter om de to af disse. De blev taget paa $38^{\circ} 47' 20''$ N. Br., $72^{\circ} 37' 00''$ V. L. den 5. Nov. 1883 og paa $38^{\circ} 25'$ N. Br., $72^{\circ} 40'$ V. L. Den tredje, som allerede har været nævnt i dette Arbejde p. 140, fandtes islandrevnen paa Bermudas Øerne i September Maaned 1906. Disse 3 Fund er afsatte paa Kortet, hvoraf man ser, at de netop forekommer indenfor eller nær ved det Omraade, hvor Temperaturen i Dybet (1000 Meter) er højest i hele den vestlige Del af Atlanterhavet². At det netop er herfra, at vi har Underretning om Forekomsten af *Anguilla chrysypa*'s Larver og dermed til en vis Grad

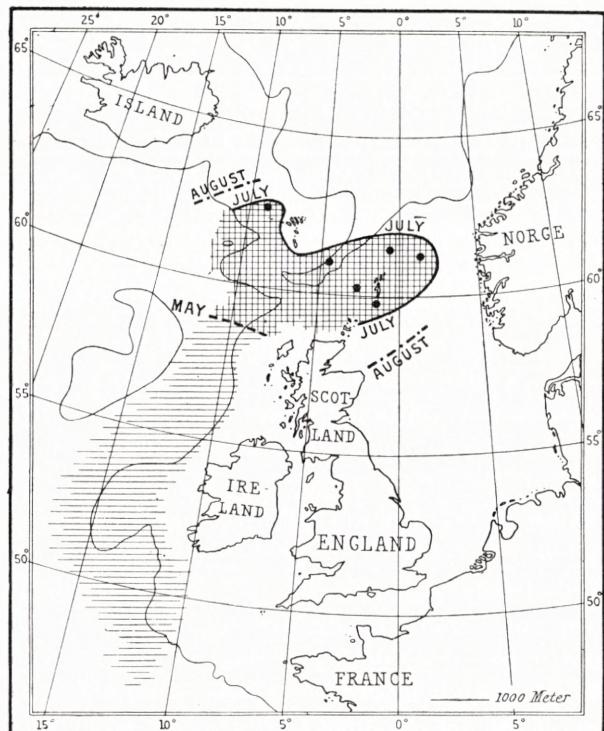


Fig. 1.

Drift af Salper (*Salpa fusiformis*) efter »Thor's« Undersøgelser. De skraverede Omraader angiver Udbredningen af Salperne i Mai—Juli 1905. I Mai laa Nord- og Østgrænsen Vest for Skotland, men i Juli var de flyttede langt mod Nord og Øst og i August endnu længere.

om denne Arts Yngleplads, kan jeg ikke ansé for tilfældigt, tværtimod maa jeg an-

¹ Ved det Togt med "Thor" til Middelhavet og de tilgrænsende Dele af Atlanterhavet, jeg har foretaget i Vinteren 1908—09, fandt jeg Aalens Larver saa langt mod Syd i Atlanterhavet som til udfor Vestkysten af Marocco. De er saaledes nu paavist paa hele Strækningen fra Vest for Færøerne til Vest for Marocco.

² Jeg kan her indskyde den Bemærkning, at jeg efterat have faaet Temperaturene i 1000 Meters Dybde aflagt paa Kortet og studeret deres Fordeling, følte mig overbevist om, at den amerikanske Aal maatte forekomme paa Bermudas Øerne, der jo ligger nær ved Centret for de højeste Temperaturen. Derfor lod jeg mig ikke nøje med, at Ferskvandsaalen ikke forekom i den eneste mig tilgængelige Liste over Bermudas Fiske, af GÜNTHER (Challenger, 1880, p. 8—9), men søgte nærmere Underretning i denne Sag, hvad der, som nævnt S. 140, resulterede i, at det blev oplyst, at *Anguilla chrysypa* tiltrods for Bermudas Øernes Mangl paa Ferskvand forekommer almindeligt overalt paa disse Øer.

tage, at vi netop her, omkring ca. 35° N. Br. og ca. 70° V. L., befinder os nær Produktionscentret for den amerikanske Aal, der da rimeligvis maa have noget lignende Fordringer til Temperatur og Saltholdighed som dens nære europæiske Slægting.

Naar vi paa Kortet studerer Udbredningen af den amerikanske Aal, ser vi, at dens Forekomst i Vestindien med Guiana, Mexico og de Forenede Stater ikke frembyder noget mærkeligt¹. Mere paafaldende er Forekomsten i Canada, Newfoundland og Labrador, thi, som Kortet viser, er Temperaturerne i Dybet udfør de sidstnævnte Lande yderst lave, kun ca. 2° til 3° i 1000 Meters Dybde. Med hvad vi lærte om den europæiske Aals overordentlig store Evne til at foretage vidstrakte Vandringer, baade som Yngel og som ældre, bliver denne Forekomst dog mere forklarlig, særlig naar vi tager et Strømkort for os. Af et saadant, f. Ex. Kort No. 2640 (3528) udgivet af det engelske Admiralitet under Titlen "Pacific, Atlantic and Indian Oceans, Mean directions and velocities of their stream and drift currents", vil man se, at der maaske intetsteds i Verden er saadanne Betingelser for en effektiv passiv Transport af pelagiske Organismer ved Hjælp af Havstrømmene som netop udfør Kysten af de Forenede Stater og nordefter, d. v. s. fra det Omraade, hvor den amerikanske Aal vides at yngle, til udfør Canada og Newfoundland. Saaledes angiver Strømkortet her maximale Hastigheder af ikke mindre end 40—80 miles pr. Døgn, medens Minimalhastighederne angives til 10—15 miles, Hastigheder som selvfølgelig i høj Grad vil fremskynde Aaleyngelens Vandring nordefter og muliggøre, at den kan naa længere i denne Retning, end det ellers vilde kunne ske. Iøvrigt vil man ved at sammenligne Distancerne med dem, vi kender for den europæiske Aals Vedkommende, se, at de gennemgaaende slet ikke er større (smlgn. paa Kortet Afstandene fra Findestederne for Larverne af *A. chrysypa* Øst for de Forenede Stater til Canada, Newfoundland, Labrador, ja selv til det sydlige Grønland, med Afstandene fra den europæiske Aals Ynglepladser V. for de britiske Øer og Frankrig til det nordlige Norge og den indre Østersø).

Med denne Betragtning stemmer den store Aalerigdom i Canadas mest maritime Provinser, New Brunswick, Nova Scotia og Prince Edward Island, og i de Forenede Staters østlige Dele, særdeles godt, som man vil se af Kortet. Men vi har ogsaa et

¹ Ved en Betragtning af Kortet vil man se, at i det caribiske Hav er Temperaturen i 1000 Meters Dybde kun mellem 5° og 6° , og der foreligger heller ikke noget, som tyder paa, at der produceres Aal i dette Hav. Tværtimod synes Mangelen eller i hvert Fald Sparsomheden af denne Fisk i Centralamerika og de tilgrænsende Dele af Sydamerikas Nordkyst (Venezuela, Columbia) nærmest at tyde paa det modsatte, medens den sikkert konstaterede Forekomst af Aal ved Nordgrænsen af det caribiske Hav over hele den direkte af Atlanterhavet beskyllede Strækning fra Cuba østefter over den vestindiske Ørække til det dermed i Flugt liggende Guiana meget vel lader sig forklare som stammende fra Produktionsstederne i Atlanterhavet.

Med Hensyn til Spørgsmaalet om, hvorvidt Aalen yngler i den mexikanske Golf, hvor Temperaturen i 1000 Meters Dybde kun er mellem ca. $4\frac{1}{2}^{\circ}$ og 6° (KRÜMMEL, 1907, p. 459), da foreligger der jo ingen direkte lagtagelser i den Retning, saa vidt mig bekendt, og der er intet, som viser, at det maa være Tilfældet. I hvert Fald kan det neppe dreje sig om nogen stor Produktion. Dette ser man af den relative Sparsomhed af Aal i det centrale Omraade af de Forenede Stater (jfr. S. 128), hvor der jo kun toges ca. 2 % af Staternes samlede Udbytte af Aal, og endvidere af at Aalen, ifølge det foreliggende, ikke er nogen videre hyppig Fisk i Mexico, hvor den sydefter endog siges ganske at forsvinde.

andet Middel til at prøve Rigtigheden af den her fremsatte Anskuelse, at disse nordlige Landes Aalebestand rekruterer fra Jængt sydligere beliggende Dele af Havet. Vi kan saaledes for Kysten af Nordamerika gøre en lignende Betragtning gældende, som jeg tidligere har anvendt for Europa (SCHMIDT, 1906, p. 217 ff.), nemlig undersøge, hvorvidt Tidspunktet for Aaleyngelens Opgang paa forskellige Steder i de Forenede Stater, Canada osv. stemmer med den Antagelse, at hele Nordamerikas Aalebestand stammer fra Ynglepladserne udfør de Forenede Staters Østkyst. Paa en detailleret Undersøgelse i denne Retning har jeg ikke ment at kunne indlade mig; dette vilde have krævet langt mere Tid, end jeg har til Raadighed, og vil desuden kunne gøres baade lettere og bedre af amerikanske Naturforskere, for hvem der heri foreligger en smuk og sikkert meget taknemmelig Opgave. Jeg skal derfor indskrænke mig til nogle faa Betragninger, som iøvrigt synes at vise, at den omtalte Tankegang er rigtig. — De Oplysninger, der foreligger om Aarstidsfænomenerne for den amerikanske Aals Larvers og Glasaaals Opræden, er langtfra saa fuldstændige som for den europæiske Aals Vedkommende. Dog er de tilstrækkelige til at vise, at disse Fænomener ikke er sammenfaldende med Hensyn til Aarstiden. Medens det 1ste Larvestadium af *Anguilla vulgaris* fortrinsvis optræder om Forsommeren, er det tilsvarende Stadium af *Anguilla chrysypa* hidtil kun fundet om Efteraaret, og paa samme Maade synes, saavidt de sparsomme Oplysninger rækker, de efterfølgende Udviklingstrin (5te og 6te Stadium eller "Glasaal" og "montée") af den amerikanske Aal at optræde ca. $\frac{1}{4}$ — $\frac{1}{2}$ Aar senere end de tilsvarende Stadier af den europæiske Aal. Vi skal herefter betragte Tidspunktet for Aaleyngelens Opgang paa nogle af de faa Steder af Østkysten af Nordamerika, om hvilke jeg har kunnet skaffe mig Underretning.

Tidspunktet for Aaleyngelens Opgang.

Den Side 131 omtalte Aaleyngel, paa hvilken jeg talte Hvirvler, stammede fra Woods Hole, Mass., som ligger ved den aabne Havkyst. Yngelen, som toges 1ste Marts, er meget svagt pigmenteret ("Glasaal"). Derfor afgiver Tidspunktet for dens Fangst et ganske nyttigt Kriterium for Bedømmelsen af den Aarstid, paa hvilken Glasaalene ankommer til denne Del af de Forenede Staters Kyst, herefter allerede i Slutningen af Vinteren og det tidlige Foraar.

Paa Forespørgsel meddeler Mr. BARTON A. BEAN fra "U. S. National Museum" følgende:

"The young eels swarm in their migration up our east coast rivers in March and April (Susquehanna and Potomac); in southern rivers earlier".

SMITH og BEAN (1899, p. 183) udtales:

"In spring the young ascend the river, large straggling schools being seen along the rocky shores above Georgetown".

NORNY (1885, p. 315) er mere nøjagtig med Hensyn til Tidspunktet. Han anfører følgende Iagttagelser fra Odessa, Del. fra Midten af April:

"At the same time the flats here at low water, just at the waters edge, when the sun shone warm, showed myriads of young eels, not larger than a cambric needle".

Paa Forespørgsel meddeler Dr. HUGH M. SMITH, fungerende "Commissioner of Fisheries," Washington, følgende i Brev af 29de April 1909:

"The elvers or "glass-eels" appear in streams on our Atlantic coast in spring. In Maine they have been observed early in May".

SAWYER (1887, p. 218) siger:

"— — — as early as May large numbers of the little eels can be seen ascending the streams".

Den sidste Iagttagelse, som refererer sig til Millrift, Pike County, PA., omtrent 150 miles højere oppe ad Delaware Floden end det ovenfor omtalte Odessa, og som saaledes svarer meget godt til den fra Odessa, kan ikke anvendes til Sammenligning med Iagttagelserne fra de tidlige nævnte Steder, der er beliggende nærmere ved Kysterne.

Ovenstaaende er tilstrækkeligt til at vise, at Aaleyngelens Opgang finder Sted paa de Forenede Staters Østkyst omkring 40° N. Br. i det tidlige Foraar eller endog i Slutningen af Vinteren. Efter Mr. BARTON A. BEAN's Angivelse foregaar Opgangen tidlige i de længere mod Syd beliggende Floder.

Canada. Som nævnt Side 125 meddeler Professor E. E. PRINCE, "Commissioner of Fisheries for Canada", i Brev følgende:

"The Elvers ascend from the Sea in July and August".

Af hvad her er anført, fremgaar at ved Østkysten af Nordamerika synes Aaleyngelens Opgang i det ferske Vand at ske tidlige paa Aaret længere sydpaa, d. v. s. i den Del af de Forenede Stater, som ligger udfor de Steder, hvor Aalen gennem Fund af Larver vides at yngle, end længere nordpaa, f. Ex. i Canada. Forholdet er saaledes tilsyneladende ganske parallelt med det, jeg tidlige har omtalt for Europas Vedkommende: jo fjernere fra Ynglepladserne, desto senere Opgang af Yngelen. Men endnu har vi langtfra saa fuldstændige Oplysninger fra Amerika som fra Europa, og vi maa derfor haabe, at denne interessante Sag maa blive taget op til nærmere Undersøgelse af amerikanske Naturforskere. Saameget ved vi dog allerede, at Tiden for Opgangen strækker sig lige fra det tidlige Foraar til Eftersommeren (jfr. Marts i Massachussets og August i Canada), altsaa ligesom ved Europa over et Tidsrum af adskillige Maaneder, men tilsyneladende senere paa Aaret end i Europa i Overensstemmelse med, at Larvestadierne optræder senere end Hovedmassen af den europæiske Aals Larver.

Jeg maa i denne Sammenhæng ogsaa henvise til, hvad der tidlige i dette Skrift (jfr. S. 128) er udviklet om Aale-Tæthedens i de Forenede Stater paa Grundlag af den officielle Fiskeristatistik. Vi saa heraf, at af det samlede Udbytte af Aalefiskerierne, som androg 3822,434 lbs, toges de 3740,395 lbs (eller 97,90 %) i det østlige Omraade N. for Florida. Men vi kan føre denne Betragtning endnu videre. Vi vil saaledes betragte Strækningen mellem Cape Hatteras og Cape Cod, imellem hvilke Punkter Afstanden kun er godt 450 miles. Ikke desto mindre viser det sig nu, at af de 3822,434 lbs, som udgjorde det samlede Udbytte af Aalefiskeriet i de

Forenede Stater, maa over 3 Millioner lbs stamme fra Aal, der er stegne op i ferskt Vand paa den korte Strækning mellem Cape Hatteras og Cape Cod¹, der, som det vil ses af Kortet, er beliggende lidt nordligere end det Omraade, hvor det varmeste Vand i Dybet findes.

Vi ser altsaa, at alle de foreliggende Data, som er i stand til at belyse Spørgsmålet om den amerikanske Aals Ynglepladser, viser hen til, at Produktionscentrerne paa denne Side af Atlanterhavet, hvorfra selv de nordligste Egne som Canada, Newfoundland, Labrador, ja endog det sydlige Grønland forsynes med Yngel, er beliggende udfor de østlige Dele af de Forenede Stater, d. v. s. i den Del af det vestlige Atlanterhav, hvor Temperaturerne er højest i Dybet. Den amerikanske Aal synes derfor i sine biologiske Forhold at ligne den europæiske meget, thi ogsaa dennes Ynglepladser var jo indskrænkede til de forholdsvis smaa Dele af det østlige Atlanterhav med høje Temperaturer i Dybet (i det højeste vel fra Færøerne til syd for Canarerne, men ialtfald til udfor Marokko, det sydligste Punkt, hvor jeg har fundet Larverne; se Kortet).

Efter nu at have set, at Aarsagen til Mangelen af Ferskvandsaal ved store Dele af Atlanterhavets Kyster maatte søges i altfor lav Temperatur (og Saltholdighed²) i de Dybder, hvor Aalen forplanter sig, vil der tilsidst være Anledning til at undersøge, om denne Forklaring har Gyldighed overalt indenfor det atlantiske Omraade. Dette sker lettest ved en Betragtning af Udbredningskortet. Man ser heraf, at Forklaringen overalt synes at slaa til baade for selve det atlantiske Ocean og for de Indhave, der staar i Forbindelse med dette. Kun een Undtagelse er der, nemlig det Sorte Hav, ved hvis Kyster Aal jo mangler tiltrods for den høje Temperatur, der findes i Dybet, nemlig 9°.

Forholdene i det Sorte Hav har derfor Krav paa en lidt nærmere Betragtning her. Jeg skal da efter KRÜMMEL (1907, p. 300) anføre nogle af ARSEN LEBEDINTZEFF offentliggjorte Maalinger, der er anstillede i det Sorte Hav i Aarene 1891—92 om Sommeren.

Disse Tal giver os strax Forklaringen paa, hvorfor Aalen mangler i det Sorte Hav og de hermed i Forbindelse staaende Floder. I Dybet, hvor Temperaturen vel er høj nok til at tillade Aalens Forplantning, indeholder Vandet den alt højere organisk Liv udelukkende Svovlbrinte, og rent bortset herfra er Saltholdigheden utvivlsomt ogsaa altfor lav, nemlig kun ca. 22 ‰, medens vi i Atlanterhavet fandt, at den i det mindste maatte overstige 35,20 ‰.

¹ Dette ser man simpelthen ved at addere Udbyttet af Aalefiskeriet i de Stater eller Dele af Stater, hvis Floder løber ud i Atlanterhavet indenfor den nævnte Strækning.

² Lav Temperatur og lav Saltholdighed følges stedse ad i Oceanernes dybe Vandlag ligesom høj Temperatur og høj Saltholdighed. Af denne Grund er det i og for sig umuligt at afgøre, om det er den lave Værdi af den ene eller den anden af disse Faktorer eller maaske af begge, der umuliggør Aalens Forplantning,

Det Sorte Hav.

Dybde (Meter)	Temperatur	Saltholdighed °/oo	Svovlbrinte (H ₂ S) cc
0	24°0	18.1	0
9	21°5	18.5	0
18	12°8	18.3	0
27	8°9	18.5	0
91	8°0	20.6	0
183	8°8	21.6	0.39
366	8°9	22.1	1.88
1464	9°0	22.5	4.44
2120	9°0	22.5	6.00

Det er altsaa klart, at Aalen ikke kan yngle i selve det Sorte Hav, og ser man hen til den overordentlig snævre Passage, der fører ind til dette Hav, er det ogsaa tydeligt, at det kun vil kunne lykkes faa Aaleunger at naa herind fra Middelhavet og videre til de store Floder, der udmunder i det Sorte Hav. Ad kunstig Vej har man fra Italien og Frankrig indført Aaleyngel til Donau-Floden, hvor Aalen har trivedes godt, uden at den dog naturligvis har forplantet sig. (Jfr. S. 143 ff. og S. 165 ff.).

IV. AFSLUTTENDE BEMÆRKNINGER.

Skønt der endnu mangler meget i, at de vigtigste biologiske Forhold hos det atlantiske Omraades Aal er opklarede, vil man dog efter Læsningen af foranstaende Sider have faaet det Indtryk, at der allerede foreligger Momenter hertil. Man vil have set, at Ferskvandsaalenes Udbredning i Amerika, Europa og Afrika finder en naturlig Forklaring ved den Antagelse, at det er Temperaturerne og Saltholdighederne i Havets Dyb i Forbindelse med flere andre sekundære Faktorer (Havstrømmenes Retning og Styrke, Afstanden fra Ynglepladserne etc.), der bestemmer disse Fiskes Udbredning i de Egne af det atlantiske Omraade, hvor de klimatiske Forhold er saaledes, at de opvoxende Aal overhovedet kan trives¹.

Vi har i dette Arbejde kun beskæftiget os med den europæiske og amerikanske Aal, væsentlig fordi disse to er de bedst kendte indenfor Slægten *Anguilla*. I det pacifiske Omraade kommer der andre Aale-Arter med tilsyneladende andre biologiske Forhold, men de vil, skønt en betydelig Række af Undersøgelser allerede er foretagne, dog først kunne blive behandlede biologisk, naar Undersøgelserne over deres systematiske Forhold er bragte til en tilfredsstillende Afslutning, hvad der forhaabentlig kan ske i Løbet af faa Aar.

Set i Belysning af mine tidligere ved Europa foretagne Undersøgelser over Aalens Biologi kan de her fremdragne Forhold kun siges at bringe yderligere Bekræftelse. Adskillige af de der fremsatte Betragtningers Gyldighed er saaledes blevet prøvet paa større Forhold, paa et meget videre Omraade, idet ogsaa Sydgrænsen for Aalenes Forekomst i Atlanterhavsomradet er blevet draget med ind i Undersøgelsen, der tidligere havde maattet indskrænke sig til Nordgrænsen, hvad der selvfølgelig ikke kunde give den Sikkerhed i Slutningerne f. Ex. med Hensyn til Bestemmelsen af de minimale og maximale Temperaturer for Forplantningen osv.².

¹ I rent arktiske Egne, hvor det ferske Vand altid eller næsten altid er frossent, vil der naturligvis ikke kunne leve Aal, selv om der var nok saa gode Betingelser for Tilgang af Yngel. Det samme gælder naturligvis ogsaa saadanne Vande, der indeholder giftige Mineraler eller Luftarter.

² Ved de tidligere Undersøgelser (I. c., 1906) var jeg jo kommen til det Resultat, at ca. 7° i en Dybde af ca. 1000 Meter omrent maatte repræsentere den minimale Temperatur, hvorved Forplantningen kunde foregaa, og efter hvad der i det foregaaende er meddelt, synes Forholdene ved Sydgrænsen at føre til nogenlunde samme Resultat. Paa den anden Side er det udfra det Faktum, at Aalen (ifolge de

Hvis der endnu skulde være nogen, som tvivlede paa, at Ferskvandsaalen yngler i Havet, vil de her fremsatte Betragtninger forhaabentlig bidrage til at fjerne denne Tvivl, saaledes bl. a. det Faktum, at Aalene forekommer paa isolerede, ofte helt ude i Oceanerne beliggende Øer, hvor Ferskvandsfisk ellers mangler (Azo-rerne, Madeira, Bermudas, Balearerne f. Ex.). Dette vilde ellers være ganske ufor-staaeligt, men, som viist i det foregaaende, bidrager det nu netop i høj Grad til at styrke de her fremsatte Anskuelser, ifølge hvilke Aalens Forplantning sker ude i Oceanet¹, hvor det er de paa Stedet herskende fysiske Forhold (Temperatur og Saltholdighed), som er afgørende, og som derfor i første Linie bliver bestemmende for Udbredningen.

Dersom man, hvad der er ganske berettiget, naar det drejer sig om et Ar-bejde, der omhandler Fiskearter af stor økonomisk Betydning, tilsidst stiller det Spørgsmaal, om der ved dette Arbejde er tilvejebragt nye Momenter og Resul-tater af praktisk Interesse, da maa der svares, at selv om det tilsvyneladende er uden Betydning for det praktiske Aalefiskeri i Europa og Amerika, at man for-staar Aarsagerne til Aalenes Udbredning i disse Omraader, holder dette dog ikke ganske Stik overfor en nærmere Betragtning. Thi rent bortset fra at forøget Viden altid frembyder Muligheder, som før eller senere maaske kan blive af Betydning, er der et Forhold, som fortjener at fremhæves allerede nu. Jeg tænker her paa Foretagelsen af saadanne Transplantationer af Aal og Aaleyngel, som man flere Steder allerede i længere Tid har realiseret, og som efter de sidste Aars Resultater i Aaleforskningen synes at skulle tage stærkere Fart (jfr. den hamborgske Fiskeri-direktør LÜBBERT's Forsøg med Indplantning af Aaleyngel fra Bristolkanalen til Østersølandene, FISCHER & LÜBBERT 1908).

Efter hvad der er fremført i det foregaaende, er det indlysende, at man, naar man ønsker at transplantere Aal eller Aaleyngel, maa være ganske klar over, om man vil propagere eller kun opdrætte de omplantede Exemplarer. Vi saa jo, at store, paa Ferskvand rige, Arealer baade i Amerika og Afrika var aale-tomme, saaledes Størstedelen af Vestafrika, hele det vestlige Amerika og Østkysten af Syd-amerika. Dersom man til disse Egne vilde indføre Yngel af den europæiske eller italienske Forfattere) yngler i Middelhavet, hvor Temperaturen i Dybet ikke synker under 13°, givet, at den maximale Temperatur for Forplantningen ikke kan være under ca. 13°, saa at Spillerummet altsaa bliver mindst ca. 6°. Maaske repræsenterer de ca. 13° Maximumstemperaturen, men vi har ingen Midler til at afgøre dette, saaledes som det har kunnet ske for adskillige Gadoiders Vedkommende (SCHMIDT, 1909 a), thi Temperaturen i Dybet er intetsteds saa høj som i Middelhavet, naar undtages det Røde Hav, hvor den naaer den fænomenale Højde af 21° i 1000 Meters Dybde. Desværre tør jeg ikke af de fore-liggende altfor usfuldstændige Beretninger fra Egnene langs det Røde Hav slutte, at deres tilsvyneladende Mangel paa Aal virkelig er ensbetydende med, at disse Fisk ganske mangler, selv om dette er sand-synligst. Denne Sag fortjener en nærmere Undersøgelse; thi det kunde jo meget godt tænkes, dersom Aal virkelig mangler i Landene ved det Røde Hav, at Aarsagen hertil var den, at Temperaturerne og Saltholdighederne i Dybet er for høje for Forplantningen, ligesom vi jo saa, at de andetsteds var for lave. Dog kan ogsaa andre Forhold være bestemmende med Hensyn til den eventuelle Mangel af Aal ved Rødehavets Kyster, saaledes disse Kysters overordentlige Tørhed og Mangel paa Ferskvand.

¹ Jeg minder ved denne Lejlighed om Fundet af en stor (90 cm. lang) *Anguilla vulgaris* i Maven af en Kaskelot dræbt i Havet ved Azorerne (VAILLANT, 1898, p. 1429—30, og SCHMIDT, 1906, p. 145).

amerikanske Aal, ligesom man flere Steder har indført andre Ferskvandsfisk (navnlig af *Salmo*-Slægten) fra helt andre Egne af Jorden, da vilde man blive skuffet, hvis man gjorde Regning paa, at saadan transplanterede Aal ligesom Laxene skulde vinde Fodfæste og formere sig, saa at man uden videre i Fremtiden kunde fiske Aal her, hvor de tidligere ikke fandtes. Vi forstaar nu, at dette ikke kan lade sig gøre, thi Betingelserne for, at Forplantningen kan finde Sted, har vi jo set mangler, og det højeste, man i disse Egne kan opnaa ved Transplantationer, vil altsaa være at finde gunstige Opdrætningssteder for de indplantede Individer. Paa denne Maade kan den foreliggende Undersøgelse bidrage sit til Undgaaelse af Fejltagelser, naar det drejer sig om at indføre Ferskvandsaal til saadan Steder, hvor de i Forvejen mangler.

I denne Sammenhæng vil det tilsidst have sin store Interesse at se lidt nærmere paa de Omplantningsforsøg, man har foretaget i de Forenede Stater. I et overordentlig interessant Arbejde (A review of the history and results of the attempts to acclimatize fish and other water animals in the Pacific States, U. S. Bulletin, 1896, p. 379—472) har HUGH M. SMITH gjort Rede for det storslaaede Arbejde, der er udført med Omplantning af Fisk fra de østlige til de vestlige Stater. Der omtales her en hel Række af Fisk, der med største Held er overført til Stillehavskysten, hvor de har vundet udmarket Fodfæste og ved deres Frugtbarhed er blevne saa talrige, at de har faaet stor Betydning for Fiskeriet. Blandt saadan Fiskearter kan nævnes "shad" (*Clupea sapidissima*), "striped bass" (*Roccus lineatus*), forskellige Karper (*Cyprinus carpio* og Varieteter), forskellige Laxe-Arter, "catfish" (*Ameiurus*-Arter etc.) etc. etc. Det er navnlig af stor Interesse at læse om, hvorledes flere af disse Fisk modificerer deres Gydetid efter de nye Forhold, de er komne til at leve under, og om hvor overordentlig stærkt de forplanter sig i deres nye Hjem, saa at de i flere Tilfælde hurtigt breder sig over store Arealer.

De Forsøg, der her navnlig interesserer os, er naturligvis de, der udførtes med den Hensigt at akklimatisere den i de østlige Stater alm. forekommende Aal (*Anguilla chrysypa*) i Veststaterne. De paabegyndtes af den bekendte Mr. LIVINGSTON STONE af "the U. S. Commission of Fish and Fisheries", der har indlagt sig saa stor en Fortjeneste af Udviklingen af Fiske-Kultur og Fiske-Akklimatisation, og som førte de til Udsætning bestemte Fisk over Kontinentet i en saakaldt "aquarium car".

Forsøgene udførtes i Aarene 1874, 1879 og 1882, og det lykkedes at overføre adskillige Tusinde mindre og større Aal i levedygtig Stand, hvilke blev udsatte paa forskellige Steder i ferskt og salt Vand i Nærheden af San Francisco. I Beretninger fra "the Commissioners of Fisheries of the State of California" gives der nu i de følgende Aar Underretning om de udsatte Fisks videre Skaebne. Jeg skal efter HUGH M. SMITH anføre disse.

- 1874—75. "Of the fresh-water eels placed in a tributary of the Sacramento River, we learn that one had been caught in Willow Slough, in Yolo County, which had grown to be more than a foot in length. We have no knowledge that the salt-water eels placed in Sacramento Bay have ever been seen".
- 1876—77. It was stated that a few eels had been caught, but they had not become numerous. The next report recorded the capture of several "taken in the fresh water, near Sacramento, full grown, and 3 feet in length".
1880. "Occasionally we hear of an eel being captured, but as yet they have not shown an increase in proportion to that of other imported fish".
1882. "The San Francisco Chronicle of February 8 reports the catch by George Bird of the first eel, resulting from a plant of 12,000 made by the California fish commissioners. It was caught on the easterly shore of San Francisco Bay and measured 3 feet in length".
- 1883—84. "Eels placed in our waters by the former commissioners, have not been a success. It is probable that the place where they were deposited and where they have made their home has not yet been discovered, at all events none have been taken since they were planted. It seems to us that they ought to do well in our inland waters, as they are fond of the bottoms of ponds or streams where mud prevails, as is the case in our lakes and rivers".

Om Forholdene 10 Aar senere meddeler HUGH M. SMITH følgende paa Grundlag af egne Erfaringer:

"In 1894, when the writer visited the Pacific Coast, no eels were at any time seen in the markets of San Francisco or other cities, and the following statement, based on his observations, was printed in a report embodying the data on certain phases of the fishing industry at the time: "Inquiries regarding the results of the attempted acclimatization of the eel (*Anguilla chrysypa*) on this coast are apt to elicit misleading information unless great care is exercised. In the San Francisco markets one learns that eels are not infrequently exposed for sale, and that both salt water and river fishermen catch them occasionally, but an examination of the reported eels usually shows them to be lampreys"".

HUGH M. SMITH slutter sin Omtale af Forsøgene paa at akklimatisere Aalen i Californien med følgende Ord:

"In view of the hardiness and great prolificness of the eel, it is somewhat remarkable that it has not gained a firm hold in California and become abundant. It is, of course, possible that the failure to catch more of them has been due to the absence of suitable pots or traps, but the fact that the fish are so seldom taken with the various forms of apparatus now used can only be explained by their actual scarcity, and in their last report (1894—95) the California fish commissioners regard the eel as one of the fish from whose attempted introduction "no result can be said to have come"".

Med vor nuværende Viden er det ikke vanskeligt at indse, hvorfor disse Forsøg paa at akklimatisere Aalen ved Stillehavets Kyster mislykkedes. Tværtimod synes de, saa vidt det da efter de foreliggende Beretninger er muligt at dømme, at være forløbne nøjagtigt, som det var at vente: I de første Aar efter Udsætningen fanges der af og til Aal, hvoraf nogle synes at have voxet meget hurtigt, maaske paa Grund af de gunstige Lokaliteter, man havde valgt til Udsættelsen. Men efter faa Aars Forløb er det hele forbi, uden at der som af de andre transplanterede Fiskearter har vist sig Yngel til Erstatning og Mangfoldiggørelse af den udsatte Bestand.

Paa lignende Maade kan enhver Gentagelse af disse Forsøg forudsiges at ville gaa, thi selv om man sørger for at give de transplanterede Aal nok saa gunstige Forhold at voxer op under, vil dog ingen menneskelig Magt kunne skaffe dem de Forhold i Havet udenfor, som de behøver for at kunne forplantte sig.

En anden Sag er det jo naturligvis, dersom det skulde kunne tænkes at være fordelagtigt fra Øststaterne til Veststaterne at overføre et Antal Aaleynge med den Hensigt senere at "høste" de samme Individer, naar de var voxede op, saaledes som det sker paa flere saadanne Steder i Europa, hvor Aalefiskeriets Teknik er særlig højt udviklet, eller hvor Priserne paa Aalen, som forhandles levende, er meget høje. Men herom kan der vist neppe være Tale i Amerika, i alt Fald ikke saalænge Aalefiskeriet ikke spiller nogen større Rolle end det nu er Tilfældet.

V. RESUMÉ AF DE VIGTIGSTE RESULTATER.

Ferskvandsaal (*Anguilla*-Slægten) er vidt udbredte over Jorden og findes saaledes baade i det atlantiske, indiske og pacifiske Omraade. Kun de i det atlantiske Omraade forekommende, nemlig *Anguilla vulgaris*, Turt., som lever i den østlige, og *Anguilla chrysypa*, Raf., der hører hjemme i den vestlige Del af dette Omraade, og som begge er ensfarvede, er her gjorte til Genstand for Omtale, da de er de eneste, som er nogenlunde vel karakteriserede i systematisk og biologisk Henseende.

I det indiske og det pacifiske Omraade findes der foruden ensfarvede ogsaa brogede *Anguilla*, men man ved foreløbig for lidt om dem, til at deres Udbredningsforhold kan behandles paa lignende Maade, som her er sket for Atlanterhavs-For mernes Vedkommende (jfr. S. 122 og 147—52).

Medens Ferskvandsaal mangler ved Stillehavskysterne baade af Nord- og Syd amerika, findes de ved de atlantiske Kyster af Nordamerika og Mexico, i størst Mængde i Canada's og de Forenede Staters østligste Del, men iøvrigt lige fra det sydligste Grønland og Labrador til det vestindiske Archipelag og Guiana. Derimod mangler de i Sydamerika syd for Guiana, baade i Brasiliens og Argentinas store Flodssystemer, og det Punkt, hvor de forsvinder, maa saaledes ligge etsteds i det nordlige Brasilien eller deromkring (jfr. S. 138 og Kortet).

Desuden forekommer de paa saa at sige alle de i Atlanterhavet Nord for Ækvator beliggende Øer (Bermudas, Azorerne, Madeira, Canarerne, Island etc.), og, hvad der særlig fortjener at fremhæves, selv paa saadanne, hvor andre Ferskvands fisk ganske mangler (jfr. S. 138—42 og Kortet).

Ved Østranden af det atlantiske Ocean er Aalenes Udbredningsforhold følgende. De mangler ved Nordkysten af Asien og Rusland, men findes omtrent fra Nordecap i det nordlige Norge og sydefter langs Europas Kyster, ved alle Middelhavets Kyster (undtagen det Sorte Havs) og ved den nordvestligste Del af Afrikas Kyst. Her forsvinder de, sandsynligvis ved Rio del Oro-Omraadet eller i Senegal, og mangler der efter ved hele Afrikas Vestkyst, saaledes i Niger's og Congo's store Flodomraader (jfr. S. 146 og Kortet).

I Sydafrika, omtrent ved Cap Agulhas, træffes after Ferskvandsaal, og saadanne findes fremdeles paa Østkysten af Afrika, Sydkysten af Asien og paa Øerne i det indiske Ocean, saaledes som det strax fremgaar af Udbredningskortet. Det er endnu

ikke fastslaaet, i hvilket Forhold de her forekommende *Anguilla*-Arter, hvoriblandt der findes baade ensfarvede og brogede, staar til de atlantiske *A. chrysypa* og *A. vulgaris* (jfr. S. 148 og Kortet).

Det er saaledes konstateret, at de atlantiske Ferskvandsaal lever baade i tropiske, i varmt og koldt tempererede, ja endog i arktiske Egne, men netop med Henblik paa denne forbavsende Evne til at kunne finde sig i de mest forskelligartede ydre Forhold bliver deres faktiske Udbredning tilsyneladende uforstaaelig. Specielt gælder dette det mærkelige Forhold, at Udbredningen, saaledes som det strax fremgaar af Kortet, baade i det vestlige og østlige Omraade viser en paafaldende pludselig Standsning sydpaa, saa at Størstedelen af Sydamerika og Vestafrika, hvor nogle af Verdens største og fiskerigeste Ferskvandssystemer findes, er ganske tomme for Aal, tiltrods for at der mangfoldige Steder her skulde synes at være udmarkede Betingelser for deres Trivsel. Ogsaa Aalenes Forekomst paa oceaniske Øer, hvor Ferskvandsfisk ellers mangler, er tilsyneladende uforstaaelig (jfr. S. 153).

For at komme til en Forstaaelse af Aalenes Udbredning, specielt deraf at de tiltrods for deres store Indifferens overfor forskelligartede ydre Forhold dog ikke har formaaet at trænge længere sydpaa ved Atlanterhavets Kyster, var det nødvendigt at minde om nogle af de Resultater, der er vundne ved de seneste Aars Havforsknninger. Jeg tænker her paa Konstateringen af, at der ofte er meget stor Forskel paa en Fiskearts Følsomhed overfor Omgivelserne i dens Opvæxtperiode og dens Gydeperiode, saaledes at den i Gydeperioden stiller langt bestemtere og ofte helt andre Krav til de ydre Forhold (Dybde, Temperatur, Saltholdighed) end under Opvæxten, hvoraf Følgen igen bliver, at Udbredningen ofte kan være en hel anden i Gydetiden end under Opvæxten (jfr. SCHMIDT, 1909 a, p. 11, 151). Desuden følger heraf, at det i første Linie er de Krav, der i Gydetiden stilles til de ydre Forhold, som bliver bestemmende for Udbredningen, eller med andre Ord, for at forstaa Udbredningen maa vi skaffe os Underretning om, hvilke Krav til de ydre Omgivelser Arten stiller for at kunne udføre sin Forplantning. Hermed er vi naaede til Sagens Kerne.

Undersøgelser foretagne siden 1904 med det danske Undersøgelsesskib "Thor" og det irske "Helga" i Atlanterhavet Vest for Europa havde vist (SCHMIDT, 1906, p. 256), at den europæiske Ferskvandsaal for at kunne forplante sig kræver store Dybder (mindst ca. 1000 Meter) i Forbindelse med høj Saltholdighed og Temperatur af Vandet, nemlig over 35,20 % og over 7° i 1000 Meters Dybde. Ud fra dette blev Aalens Udbredning og Vandringer i den nordlige Del af Europa fuldkommen forstaaelige (jfr. S. 155—57).

Det ligger nu nær at anvende de for den nordøstlige Del af Atlanterhavet konstaterede Forhold paa hele Omraadet. Betragter vi Udbredningskortet, hvor Temperaturerne i 1000 Meters Dybde er afsatte, bliver de atlantiske Ferskvandsaals Udbredning med eet Slag ganske klar. Saaledes forstaar vi, at Aarsagen til Mangelen af Aal i hele Sydamerikas, det vestlige Nordamerikas og Vestafrikas store Ferskvands-

systemer er, at Temperaturen i Havet udenfor er for lav til, at Forplantning kan finde Sted. Vi maa derfor næsten sige, selv om det klinger paradoxalt, at i disse Egne, som indeholder nogle af Jordens varmeste Lande, er der for koldt, til at Ferskvandsaalene kan existere (jfr. S. 156 og Kortet).

Men ogsaa den faktiske Forekomst af Aalene i det atlantiske Omraade bliver forstaaelig, naar vi gaar ud fra, at de forplanter sig i Havet og her kun, hvor Temperaturen og Saltholdigheden i Dybet overstiger de ovenfor nævnte Værdier.

Kun ved at Forplantningen foregaar ude i Havet, bliver Ferskvandsaalenes Forekomst paa saadanne oceaniske Øer, hvor Ferskvandsfisk ellers ganske mangler, forstaaelig (jfr. S. 157 og Kortet). Af Kortet ses, at alle de oceaniske Øer i Atlanterhavet, hvor Aalene forekommer, ligger indenfor det Omraade, hvor Temperaturen i Dybet er høj.

Hvad angaar den **østlige Del** af Atlanterhavsomraadet, da har jeg nu med "Thor" paavist, at *Anguilla vulgaris*'s Forplantning finder Sted paa hele Strækningen fra Færøerne til Marokkos Vestkyst (jfr. S. 158 og Kortet). Tidligere har jeg (SCHMIDT, 1906) gjort Rede for, hvorledes Yngelen fra Gydepladserne Vest for de britiske Øer og Frankrig under og efter Forvandlingen bevæger sig østefter, og hvorledes hele det nordøstlige Europas Aalebestand rekruterer herfra. Det fremgik heraf, at Yngelens Vandringer, som begunstiges af Strømmenes Retning og af det pelagiske Livs usædvanlig lange Varighed, kan have en overraskende Udstrækning (jfr. Afstandene fra den indre Del af Østersøen eller fra det nordligste Norge til 1000 Meter Kurven i Atlanterhavet Vest for Europa) (jfr. S. 157 og Kortet).

Set paa Baggrund heraf er den amerikanske Aals (*Ang. chrysypa*) Udbredning i den **vestlige Del** af Omraadet meget forstaaelig, og det synes, som den i sine biologiske Forhold kommer den europæiske meget nær, hvad der heller ikke er underligt, eftersom de er meget nær beslægtede. Det er ved Fund af Larver konstateret, at *Anguilla chrysypa* forplanter sig i den Del af Havet udfor de Forenede Stater, hvor Temperaturen i Dybet naaer den største Højde i hele den vestlige Del af det atlantiske Ocean (jfr. Kortet, hvor Fundene er afsatte).

At Centrum for Produktionen af den amerikanske Ferskvandsaal maa ligge her, synes den faktiske Udbredning af denne Art ogsaa at vise hen til. Først og fremmest siger den amerikanske Fiskeristatistik os, at ikke mindre end ca. 98 % af de Aal, der fiskes i de Forenede Stater, kommer fra det atlantiske Omraade, og kun ca. 2 % fra Vande, der er tributære til den mexikanske Bugt (jfr. S. 128). Endnu mere slaaende er det maaske, at af de 3,822,434 lbs, som er det samlede Udbytte af Aalefiskerierne i de Forenede Stater, stammer over 3 Millioner lbs fra Aal, der som Yngel er trængt op i det ferske Vand paa den korte Strækning mellem Cape Cod og Cape Hatteras, der, som man ser af Kortet, ligger lidt nordligere end det Omraade, hvor det varmeste Vand i Dybet findes (jfr. S. 161).

Ogsaa Tidspunktet for Aaleyngelens Opstigning i det ferske Vand paa de forskellige Steder af Fristaternes og Canadas Østkyst synes, saavidt det efter de sparsomme Oplysninger er kendt, at vise i samme Retning (jfr. S. 161).

Alt tyder da paa, at Produktionscentret for den amerikanske Aal (*Anguilla chrysypa*), hvorfra selv de nordligste Egne (Canada, Newfoundland, Labrador, Grønland) forsynes med Yngel, maa være beliggende udfor de Dele af de Forenede Staters Østkyst, hvor Temperaturen i Dybet naar den største Højde i hele den vestlige Del af Atlanterhavet (jfr. Side 162 og Kortet).

Selv om Afstandene herfra til den nordligste Del af det Omraade, hvor *A. chrysypa* lever (Newfoundland, Labrador, Syd-Grønland) er meget betydelige, er de dog ikke større end de, som Yngelen af den europæiske Aal maa tilbagelægge fra Ynglepladserne Vest for Europa, og Vandringen vil i høj Gradlettes af Styrken og Retningen af Havstrømmene udfor Nordamerikas Østkyst (jfr. S. 159 og Kortet).

Havstrømmene er saaledes en sekundær Faktor af stor Betydning for Aalenes Udbredning, idet de kan bevirke, at Forekomsten udstrækkes til Egne, der ligger fjærnt fra Ynglestederne, som Tilfældet jo var baade i det nordlige Europa og det nordlige Amerika. Her begünstigede Retningen af Strømmen en saadan Udbredning nærdefter fra Ynglepladserne. Derimod er Strømretningen ikke gunstig for en tilsvarende Udbredning i sydlig Retning fra disse, og Følgen heraf bliver da ogsaa den, at Aalenes Sydgrænse kommer til at ligge langt nordligere i Forhold til Ynglepladserne, end man maaske kunde vente sig, naar man har set, hvor langt Nord for Ynglepladserne deres Forekomst rækker (jfr. S. 159 og Kortet).

Ved en Sammenligning mellem Udbredningskortet og et Strømkort vil det træde tydeligt frem, at Aalenes Udbredning svarer temmelig nøje til Periferien af den store anticykloniske Cirkulationsbevægelse i det nordlige Atlanterhav.

At Aalene ogsaa efter at være komne ind i Ferskvand kan tilbagelægge uhyre Vejlængder, har den foregaaende Beskrivelse vist flere Exempler paa. Der kan saaledes bl. a. henvises til Sydafrika, hvor der i Omegnen af Pretoria findes Aal, som er vandrede op den lange Vej fra Havet henholdsvis gennem Crocodile- og Orange-Systemerne. Endnu mere slaaende Exempler finder vi i Nordamerikas Forenede Stater, hvor der i nogle af de Stater, der grænser op til de store Søer, og som ligger meget fjærnt fra Havet, forekommer Aal (jfr. S. 148 og 129).

Ejendommeligt er det her i samme Stat, f. Ex. i Ohio, Illinois og Indiana, at finde Aal, hvoraf nogle er trængte op fra den mexikanske Golf gennem Mississipi- og andre fra selve Atlanterhavet gennem St. Lawrence-Systemet. I Sydafrika finder vi lignende Forhold, idet der ved Pretoria i ferske Vande, der ligger nær hinanden, forekommer Aal af meget forskellig Oprindelse, nemlig stammende henholdsvis fra det indiske og det atlantiske Ocean (jfr. S. 130 og 148).

Vi har set, at Ferskvandsaalenes Udbredning indenfor det atlantiske Omraade i første Linie afhænger af Temperaturene i Havets Dyb, idet det er disse, som er afgørende for, om Forplantningen kan finde Sted. At det dog ikke altid alene er Temperaturen i Dybet, som afgør, om Aalen kan forplante sig i et Havomraade, som i øvrigt er dybt nok, ser vi af det Sorte Hav; thi her, hvor Temperaturen selv paa de største Dybder ikke synker under ca. 9°, frembringes der ingen Aaleyngel, hvad der paa en slaaende Maade giver sig tilkende ved, at Aalen mangler i alle de store Floder, der har Afløb til det Sorte Hav. Her maa altsaa andre Momenter gøre sig gældende, og ved en nærmere Betragtning af de hydrografiske Forhold faar man da ogsaa Forklaringen, idet Vandet i Dybet baade er altfor lidet salt, højst ca. 22 ‰, og desuden indeholder betydelige Mængder af den alt højere organisk Liv udelukkende Svovlbrinte (jfr. S. 162).

Paa forskellige Steder af Jorden, hvor Ferskvandsaal ikke før fandtes, har man gjort Forsøg med at udplante Yngel i det Haab, at de dér skulde trives og formere sig ligesom flere andre Ferskvandsfisk, hvormed saadanne Experimenter var lykkedes. Disse Forsøg har dog kun bragt Skuffelse. Den foreliggende Undersøgelse giver Forklaringen herpaa og viser, at enhver Gentagelse heraf maa give samme negative Resultat, idet det ikke er muligt for nogen menneskelig Magt at tilvejebringe saadanne Forhold i Havet, som kræves til vore atlantiske Aals Forplantning, naar de ikke i Forvejen er tilstede. En hel anden Sag er det, at det i mange Tilfælde kan være meget nyttigt at udsætte og opdrætte Aaleyngel paa saadanne Steder, hvor Aalen i Forvejen ikke findes, eller hvor der ikke er nok af den. Dette har man allerede realiseret paa flere Steder i Europa, i størst Maalestok i Donau-Floden og i Tyskland, og det vil sikkert kunne udføres med Held ogsaa andre Steder i Lande, hvor Aalepriserne er store og Fiskeriets Teknik højt udviklet. Men man maa da være klar over, at man kun kan opnaa at opdrætte (og høste) de udsatte Exemplarer, ikke at propagere dem, saaledes som det er lykkedes med adskillige andre Ferskvandsfisk; thi Aalen er kun i højst uegentlig Forstand en Ferskvandsfisk; den er tværtimod en ægte atlantisk Dybhavsfisk, hvis Skæbne i første Linie afgøres ude i det storeaabne Hav (jfr. S. 165 ff.).

VI. LITTERATURLISTE.

- ABBOTT (1899). J. F. Abbott: The marine fishes of Peru (Proc. of Ac. Nat. Sc. Philadelphia, 1899, p. 324—364).
- BADE (1902). E. Bade: Die mitteleuropäischen Suesswasserfische, vol. II, Berlin 1902.
- BARKER-WEBB & BERTHELOT (1836—44). Barker-Webb and Berthelot: Histoire Naturelle des îles Canaries, Tome 2. A. VALENCIENNES: Ichthyologie, 1836—1844, p. 88—89.
- BELLINI (1907). A. Bellini: Esperienze di Anguillicoltura (Atti del III Congreso Nazionale di Pesca, Milano 19—23 settembre 1906, Milano 1907).
- BERG (1895). Berg: Enumeración sistemática y sinonímica de los peces de las costas argentina y uruguaya (Anal. Mus. Nac. Buenos Aires, Tomo IV (Ser. 2a, t. I), 1895, p. 1—120).
- (1895 a). Berg: Sobre peces de agua dulce nuevos ó poco conocidos de la República Argentina (Anal. Mus. Nac. Buenos Aires, Tomo IV (Ser. 2a, t. I), 1895).
- BLEEKER (1862, 63). Bleeker: Poissons de la côte de Guinée (Mém. Soc. Holl. Harlem, 1862, 63).
- BORSIERI (1904). Clementina Borsieri: Contribuzione alla conoscenza della fauna ittiologica della Colonia Eritrea (Ann. Mus. Civ. Stor. Nat. Genova (3), vol. 1, 1904).
- BOULENGER (1900). Boulenger: List of Fishes collected by Mr. J. S. Budgett in the River Gambia. With Notes by J. S. Budgett, F. Z. S. (Proceed. Zool. Soc. London, 1900, p. 511 et seq.).
- (1901). G. A. Boulenger: Les Poissons du Bassin du Congo, Bruxelles, 1901.
- (1901 a). G. A. Boulenger: On the Fishes collected by Dr. W. J. Ansorge in the Niger Delta (Proceed. Zool. Soc. London, 1901, p. 4 et seq.).
- (1902). G. A. Boulenger: On the Fishes collected by S. L. Hinde in the Kenya District, E. Africa, with descriptions of four new species (Proceed. Zool. Soc. London, 1902, vol. 2).
- (1902 a). G. A. Boulenger: List of the Fishes collected by Mr. W. L. S. Loat at Gondokoro (Ann. Mag. Nat. Hist., 7 ser., vol. 10, 1902, p. 260—64).
- (1905). G. A. Boulenger: A List of Freshwater Fishes of Africa (Ann. Mag. Nat. Hist., (7), vol. 16, 1905, p. 36).
- (1906). G. A. Boulenger: On new fishes from Lake Victoria (Ann. Mag. Nat. Hist., (7), vol. 17, 1906, p. 433—45).
- (1906 a). G. A. Boulenger: On a collection of Fishes from Gallaland (Ann. Mag. Nat. Hist., (7), vol. 17, 1906, p. 557—66).
- CANADA, DOMINION OF (1908—09). Forty-first Annual Report of the Department of Marine and Fisheries 1907—08, Ottawa, 1908—09.
- COLLETT (1905). R. Collett: Meddelelser om Norges Fiske i Aarene 1884—1901, III (Christiania Videnskabs Selskabs Forhandlinger for 1905, No. 7, Christiania, 1905).
- DAY (1878). F. Day: The Fishes of India, 1878.
- (1889). F. Day: The Fauna of British India, Fishes. vol. I, 1889.
- DAMBECK (1879). Dambeck: Die Verbreitung der Süß- und Brackwasserfische in Africa (Jenaisch. Zeitschr. f. Nat., XIII, 1879).
- EIGENMANN (1904). C. H. Eigenmann: The Fresh-Water Fishes of Western Cuba (Bull. U. S. Fish Commission, vol. XXII, for 1902, 1904).
- (1907). Carl H. Eigenmann: An account of Amazon River Fishes collected by J. B. STEERE etc. (Proceed. U. S. Nat. Mus., vol. 31, 1907, p. 659—667).
- EIGENMANN & EIGENMANN (1892). Carl H. Eigenmann and Rosa S. Eigenmann: A Catalogue of the Fresh-Water Fishes of South America (Proceed. U. S. Nat. Mus., vol. XIV, for 1891; 1892, p. 1—81).

- EIGENMANN & KENNEDY (1902). C. H. Eigenmann and C. H. Kennedy: The Leptocephalus of the American Eel and other American Leptocephali (Bull. U. S. Fish Commission, vol. XXI for 1901, 1902).
- EVERMANN & GOLDSBOROUGH (1902). B. W. Evermann and E. L. Goldsborough: A Report on Fishes collected in Mexico and Central America (Bull. U. S. Fish Commission, vol. XXI, for 1901, 1902).
- EVERMANN & KENDALL (1907). Evermann and Kendall: Notes on a Collection of Fishes from Argentina (Proceed. U. S. Nat. Mus., vol. 31, 1907, p. 67—108).
- EVERMANN & MARSH (1900). Evermann and Marsh: The fishes of Portorico (Bull. U. S. Fish Commission, vol. XX, Part I, 1900).
- FABRICIUS (1780). Fabricius: Fauna groenlandica, p. 137, 1780.
- FISCHER & LÜBBERT (1908). F. Fischer and H. Lübbert: Die Organisation des Bezuges von Aalbrut aus England für deutsche Gewässer (Zeitschrift für Fischerei, XV, 1908, p. 17—60).
- GERVAIS (1853). P. Gervais: Remarques sur les Poissons Fluviaires de l'Algérie (Annal. Sci. Nat., Zool., Tome XIX, III sér., 1853, p. 5—17).
- GIGLIOLI (1888). Giglioli: Note intorno agli animali vertebrati ad Assab e nello Scioa 1884—87 (Ann. Mus. Civ. Stor. Nat. Genova (2), vol. 6, 1888).
- GOELDI (1898). E. A. Goeldi: Primeira contribuição para o conhecimento dos Peixes do valle do Amazonas e das Guyanas (Boletim Museu Paraense, Tomo II, 1897—98, Para', 1898, p. 443—488).
- GÜNTHER (1867). A. Günther: New Fishes from the Gaboon and Gold Coast (Ann. Mag. Nat. Hist. 3 ser., vol. XX, 1867, p. 110).
- (1869). A. Günther: An Account of the Fishes of States of Central America, based on collections made by Capt. J. M. Daw, F. Godmann, Esq., and O. Salvin, Esq. (Transact. Zool. Soc. Lond., vol. VI, Part VII, p. 377—494).
- (PETHERICK, 1869). A. Günther: The Fishes of the Nile in PETHERICK: Travels in Central Africa, 2 vols., London 1869.
- (Cat., 1870). A. Günther: Catalogue of the Fishes in the British Museum, vol. VIII, London 1870.
- (1873). A. Günther: New Fishes from Angola (Ann. Mag. Nat. Hist., 4 ser., vol. 12, 1873, p. 142).
- (1880). A. Günther: A Contribution to the Knowledge of the Fish-fauna of the Rio de la Plata (Ann. Mag. Nat. Hist., 1880, p. 7—13).
- (Challenger, 1880). A. Günther: Challenger Report, Part VI, Report on the shore Fishes, 1880.
- (1894). A. Günther: Report on the Collection of Reptiles and Fishes made by Dr. J. W. Gregory during his Expedition to Mount Kenia (Proceed. Zool. Soc. London, 1894).
- (1896). A. Günther: Report on a Collection of Reptiles & Fishes made by Miss M. H. Kingsley during her travels on the Ogowa River and in Old Calabar (Ann. Mag. Nat. Hist., 6. ser., vol. 17, 1896, p. 261).
- (1899). A. Günther: An Account of a Collection of Fishes made by Mr. R. B. N. Walker C. M. Z. S., on the Gold Coast (Proceed. Zool. London, 1899, p. 716 et seq.).
- (1902). A. Günther: Last Account of the Fishes collected by Mr. R. B. N. Walker C. M. Z. S. on the Gold Coast (Proceed. Zool. Soc. London, 1902, p. 330 et seq.).
- HARGREAVES (1904). T. Sidney Hargreaves: The Fishes of British Guiana, Demerara, 1904.
- HUBRECHT (1881). A. A. W. Hubrecht: On a collection of Fishes from the St. Paul's River, Liberia (Notes from the Leyden Museum, vol. III, 1881, p. 66—71).
- JACOBY (1880). Jacoby: Der Fischfang in der Lagune von Comacchio nebst einer Darstellung der Aalfrage, Berlin, 1880.
- JENSEN (1904). Ad. S. Jensen: The Fishes of East-Greenland (Meddelelser om Grönland, vol. XXIX, Copenhagen 1904).
- JORDAN (1884). D. S. Jordan: List of Fishes collected at Key West, Florida (Proceed. U. S. Nat. Mus. 1884, p. 111).
- JORDAN & EVERMANN (1896). Jordan and Evermann: A Check-List of the Fishes and Fish-like Vertebrates of North and Middle America (U. S. Commission of Fish and Fisheries, Washington, 1896, p. 269).
- JORDAN & EVERMANN (1896a). Jordan and Evermann: Fishes of North America, 1896, p. 348).

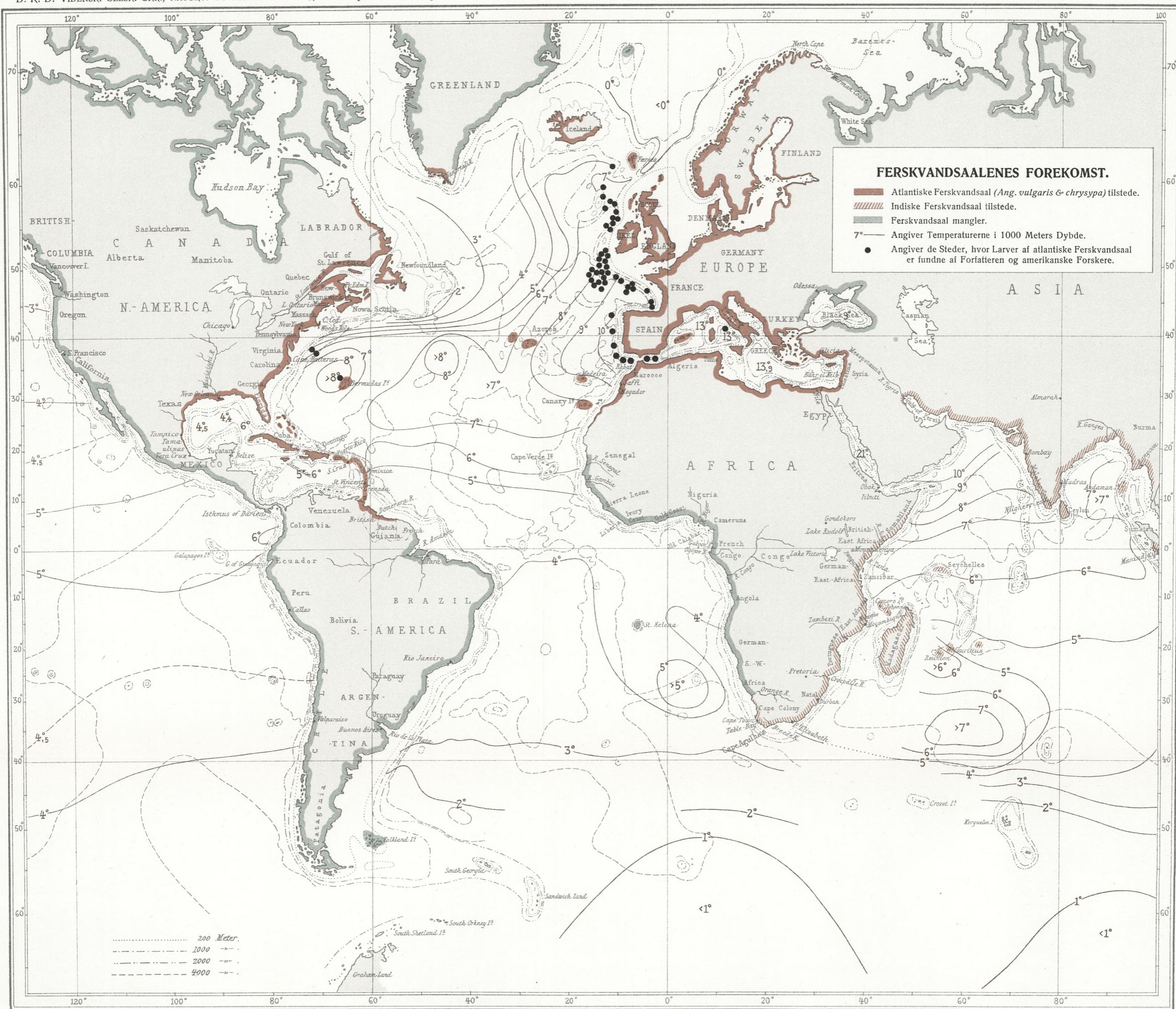
- KAUP (1856). Kaup: Catalogue of Apodal Fish in the collection of the British Museum, London 1856.
- KLUNZINGER (1870—71). Klunzinger: Synopsis der Fische des Rothen Meeres (Verh. Zool. Bot. Ges. Wien, 1870—71).
- KNIPOWITSCH (1898). N. Knipowitsch: Nachtrag zum „Verzeichniss der Fische des Weissen und Murmanschen Meeres“ (Annuaire du Musée Zool. de l'Acad. d. Sc. d. St. Pétersbourg, vol. III, 1898).
- (1901). N. Knipowitsch: Zool. Ergebnisse der Russischen Expeditionen nach Spitzbergen. Ueber die in den Jahren 1899—1900 im Gebiete von Spitzbergen gesammelten Fische (Annuaire d. Mus. Zool. d. l'Acad. d. Sc. d. St. Pétersbourg, vol. VI, 1901).
- KRÜMMEL (1907). O. Krümmel: Handbuch der Ozeanographie, Band I, zweite Auflage, Stuttgart, 1907.
- LOWE (1841). R. T. Lowe: A Synopsis of the Fishes of Madeira (Transact. Zool. Soc. London, vol. II, 1841, p. 191).
- LÜTKEN (1875). C. F. Lütken: Velhas Flodens Fiske (Kgl. Danske Videnskab. Selskabs Skrifter, 5 Raekke, mat-nat. Afd., XII, 2, 1875, p. 123—252).
- LÖNNBERG (1895). E. Lönnberg: Notes on fishes collected in the Camerouns by Mr. Y. Sjöstedt (Öfv. Kgl. Vet. Ak. Forh., 1895, No. 3, p. 179).
- MARTENS (1869—73). Ed. v. Martens: Uebersicht d. ostafrikanischen Suesswasserfische, in C. C. v. d. Decken's Reisen in Ost Africa 1859—65, 3 Bd., 1—2, 1869—73).
- MEEK (1904). Seth E. Meek: The fresh-water Fishes of Mexico North of the Isthmus of Tehuantepec (Publ. Columbian Mus., Zool., vol. V, 1904, p. 91).
- NEWFOUNDLAND (1907). Annual Report of the Department of Marine and Fisheries, Newfoundland, for the year 1906, St. Johns', Newfoundland, 1907.
- NORNY (1885). E. R. Norny: Artificial propagation of Rockfish and Eels (Bull. U. S. Fish Commission, vol. V for 1885, 1885).
- PALACKY (1891). J. Palacky: Die Verbreitung der Fische, Prag 1891.
- PELLEGRINI (1904). J. Pellegrini: Poissons recueillis par M. Ch. Gravier à Djibouti et à Obock (Bull. Mus. Hist. Nat. Tome 10, 1904, p. 543—45).
- PELLERIN (1905). Jacques Pellerin: Poissons d'Abyssinie et du lac Rodolphe (Bull. Mus. Hist. Nat. Paris, 1905).
- PETERS (1868). W. Peters: Naturwiss. Reise nach Mossambique, Zoologie, IV, Flussfische, Berlin, 1868.
- (1876). W. Peters: Ueber die von Prof. Dr. Reinhold Buchholz in Westafrica gesamm. Fische (Monatsber. Kgl. Preuss. Akad. d. Wiss. Berlin, 1876, p. 244).
- (1876 a). W. Peters: Uebersicht der von Herrn Prof. Dr. K. Möbius in Mauritius und bei den Seychellen gesammelten Fische (Monatsber. Kgl. Preuss. Akad. Wiss. Berlin, 1876).
- (1877). W. Peters: Ueber die von Herrn D. C. Sachs in Venezuela ges. Fische (Monatsber. d. Kgl. Preuss. Akad. d. Wiss. zu Berlin, 1877, 469).
- PFEFFER (1892). E. Pfeffer: Ostafrikanische Fische ges. von Herrn Dr. F. Stuhlmann 1888—1889 (Jahrb. d. Hamburg. Wiss. Anstalten, X Jahrg., 2te Hälfte, 1892, p. 169).
- PLAYFAIR & GÜNTHER (1866). Playfair and Günther: The Fishes of Zanzibar, London, 1866.
- POEY (1876). Felipe Poey: Enumeratio Piscium Cubensem, Parte segunda (Anales de la Sociedad Española de Historia Natural, vol. 5, 1876, p. 192).
- PRATO (1891). A. Del Prato: I vertebrati raccolti nella Colonia Eritrea dal Cap. V. Bottego (Bull. della Sezione fiorentina della Società africana d'Italia, vol. VII, Firenze, 1891).
- REICHENOW (1877). A. Reichenow: Uebersicht der Fische aus Chinchoxo u. a. Gegenden Westafrikas (Monatsber. Kgl. Preuss. Akad. d. Wiss., Berlin, 1877, p. 621).
- REGAN (1905). C. Tate Regan: A collection of Fishes made by Dr. H. Gadow in Southern Mexico (Ann. Mag. Nat. Hist. (7), vol. 16, 1905, p. 361—63).
- SAUVAGE (1880—81). H. E. Sauvage: Étude sur la faune ichthyologique de L'Ogôoué (Nouvelles Archives du Museum, 2 sér., Tome 3, 1880—81).
- (1882). H. E. Sauvage: Poissons du Territoire d'Assinie (Côte-d'Or) (Bull. Soc. Zool. France, 1882, p. 313—25).
- SAUVAGE (GRANDIDIER, 1891). H. Sauvage: Histoire naturelle des poissons, in ALFRED GRANDIDIER: Histoire Physique, Naturelle et Politique de Madagascar, vol. XVI, Paris 1891.

- SAWYER (1887). J. N. Sawyer: The breeding habits of the eel (Bull. U. S. Fish Commission, vol. VI, for 1886, 1887).
- SCHMIDT (1906). Johs. Schmidt: Contributions to the life-history of the Eel (*Anguilla vulgaris* Turt.) (Rapports et Procès-Verbaux du Conseil International pour l'Exploration de la Mer, vol. V, No. 4, Copenhague 1906).
- (1907). Johs. Schmidt: Marking Experiments on Plaice and Cod in Icelandic Waters (Meddelelser fra Kommissionen for Havundersøgelser, Serie Fiskeri, Bind II, No. 6, Kjøbenhavn 1907).
 - (1909 a). Johs. Schmidt: The Distribution of the Pelagic Fry and the Spawning Regions of the Gadoids in the North Atlantic from Iceland to Spain (Rapports et Procès-Verbaux du Conseil International pour l'Exploration de la Mer, vol. X, No. 4, Copenhague 1909).
 - (1909 b). Johs. Schmidt: Remarks on the Metamorphosis and Distribution of the Larvae of the Eel (*Anguilla vulgaris* Turt.) (Meddelelser fra Kommissionen for Havundersøgelser, Serie Fiskeri, Bind III, No. 3, Kjøbenhavn 1909).
- SCHOMBURGK (1841—43). R. H. Schomburgk: Fishes of Guiana, Part I, II, Edinburgh (The Naturalist's Library), 1841—43.
- SCHULTZE (1907). Leonh. Schultze: Die Fischerei an der Westküste Südafrikas (Abhandl. herausgegeben vom Deutschen Seefischerei-Vereins, Bd. IX, 1907).
- SIEBOLD (1863). C. Th. E. v. Siebold: Die Sueswasserfische von Mitteleuropa, Leipzig 1863.
- SMITH (1896). Hugh M. Smith: A review of the history and results of the attempts to acclimatize fish and other water animals in the Pacific States (Bulletin of the U. S. Fish Commission, vol. XV, for 1895, Washington, 1896. p. 379—472).
- SMITH & BEEN (1899). Hugh M. Smith and Barton A. Been: List of Fishes known to inhabit the Waters of the District of Columbia and Vicinity (Bull. U. S. Fish Commission, vol. XVIII for 1898, 1899).
- SMITT (1901). Smitt: Poissons d'eau douce de la Patagonie recueillis par E. Nordenskjöld 1898—1899 (Bih. K. Sv. Vet.-Akad. Handl. Band 26, Afd. IV, No. 13, 1901).
- SNODGRASS & HELLER (1906). Robert Evans Snodgrass and Edmund Heller: Shore fishes of the Revillagigedo, Clipperton, Cocos and Galapagos Islands (Proceed. Washington Acad. Science, vol. VI, 1905, p. 333—427).
- STARKS (1906). Edwin Chapin Starks: On a collection of Fishes made by P. O. Simons in Ecuador and Peru (Proc. U. S. Nat. Mus., vol. 30, 1906, p. 761—800).
- STEINDACHNER (1869). Steindachner: Zur Fischfauna des Senegal (Sitzungsber. d. Wiener Akademie, 60 Bd., 1869, p. 669—714 and 945—994).
- (1870). Steindachner: Zur Fischfauna des Senegal (Sitzungsber. d. Wiener Ak. d. Wissenschaft., Bd. 61; 1870, p. 580—82).
 - (1878). Steindachner: Zur Fisch-Fauna des Magdalena-Stromes (Denkschr. d. mat.-nat. Cl. d. Kais. Akad. d. Wiss., XXXIX Bd., 1878, p. 76).
 - (1879). Steindachner: Beiträge zur Kenntniss der Flussfische Südamerikas (Denkschr. d. mat.-nat. Cl. d. Kais. Akad. d. Wiss., Wien, XLI Bd., p. 151—171, 1879).
 - (1880). Steindachner: Zur Fisch-Fauna des Cauca und der Flüsse bei Guayaquil (Denkschr. d. mat.-nat. Cl. d. Kais. Akad. d. Wiss., Wien, XLII Bd., 1880, p. 56—104).
 - (1894). Steindachner: Die Fische Libérias (Notes from the Leyden Museum, vol. XVI, 1894 p. 1—96).
- TROSCHEL (1866). Troschel: Ein Beitrag zur ichthyol. Fauna der Inseln d. Grünen Vorgeb. (Cap Verdische Inseln), 1866, p. 190—239 (separate copy).
- U. S. (1902). U. S. Commission of Fish and Fisheries, Part XXVI, Report of the Commissioner for the year ending June 30, 1901, Washington, 1902.
- (1905). U. S. Commission of Fish and Fisheries, Part XXIX, Report of the Commissioner for the year ending June 30, 1903, Washington, 1905.
- U. S. BULLETIN (1896). Bulletin of the U. S. Fish Commission, vol. XV, for 1895, Washington, 1896.
- VAILLANT (1898). L. Vaillant: Sur la présence de l'Anguille commune en haute mer (Comptes Rendus, tome 126, 1898).

- VAILLANT (1900). Vaillant: Contribution à l'étude de la faune ichthyologique de la Guyane française et du contesté franco-brésilien (Arch. Mus. Hist. Nat., Paris (4), Tome 2, 123—136, 1900).
- VINCIGUERRA (1884). D. Vinciguerra: Pesci in Fauna Tunisiana (Materiali per lo studio della Fauna Tunisiana raccolti da G. e L. Doria, Genova, 1884, p. 52).
- (1890). D. Vinciguerra: Pesci di Birmania (Viaggio di Leonardo Fea in Birmania e regione vicine, Genova 1890).
- (1895). D. Vinciguerra: Pesci in „Esplorazione del Giuba e del suoi affluenti, compiuta, dal Cap. V. Bottego 1892—93 (Ann. Mus. Civ. Stor. Nat. Genova (2), vol. 15, 1895).
- WEBER (1894). M. Weber: Die Süsswasserfische des Indischen Archipels etc. in M. Weber: Zool. Ergebnisse einer Reise in Niederländ. Ost-Indien, vol. III, 1894.
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INDHOLD.

	Side
I. Indledning	(3) 121
II. Beskrivelse af Ferskvandsaalenes Udbredning	(6) 124
A. Vestlige Del af Omraadet	(6) 124
B. Atlantiske Øer	(20) 138
C. Østlige Del af Omraadet	(24) 142
III. Om de Aarsager, der bestemmer Ferskvandsaalenes Udbredning	(35) 153
IV. Afsluttende Bemærkninger	(46) 164
V. Resumé af de vigtigste Resultater	(51) 169
VI. Litteraturliste	(56) 174



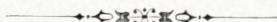
THE HOT SPRINGS OF ICELAND

BY

THORKELL THORKELSSON

WITH 13 PLATES

D. KGL. DANSKE VIDENSK. SELSK. SKRIFTER, 7. RÆKKE, NATURVIDENSK. OG MATHEM. AFD. VIII. 4



KØBENHAVN

BIANCO LUNOS BOGTRYKKERI

1910

(The plates referred to in the text will be found at the end of Part III.)

On the occasion of my exploration of the hot springs in the south-west of Iceland in the summer of 1904, it was shown that the gases from these springs contain radioactive emanations, and at the subsequent investigation in the laboratory, it was again proved by Prof. K. PRYTZ and myself¹, that the gases emanating from the springs contain argon and helium. As these investigations seemed to justify the opinion that a more extensive exploration of the radioactivity of the Icelandic springs would, on account of the isolated position and the volcanic nature of the island, contribute considerably to an elucidation of the question as to what extent radioactive substances are to be found in the earth, as well as their significance with regard to the earth's temperature, I undertook, in the summer of 1906, a new expedition to the hot springs of Iceland.

I received from the Carlsberg Fund for the expenses of this expedition, 5800 Kroner, (£ 322. 4. 6), — 5000 Kroner for the journey, and 800 Kroner for the examination of the materials collected on the journey. I herewith tender the directors of the Carlsberg Fund my respectful thanks for this support.

The experimental part of the preparations for the journey, as well as the analytical work necessary to determine the composition of the hot spring gases, by means of the sample gases taken, was carried out, with Prof. K. PRYTZ's permission, in the "*Polytekniske Læreanstalts fysiske Laboratorium*" (the physical laboratory of the Polytechnic Academy) in Copenhagen. For this permission, and for his kind advice in regard to the experimental work, I offer Prof. K. PRYTZ my heartfelt thanks. I also thank Mr. S. JÓNSSON, who accompanied me on my journey in 1904, for his interest in these investigations, evidenced by his willingness to enter a second time on the hardships of the journey, in order to help me in the scientific work. The results I have attained through this expedition, are to a great extent due to his capable assistance.

The present treatise will deal freely only with the scientific work done on the journey and in the laboratory, together with its results, disregarding for the most part the equipment and the details of the journey. But for the sake of orientation, I have included a small map of Iceland (Fig. 1), on which our route and the spring districts visited are marked.

¹ K. PRYTZ og TH. THORKELSSON: *Oversigt over det kgl. danske Videnskabernes Selskabs Forhandlinger* 1905, p. 317.

I have divided my treatise into three parts. The first contains a description of the springs we examined, while the second part treats of the methods employed in the investigation, and the third enumerates and discusses the results of the experiments.

In the third part, besides viewing the nature of the springs from a new stand-point, -- which these experiments seem to justify, - I have included several well-known theories, in so far as the latter are borne out by the present investigations; and thereby have endeavoured to make the subject under consideration more consequent and complete.

I. Description of the Springs.

Mývatn.

The hot springs at Mývatn have, in the course of time, often been described by scientific visitors to the spot. JOHNSTRUP¹, who visited these springs in 1871, has given a very detailed description of them, and has constructed a map of the surroundings of the springs. I will therefore content myself with a very short, summary description, and I must refer those who require more detailed information regarding these districts, to JOHNSTRUP's excellent treatise. Nevertheless, in order to make the positions clearer, I have included one of JOHNSTRUP's maps of the springs, (Fig. 2). We stayed at Mývatn from the 19th. June to the 1st. July 1906. During the first few days we pitched our tent a little to the north of the springs, to the east of *Námafjall* (*Námafjeld* on the map). But at that place a proper supply of water was not to be had, so that we were obliged to gather snow from the crevices of the surrounding lava, and use the water obtained by melting it, both in our experiments and for drinking purposes. This had of course great disadvantages, and as we could not keep our horses from straying from this place, we eventually moved nearer to the farm of Reykjahlíð. Thence we paid several visits to the springs.

The hot springs at Mývatn are found chiefly at two places, viz. at *Krafla* and at *Námafjall*. The hot springs at Krafla are for the most part solfataras of little or no significance, which are situated here and there in a large ravine which reaches from north to south to the immediate west of Krafla.

On the eastern slope of the ravine nearest to the south, is *Litla Viti*, an energetic and extremely noisy fumarole, which reminds one, on account of the whistling sound emitted, of *Öskurhólshver* (the roaring hill) at *Hveravellir*. As *Litla Viti* is externally very different to the small solfataras which lie a little to the

¹ Den naturhistoriske Forenings Festschrift. København, 1890.

north in the same ravine, we had intended to take samples of the gases from this spring, but we had unfortunately to give up the idea, as on closer examination it became evident that to collect the gas at that place would be an exceedingly dangerous undertaking.

To the north-west of the ravine mentioned, and separated from it by a high ridge of gravel, are the three lakes shown on the map. The largest of these, which is situated farthest west, covers the bottom of the wellknown crater *Stóra Viti*, or *Helvítí*. The lake is enclosed on all sides by the steep edges of the crater. Towards

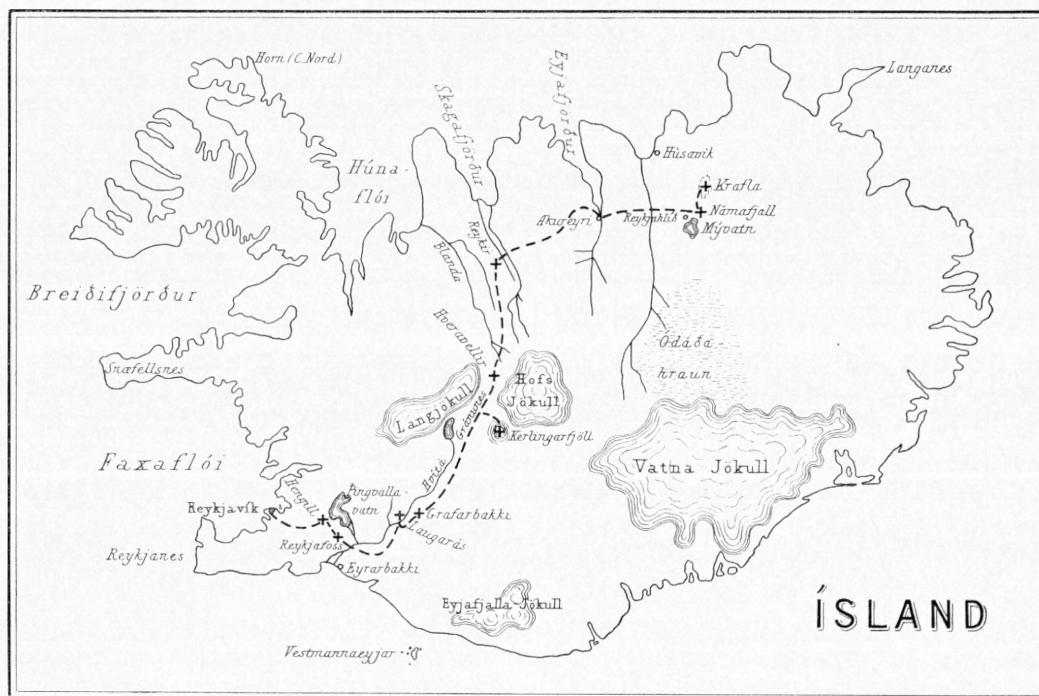


Fig. 1. Iceland.
(Showing route and spring districts visited.)

the east, where the brink of the crater is highest, it reaches, according to a measurement made by means of an aneroid barometer, the altitude of 55 m. above the level of the water. To the west the edge only reaches the height of about 20 m., on account of the declivity on which it stands. The two other lakes were, when we visited the spot, formed into one single lake. This is most probably not because a subversion has taken place, but is simply the result of the surface of the two lakes becoming higher, so that they communicate. Like *Helvítí*, these twin lakes are surrounded by rather high banks sloping down to the surface of the water, but unlike *Helvítí*, the north-eastern and eastern slopes are covered with active solfataras. The photograph (Plate I, a) shows these twin lakes, from the south;

the light-coloured sections to the right represent the position of the solfataras. The light colour is chiefly to be attributed to the sulphurous deposit from the springs. We examined here the gases from two springs, viz. *Krafla No. 1*¹, immediately to the east of the northern lake, and *Krafla No. 2*, to the north-east of the southern lake. The springs were identical in outward appearance, both being small pools of turbid water, with strong gaseous exhalations. Their altitude above the surface of the lakes was 10 cm., while they were 615 m. above the level of the sea. The temperature of the water in the twin lakes was 11.5° C. on the surface; the surface temperature of the water in *Helvítí*, taken at the same time, was 14°; whilst the temperature of the air was 3°. These observations of temperature seem to indicate that the water in *Helvítí* continually receives considerable heat from the interior of the earth, in spite of the fact that it is impossible to see the least sign, on the surface of the lake, that there is at present any connection between the water in *Helvítí* and the torrid interior of the earth. *Helvítí* probably receives most of its heat by conduction. The twin lakes apparently receive no little heat from the springs on their banks.

Námafjall is a palagonitic mountain of which the highest point, according to the altitude we took, is 500 m. above sea-level; JOHNSTRUP estimates its height at 498 m. Here the palagonitic tuffs are much disintegrated; in many places the loose, mouldering tuffs form a stratum more than a metre thick. Near *Námafjall* there is a great profusion of solfataras with considerable sulphurous deposit. Most of the solfataras are situated right up on the mountain, on its eastern slope. Smaller groups of solfataras are also to be found at *Bjarnarflag*, a tufa plain to the west of *Námafjall*.

To the east of *Námafjall* is, on the other hand, a group of hot springs consisting of from 8 to 10 large ugly mud pools (360 m. above sea-level). These sloughs, which stretch in a line from north to south, are bounded on the east by a field of lava; it appears that the mouldering tufa, which descends from the eastern side of *Námafjall*, has forced the outlet of the springs towards the lava. We examined the gases from three places in this group of sloughs.

The gas sample numbered *Námafjall No. 1* is from the largest slough in the group, the position of which is to the extreme north-west (Plate I, b). *Námafjall No. 2* is taken from a smaller cavity by the edge of the lava, to the east of No. 1. *Námafjall No. 3* comes from the slough second in point of power; it is situated a little south of the centre of the group.

Besides the above mentioned sloughs, we saw some in a groove on the east of *Námafjall*, high up at the top of the mountain. These springs were surrounded on all sides by solfataras, so that we could not approach them, but they appeared to be very active. The southern part of *Námafjall* is flat on top, and in the centre of this plain is a little isolated group of sloughs, consisting of 3 springs; the gas, marked *Námafjall No. 4*, is taken from this group, (490 m. above sea-level).

¹ Cf. Part III, Table I.



Fig. 2. The hot spring district at Mývatn.
(JOHNSTRUP.)

Námafjall No. 5 is from a little solfatara in *Bjarnarflag*. The soil was so damp at this place, that it was possible to collect the gases by packing the humid tufa around the funnel, so that the gases were forced through the tubes into the collecting bottle.

To the west of *Bjarnarflag*, — and named after it, — is *Bjarnarflagshraun*, a wild disorderly stretch of lava, ejected from a cleft of craters in *Jarðbaðshólar*, to the south-west of *Bjarnarflag*, (Plate II, a). Here and there, among this lava, warm damp gases exude from fissures and cavities. We made an examination of the gases emitted, in two places, viz. *Reykjahlíð* No. 1, which was taken just by the crater cleft (354 m. above sea-level); and *Reykjahlíð* No. 2, from the western part of *Bjarnarflagshraun* (326 m. above sea-level). These emissions of gases are not confined to *Bjarnarflagshraun*, although they are more in evidence there. Both in the lava to the east of *Námafjall*, and in the older lava as far down as the farm of *Reykjahlíð*, we found similar exhalations.

A short distance south of *Reykjahlíð* there is a large fissure in the lava, *Stóragjá*; the water at the bottom of it was 29.4° C. (JOHNSTRUP took the temperature of the water in the same rift; he found it 30° C.) Since the temperature of the water was, as far as we could perceive, quite uninfluenced by variations in the temperature of the atmosphere, the relatively high temperature must doubtless be attributed to terrestrial heat.

We noticed hot exhalations at several places in the neighbourhood of *Stóragjá*, which also shows that an arm of the terrestrial heat at this place branches out as far as *Mývatn*.

Reykir in Skagafjörður.

The hot springs near the farm *Reykir* in *Skagafjörður* are usually called *Reykjalaugar*. We spent eight days at these springs, from the 13th. to the 20th. July 1906. On account of most unfavourable weather, our stay was longer than we had arranged for. We pitched our tent on the eastern (right) bank of the river, (*Svartá*), which runs past the farm. The site of our tent was 45 m. above sea-level; the farm itself is situated about 8 m. higher, on a hill of conglomerate and sand-stone. On the same hill, to the south and south-east of the farm, are most of the hot springs. These are a striking contrast to the dirty, fætid mud springs and solfataras at *Mývatn*. The water is clear, and a luxuriant stretch of grass reaches to the brink of the springs, whereas the soil by the springs at *Mývatn* is bare and waste. We tested the gases from three of the most important springs in this neighbourhood. The sample *Reykir* No. 1 is from *Sundlaugahver*, the most southerly spring in the group. The warm water from the spring is used to impart to the adjacent swimming-bath ("sundlaug") a tepid temperature. *Reykir* No. 2 is from *Hornahver*, which is situated to the south of the church, and *Reykir* No. 3 from *Bœjarlaug*; the latter is to the east of the church. These three springs can be distinguished on the illustration (Plate II, b), by the vapour which rises, condensed

into a white mist, from the hot water of the springs. In the illustration, which is taken from the north, the swimming-bath is seen farthest away, Hornahver in the middle, and Bæjarlaug in the foreground. The farm is not shown in the photograph, as it lies nearer and more to the right. The picturesque mountains to the south-west, *Mælifellshnjúkur* (and others) are invisible also, as they were enveloped in mist. We also tested the gases, whilst staying at this spot, from two more distant springs. *Reykir No. 4* is from *Fosshver*, a little spring near the beautiful waterfall *Reykjafoss*, two kilometres to the north of Reykir. Here hot water gushes up through rifts in the rocky conglomerate on the eastern bank of *Svartá*. The water has a temperature of 65° , and there are very active gaseous exhalations. *Reykir No. 5* is from *Skiðastaðalaug*, situated on the other side of *Svartá*, about a kilometre to the west of Reykir; hot water issues from three places here at a temperature of 67° to 68° . There is a considerable volume of water. The peculiarity of this spring is that there are apparently no gaseous exhalations from the spring itself. But gases are emitted through a little pool 1 m. west of the most southerly spring. The temperature in this pool was 17.3° C.; at the same time the temperature of the air was only 4° C. The sample gas which was examined comes from this place.

A fact which characterises all the springs explored at Reykir is that the water shows a weak alkaline reaction. The spring water also contains chlorides and carbonates, and sulphates to some small extent.

Hveravellir.

Hveravellir is situated in a hollow by the northern border of the great field of lava called *Kjalhraun*. According to the altitude taken by the barometer, the place where we pitched our tent was 635 m. over sea-level; ÞORV. THORODDSEN made it 632 m., very near to our estimate.

Among previous descriptions of the springs at Hveravellir, the following are noteworthy: — “*Reise gennem Island*”, vol. II, pp. 637—639, by EGGERT ÓLAFSSON and BJARNI PÁLSSON, 1752; “*Iceland, the Journal of a Residence in that Island during the years 1814 and 1815*”, vol. II, pp. 203—209, by E. HENDERSON.

But the most exhaustive description of the springs at Hveravellir is by ÞORVALDUR THORODDSEN¹, who stayed at Hveravellir from the 24th to the 26th August 1888, made a map of the neighbouring spring district, and enumerated the most important springs. Apart from the more detailed examination of the composition of the gases, our efforts in this locality were chiefly confined to ascertain what changes the springs had undergone since Thoroddsen explored them in 1888. As a basis for this investigation, it is necessary to use Thoroddsen’s map, which is therefore reproduced here (Fig. 3).

The springs are situated on two dome-shaped silicious sinters. The sinter to the north-west is the less prominent, and most of the springs are insignificant in

¹ Ymer, 1889, p. 49; and Geogr. Tidsskrift 10, 26, 1889—1890.

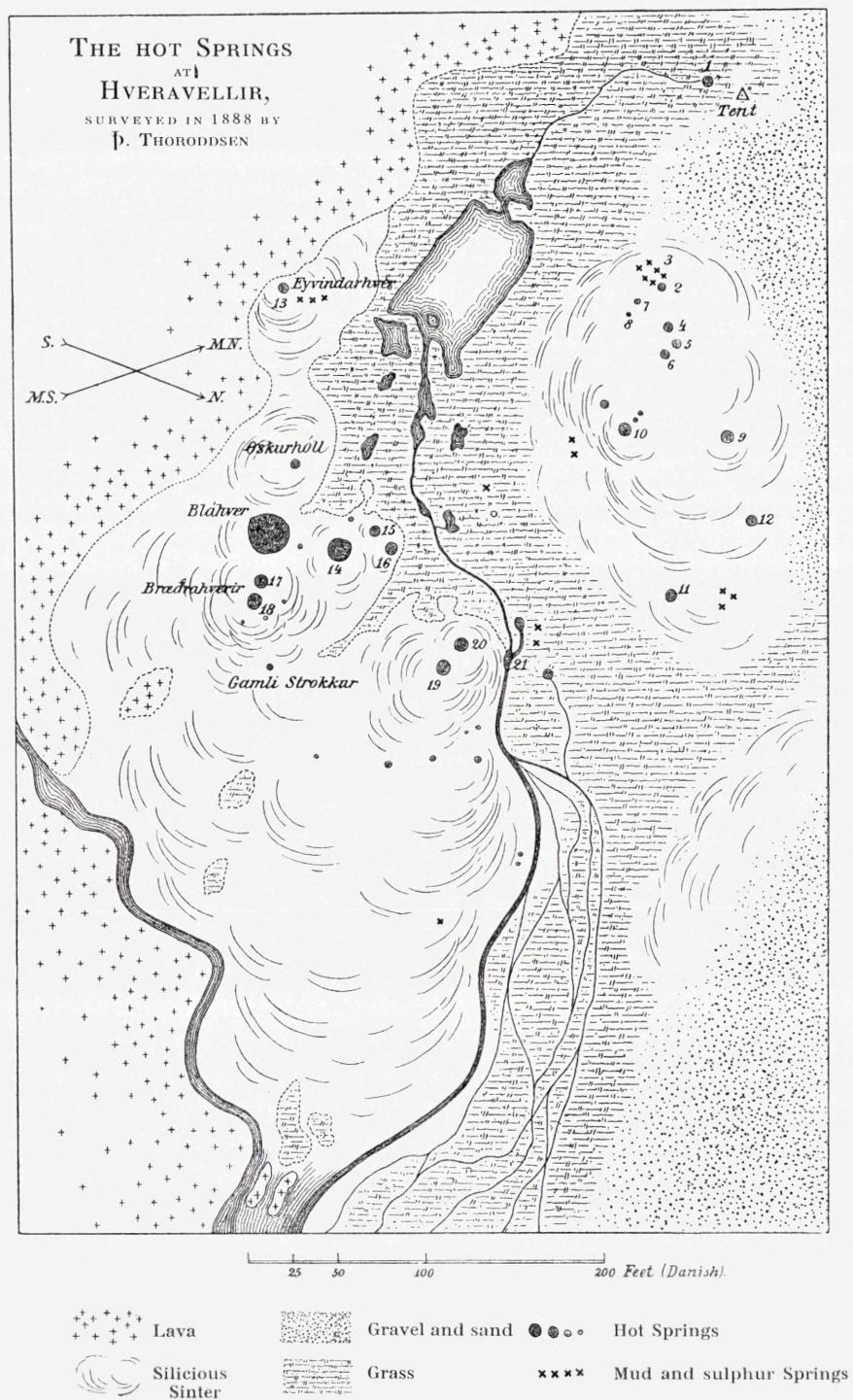


Fig. 3.

comparison to those on the south-easterly dome. In order to identify each particular spring, we measured with a line the distances between the springs on the north-western dome. The position of the springs in the south-eastern group was arrived at by measuring the distance from a given base. In making this survey we used a line and optical square. On the basis of these measurements I have made the accompanying map, which shows the relative distances of the springs in the two groups (Fig. 4). The relative position of the two groups, and the bearings,

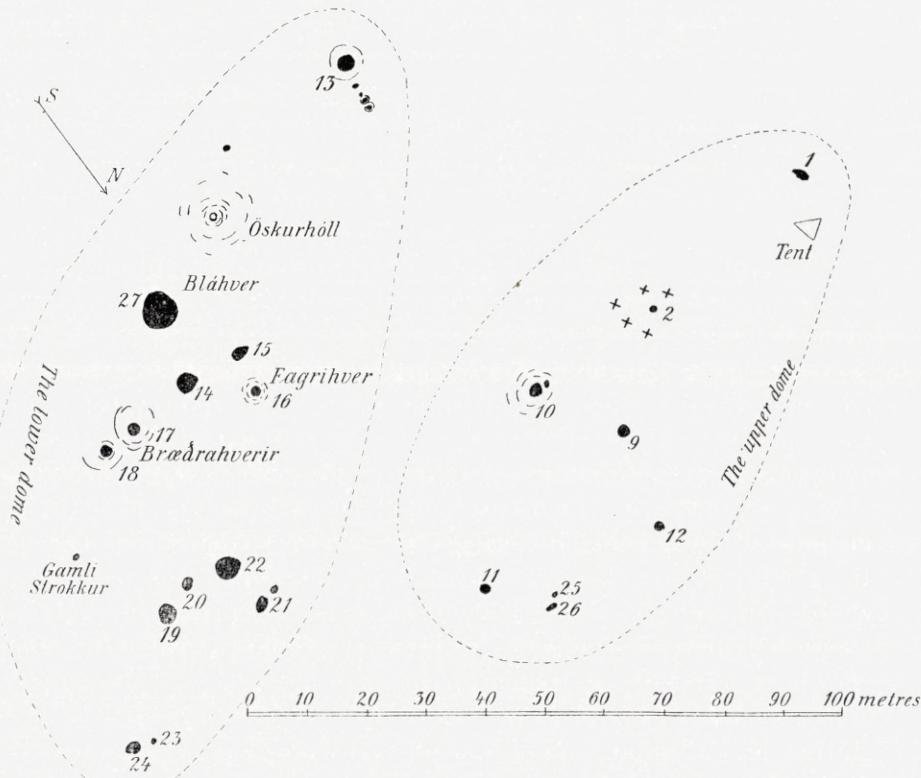


Fig. 4.

are taken from Thoroddsen's map, as these were not ascertained by direct observation. On comparing this map with Thoroddsen's, there are several points of disagreement, both in the relative position of the springs and in the distances between them.

These deviations, which can hardly be caused by changes in the position of the springs, but must naturally be put down to the inaccuracy of the maps, are nevertheless not of such a nature, as to cause doubt as to the identity of the respective springs. On the other hand, if we compare Thoroddsen's description of each particular spring with our observations, they will be found to be, in all the

main points, in agreement; in several places, however, there are insignificant disagreements which show that the springs have undergone some change since 1888. In the following remarks concerning the individual springs, particular attention has been paid to these changes, and I must refer those who desire more detailed information as to the external characteristics and appearance of the springs, to the previously mentioned treatise by Thoroddsen in the Swedish periodical "Ymer".

No. 1 has a temperature of 77° C., instead of 64° according to P. Thoroddsen. In this spring the temperature is dependent on the place where the measurement is taken. On the surface at several places it was only 64°, so that it is quite possible that the great difference in the records of temperature can be explained by the fact that each record refers to a different place in the spring. The highest temperature we found in that spring was 77°. Nr. 2 is a mud spring which throws mud incessantly to a height of 1 m. The temperature was 95°. This spring seems to be more active than in 1888, whereas the small mud holes No. 3 have disappeared from the surface. Nevertheless feeble exhalations of steam through cracks in the surface, indicate that the activity of the spring is continuing deep down, though probably with diminished vigour. From No. 2 we took some sample gases, *Hveravellir* No. 2.

The springs Nos. 4-8 can now practically be reckoned as extinct springs, at least they remained quite inactive as long as we were at Hveravellir. No. 9 is still an active spring, although its energy seems to be declining. No. 10 has also undergone some change; in 1888 it consisted of three holes; of these one has disappeared, probably the most northerly. The most southerly hole is the most active, and it has periodic eruptions, during which the water is thrown to the height of about 1 ft. (3 dm.). In 1888 the eruptions were more frequent, and the water was then 90°-95°, now it is only 84°. Around the hole in the basin of the spring, through which the gases are emitted, there was a yellow border of sulphur. We took sample gases from the north-western hole, in which the temperature was 77°, — *Hveravellir* No. 10. No. 11 has far less frequent eruptions now than in 1888; its temperature is 81°, and 91° during an eruption. No. 12: the basin is generally quite dry, but occasionally it is filled with hot water, accompanied with weak gaseous emissions. The temperature was 86°, but on another occasion it was only 56° (P. Thoroddsen 65°). No. 13, *Egvindarhver*, seems to be unchanged, temperature 87°. *Öskurhóll* (the roaring hill), which seemed in 1888 to have become defunct, has now resumed its steam exhalations, accompanied by an ear-splitting din. The steam is ejected with such power, that even in a strong wind, a column of steam rises perpendicularly for at least a metre's height (Plate III). The steam exhalations have periodical maxima and minima. The temperature is 91°. *Bláhver* is unchanged, the surface temperature is the same as in 1888, viz. 82° on the east side of the basin, and 76° on the west. Sample *Hveravellir* No. 27 is from this spring. Springs Nos. 14 and 15 have about the same temperature now as in 1888, viz. 81° and 64°, as compared to 82° and 67°, respectively; but the exhalations have become much

less. No. 15 gave no visible exhalations whilst we were at the springs. No. 16 has developed into an extremely beautiful spring, with a regular-shaped cone of creamish-yellow silicious sinter (Plate IV). In other respects this spring does not seem to have changed particularly during the last 18 years; there are now fairly strong gaseous exhalations, and the temperature is 93.5° (previously 89°). On account of the picturesque appearance of this spring, we have called it *Fagrihver* (the beautiful spring). From Fagrihver we gathered the gas *Hveravellir* No. 16. Nos. 17 and 18, *Braðrahverir*, are still the most active springs in this neighbourhood, although they do not eject the water quite so high as previously. According to P. Thoroddsen's description, they threw the water to a height of 7—10 feet, in 1888; in 1906 we estimated the height of the column at 1.5 m. In No. 17 the thermometer showed 81° , and in No. 18 84° . *Gamli Strokkur* is now quite extinct; the temperature of the water in the basin was 27° , as against 37° in 1888. Nos. 19 and 20 are only slightly altered. Their temperature was 85° and 57° . In No. 19 there were no exhalations, and in No. 20 they were very slight. No. 21 is a spring which gushes continuously and actively; we measured its temperature twice; the first time it was 90° , but the second time it was only 72° . This can partly be explained by the theory that this spring, like most of the other springs at Hveravellir, is periodic; but as there is a stream running near by, which to some extent mixes its waters with the waters of the spring (No. 21), the temperature of the latter must be largely dependent on the volume of cold water which flows from the stream into the spring. It is therefore not impossible that the difference between the two measurements of the temperature can be partly accounted for by this fact.

Besides the springs already referred to, which have all been mentioned and numbered by P. Thoroddsen, I append a brief description of the hot springs at this place which have not been dealt with by P. Thoroddsen.

No. 22 is a basin of considerable size to the south of No. 21, with a temperature of 75° . In the water-course east of No. 21 are the two springs which we have marked Nos. 23 and 24. No. 23 is a little cavity in the silicious sinter, through which hot water is ejected with considerable force. No. 24, which is situated by the northern side of the large dome of silicious sinter, covers a large surface. Vapours issue with such force from the edge of the sinter that the water in the basin of the spring is kept continually rippling. The temperature is 95° .

Nos. 25 and 26 are two pools situated side by side a little to the north-west of No. 11. Both these pools are filled with clear water, without any silicious deposits; as to outward appearance they therefore much resemble No. 1. There were active exhalations in both these springs. From No. 25, in which the temperature was 81° , we took specimen gases, *Hveravellir* No. 25; the temperature of No. 26 was 89° .

The foregoing comparison of the conditions of the springs in 1888 and 1906 seems to point out that the thermal activity at Hveravellir was less during our visit, than when P. Thoroddsen explored them, particularly the springs on the upper

dome, which are now both fewer and less prominent than in 1888. On the lower dome the thermal activity has also on the whole declined. There are, however, some exceptions, the most conspicuous being Öskurhóll, which has now resumed its resonant exhalations of vapour, well-known from ÓLAFSSON's and HENDERSON's descriptions. Amongst other springs which seems to have increased in force since 1888, Nos. 16, 23 and 24 are noteworthy. It would of course be premature to conclude from the preceding observations, that the thermal activity at Hveravellir is in a continual state of decline. Many of the changes noted can be traced to more accidental grounds. Precipitation and other meteorological conditions have doubtless great influence on the springs, and that is at least the most plausible explanation of Öskurhóll's changeability.

But the matter presents another aspect, when one compares the springs on the lower and upper domes of silicious sinter; for one must then suppose that the question of meteorological influences is essentially eliminated. The accompanying observations show with considerable certainty that the activity of the springs on the upper dome has decreased appreciably more than on the lower dome. This is in agreement with previous observations from other places, and shows that in general hot springs have a tendency to find the lowest level, -- a result which would be reached on purely physical considerations.

In the lava-field Kjalhraun to the south-east of the above-mentioned springs, there are considerable thermal exhalations. These exhalations are chiefly grouped about an imaginary line from Hveravellir, in a southerly direction, about 43° to the east. Curiously enough, Kerlingarfjöll lies in the same line, if it be produced. We examined in two places the gases which thus streamed out through rifts in the lava. Of these, *Kjalhraun No. 1* was taken about 110 m. south-east of the most south-easterly dome of silicious sinter. The exhalations, of which the temperature was 87° , produced a whistling sound as they were emitted from the holes in the lava.

Kjalhraun No. 2 was taken up in the lava about 1 kilometre south-east of Hveravellir. The temperature of the exhalations was 88° .

Our visit to Hveravellir extended over 4 days. On the 26th. July, we left Hveravellir, and pitched our tent at *Gránunes*, whence we made excursions to the springs at *Kerlingarfjöll*. It was originally our intention to camp west of *Áskarðsfjall*, just to the north of Kerlingarfjöll, but as the early part of the summer of 1906 was unusually cold in Iceland, there was not sufficient pasture at that place for the horses during our stay. We were compelled therefore to choose Gránunes as our camping-ground, although it was at least three times as far away from the springs. The double journey between Gránunes and the springs took more than 6 hours, and moreover we had to make a difficult crossing over the river *Jökulkvísl*. We stayed at Gránunes for 6 days, but on account of unfavourable weather we could only make two excursions to Kerlingarfjöll, viz. on the 28th. and 31st. July 1906.

The hot springs at Kerlingarfjöll.

The springs at Kerlingarfjöll are, in spite of their great number, homogeneous pools, with a strong odour of sulphuretted hydrogen, and with turbid water, which is kept continually in agitation, as if boiling, on account of its high temperature and the active exhalation of gases.

On account of the high altitude of the place (940 m. and more), all the ravines and hollows were filled with snow whilst we were at Kerlingarfjöll, except where the warmth of the springs had melted the snow. The springs are engaged in a continual struggle for the mastery with the snow, and in this way the most remarkable snow-figures are formed. The snow cannot remain in the immediate neighbourhood of the springs, not being able to resist the warmth emitted by them, but a little farther away we saw in several places large steep walls of snow, over 10 m. high.

During the winter, when the cold is at its greatest, these snow walls can advance nearer to the springs and perhaps embrace them entirely; but by the summer the heat from the springs has obtained the upper hand, and the snow has to withdraw.

Under these conditions, the snow does not so readily melt on the surface as near the earth, which receives heat from the springs, and the masses of snow thus undermined break off (Plate V), and large pieces of snow are precipitated towards the springs. We saw several steep, isolated masses of snow, from 6 to 10 m. high, which had in this way become detached from the rest, and which, on account of the sloping ground, glided slowly down towards the springs. At other places, we saw the misty vapours rise from the middle of a large expanse of snow. These vapours evidently came from smaller isolated hot springs, which had not yet succeeded in getting rid of their covering of snow, and had therefore to let a small hole suffice as an outlet for the vapours up through the snow.

The hot springs which we visited at Kerlingarfjöll are all to be found in a large valley, almost in the shape of a right angle, the sides of which are intersected by a great number of smaller valleys or ravines. The whole of the spring district, which is called by the one name *Hveradalir*, falls naturally into three divisions, viz. *Vestur-Hveradalir* (Plate V), to the west, nearest to the outlet of the valley, *Mið-Hveradalir* (Plate VI), the middle part of the valley, where it turns to the east, and *Austur-Hveradalir*, farthest in the valley, towards the east.

From *Vestur-Hveradalir* one can see some of the springs in *Mið-Hveradalir*, but on account of the bend in the valley toward the east, *Mið-Hveradalir* seems to be the end of the valley. Not one of the springs in *Austur-Hveradalir* can be seen until one has come to *Mið-Hveradalir*, and the majority of them are not to be seen before one is quite close to them.

The springs in *Hveradalir* are mostly found in the sides and at the bottom of the small ravines. An exception is found in a very large spring situated high up

on the large gravel ridge which separates Austur-Hveradalir from Mið-Hveradalir. As this spring is visible from Mið-Hveradalir, it can serve as a guide to anyone seeking the hot springs in Austur-Hveradalir.

The time we had for our stay at the hot springs being very limited, and a great amount of time being spent in collecting specimens of the gases, we had to content ourselves with a rapid examination of the remaining springs. We were able, however, to substantiate that the springs resemble each other strongly. We did not see any mud springs or mud volcanoes here, with thick mud, of which there are so many examples at *Mývatn*, *Hengill* and *Krisuvík*; where one would expect to find such mud springs, the water was only muddy on account of the deposit of small particles. The great rainfall at Kerlingarfjöll has the effect of adding so much water to the springs, that the small particles produced by the action of the springs, can be continually conveyed away by the water. The streams, which are found in the small ravines, and which eventually unite into a river, *Áskarðsá*, which runs through the main valley, are greyish-white from the particles which the water carries from the springs. *Áskarðsá* bears away proportionally more suspended substances than the other glacier rivers.

The hot springs in Vestur-Hveradalir and Mið-Hveradalir have, on the whole, a greater volume of water than the springs in Austur-Hveradalir, which is naturally to be attributed to the higher altitude of the latter. In Austur-Hveradalir there are even a considerable number of solfataras with sulphur deposits, but as JOHNSTRUP has shown, the deposit of sulphur in solfataras only takes place when the soil is sufficiently dry and porous to permit the mixture of the atmosphere with the gases of the springs, under the surface of the earth.

With regard to the individual springs, I will content myself with describing one spring in Austur-Hveradalir, which is distinguished from all the other springs we saw in this place, by its activity and outward appearance. This spring, which is situated close to the stream running through the main valley, is a steam spring of the same kind as *Öskurhóll*, at *Hveravellir*, only it is still more powerful. Vapour and gases are emitted with indescribable force through a little hole in the rocky ground, and the emissions of vapour are accompanied by a deafening noise. When one considers that a large extent of the valley around the actual spring is filled with mist, which comes mostly from the vapour of this spring, one can form some slight idea of the tremendous amount of steam emitted by the spring. We called this spring *Öskrandi* (the Bellower). (Plate VII, a.)

The specimens of gases collected at Kerlingarfjöll were as follows: *Kerlingarfjöll No. 1 and 2*, from the same ravine in *Vestur-Hveradalir*, to the west of *Áskarðsá*, No. 1 nearer to *Áskarðsá*, No. 2 higher up in the ravine. *Kerlingarfjöll No. 3* comes from a large spring reservoir in *Mið-Hveradalir*. *Kerlingarfjöll No. 4* is from a little spring in *Austur-Hveradalir*, near *Öskrandi*. Altitudes: *Vestur-Hveradalir* 945 m.; *Mið-Hveradalir* 980 m.; and *Öskrandi* 1000 m.

Grafarbakkahverir.

We stayed here from the 4th. to the 7th. August 1906. P. THORODDSEN, who visited these springs in the summer of 1888, has described them in "Geografisk Tidsskrift"¹. The elevation of the springs is 60 m. above sea-level. The most important springs are situated on a little narrow eminence on *Litla Laxá*'s right (northern) bank, (Plate VII, *b*). Farthest to the north there are two fountain-springs or geysers; the one towards the south spouts highest, about 1.7 m., while the northern one throws a column of water only 0.7 m. high, (Plate VIII, *a*). In 1888 the reverse was the case; according to P. Thoroddsen's statement the northern spring then spouted higher (4 ft.; the other 2 ft.). In both of these springs the temperature of the water between the eruptions was 95° (P. Th. 97°). But during the eruptions the temperature was 99.3° in the northern spring, and 98.4° in the southern.

With regard to the frequency of the eruptions I refer the reader to Part III, Table II—III. About midway between the eruptions a large quantity of boiling water is emitted from a fissure 0.4 m. long.

From this spring, which we named *Klofi*, we took the sample gas *Grafarbakki No. 1*.

Básahverir is the name of two deep hot-water basins, surrounded by sod. There is very little gas emitted from these springs; the depth of the water was about 3 m. The surface temperature was, in the northern basin 95°, and in the southern, 91.5°; but at the bottom, the temperature was 96.7° and 93.8° respectively. To the extreme south-west, close to the right bank of *Litla Laxá*, is *Vadmalahver*, with a regular-shaped basin in which the water is in a state of continual agitation. The surface temperature was 98.4° (P. Th. 96°); at the bottom, 99.4°.

The same series of springs is continued on the opposite bank of *Litla Laxá*; close to the river there are two springs, of which the larger, like *Klofi*, rises out of the rocky ground, through a fissure 0.4 m. long. We obtained the sample *Grafarbakki No. 2* from this spring. A little farther on in the same direction, and higher up on the hill on which the farm *Grafarbakki* is situated, is a large boiling spring. The water from this spring is used by the inhabitants of *Grafarbakki* for drinking purposes.

Smaller groups of springs can be seen still farther away in a south-westerly direction towards the farm *Gröf*. We only visited the nearest of these groups, which lies on the left side of *Litla Laxá*, to the west of the above mentioned hill. The springs here are for the most part insignificant pools with gaseous exhalations. The gas sample *Grafarbakki No. 3* comes from the most northerly spring in this group.

In all the springs examined here, the water is alkaline and contains chlorides. In the two *Básahverir*, there are also traces of sulphates in the spring water. The gases in each case, showed positive reaction on being tested for sulphuretted hydro-

¹ Geogr. Tidsskr. **10**, 18, 1889—90.

gen and carbon dioxide. The stones and pieces of rock which were around the springs, and which come in contact with the spring water, were covered with a thin shell of silicioussinter.

Laugarásshverir.

The farm *Laugarás* is situated on an elevated ridge 67 m. above sea-level. A little to the west of the ridge, probably 50 m. above sea-level, most of the hot springs are grouped together within a small space. The most important springs, taken from north to south, are the following: — *þvottahver*, 96°, sample *Laugarás* No. 1; *Draugahver*, 100° and *Suðuhver*, 98.5°, from which the sample *Laugarás* No. 2 is taken.

Down by the river Hvítá, about 200 m. to the south of the springs, there are also some smaller hot springs. The specimen *Laugarás* Nr. 3 is taken from the most easterly spring of this group. The spring water in the above mentioned springs is alkaline and contains chlorides and carbonates with traces of sulphates. In the gases were found traces of sulphuretted hydrogen, but no carbon dioxide. There were much smaller deposits of silicious sinter on the stones around the springs here than at Grafarbakki.

With regard to their outward appearance, these springs remind one very much of the springs at Reykir and Grafarbakki, and many plants uncommon in Iceland thrive exceedingly well in the warm soil around them. But the great heat of the water hinders the growth of plants, however, in such close proximity to the springs as is the case at Reykir in Skagafjörður.

We remained three days at Laugarás, from the 8th. to 11th. August 1906.

The hot springs at Reykjafoss in Ölfus. — Ölfushverir.

We spent from the 12th. to the 16th. August here. These springs are by the highway, and have therefore been more often visited than any other Icelandic springs, with the exception of those at *Stóri Geysir*. A good account of their topography and history is given in P. Thoroddsen's description in the "Geografisk Tidsskrift"¹.

The best known spring at this place is *Litli Geysir* which has formerly been a very strongly spouting-spring. When R. BUNSEN visited Litli Geysir in 1846, it spouted regularly at even intervals; but it has now quite ceased spouting. The largest geyser at present is *Grýla* or *Grýta* (Plate VIII, b); it is situated 1 km. to the north of Reykjafoss. Grýla emits steam for a short period after an eruption, which is quite unusual with Icelandic springs.

Of the specimens of gases we examined in this spring district, there are 3 from *Hveragerði*, (Plate IX, a), to the west of Reykjafoss (25 m. over sea-level), viz. *Reykjafoss* No. 1, from a basin with clear alkaline water, which contained chlorides and

¹ Geografisk Tidsskrift 17, 98, 1903—1904.

traces of sulphates. This spring lies to the extreme south of the alkaline springs here, only 2 m. from the spring examined in 1904 as "Reykjafoss Nr. I"¹ which seems to be extinct, at least there are no further exhalations. *Reykjafoss No. 2 and 3* come from two small mud pools in Hveragerði, to the south-west. These springs, containing sulphuretted hydrogen, naturally gave an acid reaction. The fourth sample of gases, *Reykjafoss No. 4*, was taken from a little hot spring to the east of *Varmá*, just below the neighbouring waterfall (Reykjafoss).

The warm springs around Reykjafoss really constitute the southern part of a larger spring district which stretches towards the north with varying intervals of space, to the east of the highest point of the mountain *Hengill*. In this district there are solfataras, mud pools, clear, alkaline water basins and geysers, so that nearly all the more general kinds of springs in Iceland are represented here.

Apart from the springs around Reykjafoss, we were only able to examine the most northerly groups of springs in this district. These are named:—

Henglahverir.

Our sojourn at these springs lasted from the 17th. to the 20th. August 1906.

They are situated on the eastern slope of the mountain *Hengill*, where a large number of, for the most part, very strong hot springs are in evidence, collected in several separate groups. The distances between the groups are greatest in the direction from north to south; it is in some cases almost 1 km. On the other hand, the differences in their elevation are proportionately much less, in that they are all situated at the place where the slope of the mountain towards *þingvallavatn* lessens. It appears as if the hot springs here resort preferably to depressions in the ground. The southern groups go under the name of *Ölvisvatnslaugar*, while the northern are called *Nesjavallalaugar*. On the whole, the thermal activity in *Hengill* is at least as great as at any other of the places we have visited, with perhaps the exception of *Kerlingarfjöll*. In appearance, these hot springs most resemble the springs at *Mývatn* and on *Kerlingarfjöll*, in as much as they are either solfataras or mud springs.

On account of the great number of these springs, I must refrain from a detailed description of them, though they are in many respects highly interesting, and content myself with a summary account of the most important groups.

To the extreme south there is an isolated mud pool in the centre of a grass plot. One cannot see the spring itself until one is close to it, as it gives off, in contrast to most of the other hot springs, very little steam. On the other hand, one can hear at a distance of 200 m. the rippling sound made by the large bubbles of the gases forcing themselves up through the mud, which is of a pulpy nature. Each bubble is from 1 to 2 litres in size, and when it emerges from the surface and the mud closes in again this peculiar sound is emitted. This mud pool seems

¹ K. Prytz og Th. Thorkelsson loc. cit. p. 325.

to have been in existence only for a short time. A little to the north of this spring, and higher up on the mountain slope, there is a small group of springs, which, on account of its dome-shaped deposit of silica, reminds one to some extent of the hot springs at Hveravellir.

Farther to the north, and on about the same level as the mud pool previously mentioned, is a rather large group of springs consisting of mud pools and solfataras. The springs are situated around a powerful steam volcano, which, with an ear-splitting report, throws up a strong column of steam. From this group we took two gas samples: *Hengill No. 1* and *Hengill No. 2*. *No. 1* is from a spring to the south of the steam volcano. The spring water, which had an acid reaction, and contained sulphates to a considerable extent, but no chlorides, had a yellowish tint on account of deposited particles of the same colour. *No. 2* comes from a little spring immediately to the north of the steam volcano.

The nearest group of springs to the north, is situated at a much greater altitude. The distance between these groups is presumably about 600 or 700 m. In the group which is seen to the left in the picture (Plate X), there are several solfataras and mud pools, but the most peculiar is perhaps a spring with a temperature of 23.3°, which lies just to the north of the group. This spring contains a large volume of water, which has deposited a yellowish-white layer, about 4 or 5 cm. thick, in its bed. This layer consists chiefly of precipitated sulphur, which, it follows, the spring water must contain. How this sulphur is produced cannot at present be decided; at any rate it does not seem probable that it has been occasioned by the imperfect combustion of sulphuretted hydrogen in the atmosphere. JOHNSTRUP's¹ theory on the formation of sulphur in Iceland cannot therefore be applied to this case, even though it seems in most other places to give the most feasible explanation of the formation of sulphur around the solfataras.

In a north-eastern direction from the last-mentioned group of springs, there is another large group situated directly north of a high grass bank. This group, which is seen in the foreground to the right of the illustration (Plate X), was on a level with the site of our tent, which was, according to the elevation we took, 300 m. above sea-level. At this place there are two large mud volcanoes, which throw up mud and water incessantly to a height of about half a metre (Plate IX, b). The specimen *Hengill No. 3* is taken from a little spring just to the north of the mud volcano shown in the illustration.

Some distance north of the groups of springs already mentioned, there are yet three more groups. Of these the one to the extreme south-east consists almost exclusively of solfataras (Plate XI). In the middle group, which is to be seen in the background of the photograph, (Plate XII), we collected the specimen *Hengill Nr. 4*. It seems that the thermal activity around this group is increasing in extent. For instance, we noticed that the grass upon a little plot which in our opinion must recently have been covered with grass, had mostly been destroyed by the

¹ loc. cit.

heat. Nearest to the springs the remnants of vegetation were quite black, farther away they were whitish, and finally yellowish, as a transition to the natural green colour. On the whole the terrestrial heat is probably on the increase in the hot springs here. This is confirmed, amongst other things, by the fact that in the group to the extreme north-west, there is a large mud volcano, which appears to have come recently into existence. This mud volcano (Plate XII) is about 5 m. in diameter, and we estimated its depth, reckoned from the edge of the spring down to the surface of the mud, at 2 m. The mud is continually thrown up to the level of the edge of the basin, that is, about 2 m. high. About 10 or 12 m. south of the mud volcano, we saw a peculiar little spring which also appears to be quite recent. As the illustration shows (Plate XIII) the spring has piled up the thick mud around its mouth, and in that way a sharp-pointed cone has been raised; this is on account of the mud indurating as soon as it is thrown from the outlet of the spring, and therefore obtaining sufficient solidity to stand upright in a conical form.

II.

The methods employed in the experimental work.

1. Testing the Radioactivity.

The investigation of the radioactivity of the hot springs comes under two heads, viz.: testing the radioactive emanations contained in the gases from the springs, and the examination of the sediment and mud taken from them, with a view to determining the radioactive substances they may contain.

The apparatus which I have employed to gauge the radioactive emanation, is reproduced in the accompanying outline drawing, (Fig. 5). The apparatus consists of four parts: the electroscope (*E*), the ionisation chamber (*I*), the battery (*B*), and a reading microscope (not shown in the illustration).

The electroscope (*E*) differs from an Elster Geitel electrometer in that it has only one aluminium leaf, and that the electroscope vessel is entirely of brass. In order to be able to observe the leaf, the electroscope vessel is provided with two circular windows, 15 mm. in diameter. The window in the front of the vessel is closed by a plane sheet of glass, through which the charged leaf may be observed, while the leaf receives the light necessary to the observation through the window on the back side of the vessel, this window consisting of a sheet of opaque glass. The rod (*g*), which holds the aluminium leaf, passes airtight through the amber cork, and its lower end is made to screw on to a brass cylinder (*k*) 12 cm. high and 2 cm. in diameter. This cylinder is enclosed in the ionisation chamber, — a sheet

metal vessel of the same shape, 22 cm. high and 13 cm. in diameter, and provided with two tubes (*l*) through which the gases to be examined are introduced. The ionisation vessel and the inner cylinder (*k*) are concentrical and together form a condenser.

When in use, the electroscope, the inner cylinder and the testing vessel are firmly connected by means of screw threads, but under transport these three parts of the apparatus are detached; a brass cover is then screwed on to the bottom of the electroscope in order to protect the lower surface of the amber against moisture and dust. A distinctive feature of this testing apparatus is the adjustment of the

neck of the vessel into which the electroscope is screwed. The ebonite ring (*n n*) establishes a firm connection between the brass ring (*r r*) and the lid of the vessel. For this purpose the lid is fitted with a raised rim, which fits hermetically into the ebonite ring. The electroscope is attached to the testing vessel by means of a worm on the inner side of the brass ring (*r r*). The distance between the brass ring and the rim (*s s*) is about $\frac{1}{2}$ mm., so that the electroscope vessel is insulated from the ionisation chamber. A thin india-rubber ring is placed between the outside of the brass ring and the electroscope in order to make the connection between the electroscope and the ionisation chamber airtight.

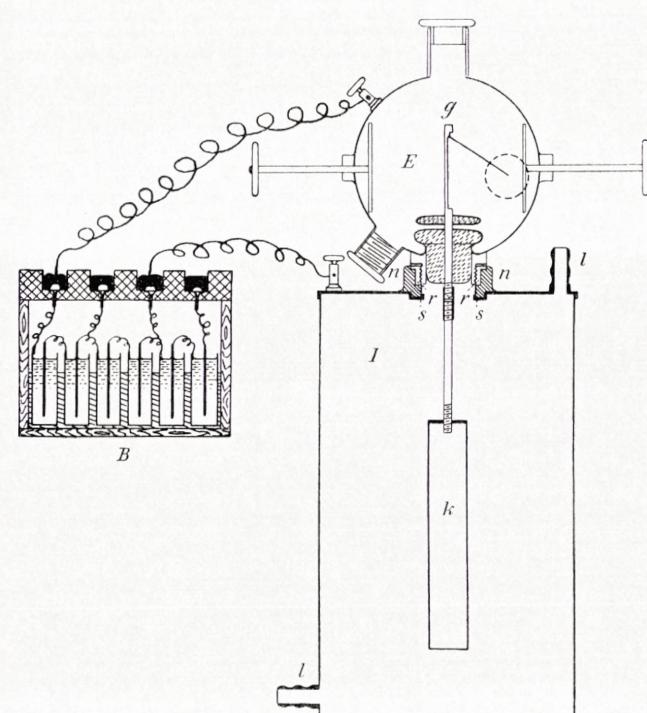


Fig. 5.

The electroscope vessel and the ionisation chamber, when connected, form the outside of a perfectly closed condenser (a Faraday case). The inside of the condenser is represented by the aluminium leaf, the rod (*g*) and the cylinder (*k*). But when the connection is broken, we have in the electroscope vessel and the ionisation chamber two separate closed condensers of which the inner surfaces are in connection with each other.

Such a system of condensers establishes the theory that the fluctuations in the charge of the inner system of conductors is proportionate to the changes in the potential difference between the two outer conductors, provided that the

potential difference between the inner systems and either of the outer conductors is constant.

This can be demonstrated in the following manner.

In a closed condenser, the charge that the inner system of conductors carries is expressed by

$$E = c(v_1 - v_2),$$

where c , the capacity of the condenser, and v_1 and v_2 are respectively the potentials of the inner and the outer system of conductors. In the above mentioned apparatus the charge e , held by the inner cylinder (k), the rod (g) and the aluminium leaf, can be analogically expressed by the formula: —

$$e = c_e(v_i - v_e) + c_b(v_i - v_b), \quad (1)$$

c_e and c_b are the respective capacities of the electroscope and the ionisation chamber, and v_i , v_e and v_b are the potentials of the inner cylinder, the electro- scope vessel and the ionisation chamber respectively. Leakage from the inner cylinder will cause a change in e , v_i , v_e and v_b and we get in the same way as before

$$e' = c_e(v'_i - v'_e) + c_b(v'_i - v'_b), \quad (2)$$

when the new values of the variable quantities are marked. Subtracting (2) from (1) we have

$$e - e' = c_e((v_i - v_e) - (v'_i - v'_e)) + c_b((v_i - v_b) - (v'_i - v'_b)).$$

Assuming that the potential difference between the electroscope vessel and the rod (g) remains constant, we have

$$v_i - v_e = v'_i - v'_e. \quad (3)$$

Hence we get

$$\begin{aligned} e - e' &= c_b((v_i - v_b) - (v'_i - v'_b)) \\ &= c_b((v_i - v'_i) - (v_b - v'_b)) \\ &= c_b((v_e - v'_e) - (v_b - v'_b)) \\ e - e' &= c_b((v_e - v_b) - (v'_e - v'_b)), \end{aligned} \quad (4)$$

which affords the required proof.

Equation (4) shows that the leakage is equal to the product of the capacity of the ionisation chamber and the change in the potential difference between the electroscope vessel and the ionisation chamber. The leakage is, on the other hand, independent of the electroscope capacity and of the absolute potential of the inner cylinder.

A possible objection to the above demonstration is that the formula (1) is not applicable because the two condensers regarded separately are not entirely closed, but as I have shown in Phys. Zeitschr.¹ the formula holds good, provided that the electroscope and the ionisation chamber form a single closed condenser when a conductive connection is established between them.

¹ Phys. Zeitschr. 7, 834, 1906.

When the apparatus is to be used to measure radioactivity, it must be remembered that the activity is generally proportionate to the leakage from the inner cylinder divided by the time. Therefore in these measurements it is necessary to record the time, as well as to measure the leakage.

It is evident from equation (4) that measurements made by means of the testing apparatus may be executed in two different ways. In the first place by allowing the potential difference between the electroscope vessel and the inner cylinder to remain constant, when the amount of the leakage is obtained by determining the potential difference between the electroscope vessel and the ionisation chamber at fixed intervals. Secondly, the rate of leakage is obtained by determining the time that elapses before the potential difference between the inner system of conductors and the electroscope vessel has acquired a fixed value, after having made a given alteration in the potential difference between the electroscope vessel and the ionisation chamber. For reasons of a practical nature I preferred to use the latter method of observation.

We have a good criterion as to the identity of the potential differences between the electroscope vessel and the inner system of conductors, when the deflection of the aluminium leaf is constant.

The measurements were made in the following manner. One's first care is to see that the potential difference between the electroscope vessel and the ionisation chamber remains constant, e. g. by connecting them with the poles of a constant battery, or at any rate by connecting them with a thin copper wire, so that the potential difference becomes zero. Then the inner system of conductors is charged until the aluminium leaf makes a suitable deflection.

The potential difference between the aluminium leaf and the electroscope vessel was about 300 volts in my experiments. The microscope is then adjusted so that a clear outline of the leaf is seen in the neighbourhood of a mark in the eye piece, — two threads crossways will serve this purpose.

The deflection of the leaf decreases gradually on account of the leakage from the inner cylinder, and by adjusting the microscope one ensures that the edge of the leaf can be seen moving towards the fixed mark in the eye piece.

Note is taken of the time at which the image of the edge coincides with the mark. The potential difference between the electroscope vessel and the ionisation chamber is altered, so that the deflection of the leaf becomes greater, and the time at which the next coincidence of the edge of the leaf and the mark in the eye piece takes place is also noted. Let t represent the number of seconds between the two periods of coincidence; then the rate of leakage per second is given by

$$E = \frac{e - e'}{t} = \frac{c_b}{t} ((v_e - v_b) - (v'_e - v'_b))$$

or

$$E = \frac{c_b u}{t},$$

when $u = (v_e - v_b) - (v'_e - v'_b)$ is the change in the potential difference between the electroscope vessel and the ionisation chamber that has been produced.

The most convenient way of charging the inner system of conductors is by means of influence. A rod provided with an insulated handle, is brought into contact with the rod g , and a charged body, a rod of sealing wax for instance, is brought close to the upper end of the charging rod until the leaf has made a suitable deflection. Then the charging rod is taken off and the cover of the electroscope vessel put on. In order to impart a sufficient charge to the inner cylinder it is necessary that the end of the charging rod toward which the rod of sealing wax is brought, be flat shaped.

In order to produce the potential difference between the electroscope vessel and the ionisation chamber I used 10 small dry cells (Helleesen's pattern). These were embedded in paraffin in two wooden boxes containing four and six cells respectively. In each box the cells were connected in a series, and one pole of every alternate cell was attached to one of the copper stoppers which formed the bottom of the small holes in the thick ebonite plate in the lid of the box, (see Fig. 5). The copper stoppers render the holes mercury-tight, and when the battery is to be used the holes are filled with mercury. When the poles of the cells are to be connected to the electroscope vessel and the ionisation chamber, the ends of the connecting wires are placed in the mercury. In transit the holes in the ebonite plate are emptied of their contents of mercury, and then the poles of the cells are represented by the copper stoppers in the bottom of the holes. In this way the cells are protected against injury by accidental overstraining. Hence the cells remained constant during the whole journey.

Of course the connections between the testing apparatus and the battery are arranged at the beginning of every experiment, that is to say, before the adjustment of the microscope, so that one is able to make the greatest change in the potential difference that the cells in use permit, without altering the adjustment of the microscope. If the inner cylinder is charged positively, then the positive terminal of the battery should be connected with the electroscope vessel.

As the change produced in the potential difference between two consecutive observations depends on the rate of leakage, one must endeavour as far as possible to arrange that the intervals of time to be measured be kept within certain limits, preferably about one minute. If the intervals are much longer, the measurement takes too long, whilst on the other hand, if the interval be much shorter, the inevitable errors will proportionally be so great as to affect seriously the accuracy of the final results.

When the ionisation is small and the downward movement of the leaf is correspondingly slow, one does not need to move one end of the connecting wire farther forward than one hole in the battery case at a time; the established alteration in the potential difference ($v_e - v_b$) then amounts to about 2.9 volts, i. e. double

the E. M. F. of one cell. This is the least variation in the potential difference that can be produced by means of the above mentioned battery boxes.

The increase in the deflection of the leaf effected by such a variation of potential difference amounts to very nearly 3 mm., as seen in the eye piece of the microscope. As it would easily be possible to distinguish $\frac{1}{30}$ of this, I was enabled, according to equation (4), to detect with this testing apparatus a decrease in the charge corresponding to $4.9 \times \frac{2.9}{30} \times \frac{1}{300} = 1.6 \times 10^{-3}$ E. S. units, the capacity of the ionisation chamber being 4.9 cm. in absolute electrostatic units.

When the ionisation is stronger, a correspondingly greater change is produced in the potential difference ($v_e - v_b$). By means of the two battery boxes I was able to make in all ten different changes in the potential difference, viz. 2.9; 2×2.9 ; 3×2.9 etc. up to 10×2.9 volts. In my opinion a greater alteration of the potential than 29 volts is not necessary, because, if the ionisation is too intense to be measured with sufficient accuracy by means of a potential variation of 29 volts, we are running the risk of there being an absence of saturation current in the testing apparatus, on account of the potential of the aluminium leaf and connecting conductors being restricted. In this case it is more reliable to introduce the active gas in smaller quantities into the ionisation chamber, and in this way avoid testing gases too intensely ionised.

The chief advantage of the method of measurement just described is that it is only necessary to know the small potential difference between two conductors, i. e. the electroscope vessel and the ionisation chamber, in order to compute the ionisation, it not being necessary to determine the high potential of the inner system of conductors exactly. But so few cells were required in order to gauge the small potential differences, that we could take them with us on the journey. Hence I was enabled to use the microscope instead of the magnifying glass in observing the aluminium leaf, the rate of leakage being measured in this case by comparison with the E. M. F. of the small cells taken with us, instead of by means of a scale, which would have had to be ganged every time the testing apparatus was set up.

The observation is preferably made by means of the microscope than by means of the magnifying glass, as the measurement can be made with greater speed without diminishing the accuracy. It is of great importance that the measurements be made expeditiously in the study of radioactive substances, as they are generally of an extremely changeable nature. Microscopic observations also save time, when the discharge through slightly ionised gas is to be determined.

Although the leaf can only be seen within a very restricted potential interval on account of the magnifying power of the microscope, the special method of observation here employed renders it possible to use the microscope for measuring at least as great a potential fall as a magnifying glass, i. e. much greater than can ordinarily be measured by the microscope.

From this it is evident that this method of observation is equally suitable for

measuring slight and strong ionisation, since it combines the advantages of the ordinary microscope observation in measuring slight ionisation, with the superiority of the magnifying glass in measuring strong ionisation. Thus we can dispense with the auxiliary condensers for varying the sensitiveness of the testing apparatus.

The change in the deflection of the aluminium leaf is observed by the ordinary methods of observation, but on account of the change in the position of the leaf, the capacity of the electroscope is also slightly altered. By my method of observation, however, the capacity of the electroscope remains quite unaltered throughout a series of observations, because the deflection of the leaf is identical at every observation.

Owing to the special arrangement of the electroscope and the ionisation chamber shown in Fig. 5, the measurements are quite independent of the moisture of the atmosphere. For the only place where the insulation may be defective on account of moisture is the surface of the amber stopper, and owing to the arrangement of the apparatus, this may easily be dried by means of metallic sodium. The electroscope vessel is provided with a side tube, in which the sodium is put when the upper surface of the amber is to be dried. The lower surface of the stopper is most conveniently dried by separating the electroscope vessel from the ionisation chamber, and closing the bottom of the vessel by the previously mentioned cover, in which a small piece of sodium is placed beforehand. On account of the small space to which the action of the sodium is confined the surface of the amber is quite dry after a few minutes.

In the first measurements of radioactivity on our journey, we noticed some remarkable anomalies in the results, but as all the testings were carried out in a tent, where considerable variations in the temperature are liable to occur, we soon perceived that these anomalies were due to air currents set up by the variations of the temperature in the electroscope vessel, the deflection of the mobile aluminium leaf being altered by the slightest movement of the air in the electroscope. In order to get rid of these disturbances, the electroscope was enveloped in a coating of thick pasteboard, covered with tin-foil. This isolation of the electroscope against heat proved to be sufficient to nullify the effect of the changes in the temperature.

When the emanation in a gas was to be measured by means of the above described apparatus, I first determined the amount of leakage through ordinary atmospheric air, then a measured quantity of the gas to be examined was introduced into the ionisation chamber. The gas was filtered through a compressed plug of cotton wool which retained the disintegration products present in the radium emanation (Ra A, Ra B, Ra C).

The time of the introduction of the radioactive gas into the ionisation vessel was noted. Then the leakage was tested several times in the course of an hour, and from these measurements the amount of radium emanation introduced with the active gas into the ionisation chamber was calculated.

The calculations were carried out in the following manner: On account of the special application of the dry cells, u is, in the following equation,

$$E = \frac{c_b u}{t}, \quad (5)$$

always equal to $2.9n$ volts, or $\frac{2.9n}{300}$ abs. electrostatic units where n is a whole number within the limits 1 to 10.

The equation (5) may be written thus,

$$E = \frac{2.9 c_b}{3000000} \times \frac{10000}{\left(\frac{t}{n}\right)} = \frac{2.9 c_b}{3000000} a. \quad (6)$$

The factor $\frac{2.9 c_b}{3000000}$ is constant, therefore instead of calculating E , I confined myself to calculating its proportional $a = \frac{10000}{\left(\frac{t}{n}\right)}$. In this manner the calculations are restricted to the determination of the reciprocal value of $\frac{t}{n}$ in a table of reciprocals. Then the values of a are corrected by subtracting the value of a corresponding to the natural leakage in atmospheric air. Now the corrected values of a are marked out as ordinates on millimeter squared paper, while the abscissae represent the time reckoned from the introduction of the active gas into the ionisation chamber. Through the points marked, an even curve is drawn, showing how a increases immediately after the active gas is introduced into the ionisation vessel.

In the case of radium emanation, the curve has a characteristic shape, so that we are able from the form of the curve to decide whether the ionisation is due to radium emanation or not. Of course, if the curve of a is to be taken as a criterion as to whether the gas does or does not contain radioactive emanations other than radium emanation, it is necessary to take care that the disintegration products of the radium emanation are not carried along with the gas into the ionisation chamber, as they will, on account of their ionising power, alter the curve perceptibly. It is well known that the increase of ionisation immediately after the introduction of the active gas, is due simply to the production of these substances from radium emanation.

If the ionisation due to the emanation or its proportional a , — which amounts to the same, — is to be used as a measure of the amount of radium emanation, then it is necessary to provide for a saturation current when the testings of leakage are carried out; if not, the ionisation is not proportional to the leakage. In the second place it must be remembered that the ionisation is a function of time. Therefore it is only on condition that the ionisation is always tested at equal periods after the introduction of the gas in question into the ionisation vessel, that it may be depended upon to determine the amount of radium emanation in the gas.

But when, as in our case, a considerable number of experiments in very varying circumstances have to be carried out, it is exceedingly difficult in every experiment consistently to test the ionisation at equal periods after the introduction of the gas into the ionisation vessel. I have therefore, as already mentioned, pre-

ferred constructing an even curve showing the progress of a in the first hour, by means of values of a obtained at fixed points of time. Then I have from the curve deduced the mean values of a corresponding to 10, 20, 30, 40, 50, and 60 minutes after the active gas was introduced into the ionisation vessel. Every one of these values of a therefore could be employed in determining the amount of emanation in the gas. But in order still further to eliminate possible errors in the measurements, I have, instead of using one of these six values, used their mean value

$$a_m = \frac{1}{6}(a_{10} + a_{20} + a_{30} + a_{40} + a_{50} + a_{60})$$

which also, as may be easily shown, is proportionate to the amount of the emanation. For if the amount of emanation, A' , at the above fixed points of time produces an ionisation represented by a'_{10} , a'_{20} , a'_{30} , etc., while another amount of emanation, A'' , is represented by the analogical quantities a''_{10} , a''_{20} , a''_{30} , etc., we get the relations:—

$$\begin{aligned} \frac{A'}{A''} &= \frac{a'_{10}}{a''_{10}} = \frac{a'_{20}}{a''_{20}} = \frac{a'_{30}}{a''_{30}} = \frac{a'_{40}}{a''_{40}} = \frac{a'_{50}}{a''_{50}} = \frac{a'_{60}}{a''_{60}} \\ &= \frac{a'_{10} + a'_{20} + a'_{30} + a'_{40} + a'_{50} + a'_{60}}{a''_{10} + a''_{20} + a''_{30} + a''_{40} + a''_{50} + a''_{60}} = \frac{a'_m}{a''_m}. \end{aligned}$$

By letting A be equal to a_m , the emanation is expressed in an arbitrary unit, besides which, it is dependent on the apparatus used. Therefore it was very important for me to find a unit for the emanation that was well defined and could be easily reproduced, so that the results of my experiments at any time could be compared with results of other scientists in the same domain. The simplest way out of the difficulty would have been to make use of the unit that ST. MEYER and H. MACHE¹ have proposed for use in expressing the radium emanation contained in spring gases. According to their definition, the unit is the amount of emanation that by means of its ionising power sets free per second an electrostatic unit of positive electricity and an equal quantity of negative electricity. The emanation is calculated per litre of spring gases.

My measurements could be easily expressed in terms corresponding to this definition of the emanation unit. In the first few seconds after the introduction of the gas liberated from the disintegration products of the emanation, the ionisation in the ionisation chamber is due solely to the emanation. Therefore if a , in equation (6), is replaced by a_0 , then E in the same equation is simply the emanation expressed in the unit proposed by ST. MEYER and H. MACHE, or

$$A = E = \frac{2.9 c_b}{3000000} a_0 = 4.73 \times 10^{-6} a_0. \quad (7)$$

Nevertheless I have not used this emanation unit in the computation of my experiments because I am of the opinion that the ionisation caused by the emanation is not only dependent on the amount of the emanation, but to a certain extent is

¹ Phys. Zeitschr. 6, 693, 1905.

also dependent on the form of the ionisation chamber. I have therefore preferred comparing the emanation in the hot spring gases with the emanation evolved by a known quantity of radium per second. In this way the unit of emanation becomes independent of the shape of the ionisation chamber, because the known quantity of emanation is measured in exactly the same way as that which it is desired to determine. It is taken for granted in this, as in every other case where measurements of emanation are to be made, that the ionisation is proportionate to the emanation, other conditions being equal.

As the unit of radium emanation, I have adopted the amount of emanation evolved per second by the radium in one gr. uranium in natural minerals. A similar used by unit is BOLTWOOD¹ in his researches of some American hot springs.

In order to obtain the value of a_m in the proposed unit, I dissolved about 0.1 gr. uraninite from Joachimthal in dilute nitric acid. The solution was put into a bottle that could be made airtight. Then the solution was freed from emanation by boiling, and the bottle closed. The radium contained in the solution incessantly evolves emanation, which is stored up in the bottle. After standing three or four days, the emanation evolved is completely removed from the solution by pumping and boiling, and the emanation thus collected is introduced into the ionisation chamber, where it is measured in the ordinary way.

According to two analyses, for which I am deeply indebted to Cand. polyt. V. FARSÖE, the uraninite used in these experiments contained 23.8 % uranium. If p gr. uraninite are dissolved, the radium in the solution evolves per second $0.238p$ emanation units. On this basis, and by making proper allowance for the decay of the emanation, the amount, q , of radium emanation in the solution at any given time, may be calculated. Of the emanation q , the fraction αq is transformed every second; here, the transformation coefficient α is, according to RUTHERFORD and SODDY², computed at 2.16×10^{-6} . Then with respect to the solution, the total increase of the emanation in the infinitesimal interval dt , is given by the differential equation,

$$\frac{dq}{dt} dt = 0.238p dt - \alpha q dt.$$

Hence we get by integration,

$$q = \frac{0.238p}{\alpha} + Ce^{-\alpha t}.$$

By letting $q = 0$ when $t = 0$, we get the integration constant,

$$C = -\frac{0.238p}{\alpha}.$$

Therefore,

$$q = \frac{0.238p}{\alpha} (1 - e^{-\alpha t}).$$

In this formula the transformation coefficient $\alpha = 2.16 \times 10^{-6}$, e the base of the

¹ Amer. Journ. Sci. 18, 378, 1904.

² See RUTHERFORD: Radio-activity 2. ed. 1905, p. 247.

natural logarithms, p the weight (in grams) of the uraninite employed, and t the time in seconds reckoned from the moment the solution was sealed up; p and t are found by experiment.

From the last equation we get q in the above proposed unit (per gram uranium per second), while a direct measurement of the emanation in the ionisation chamber gives the emanation in the arbitrary unit by means of a_m . The factor γ , which a_m is to be multiplied by to express the emanation in the right terms, is given by the equation,

$$q = \gamma a_m.$$

As a mean of two experiments I got

$$\gamma = 1.347.$$

According to measurements made by RUTHERFORD and BOLTWOOD¹, natural minerals contain 3.8×10^{-7} gr. of radium per gram of uranium. Therefore the proposed unit of emanation is produced by 3.8×10^{-7} gram of radium per second. Thus we are enabled to refer this unit to CURIE and LABORDE's² unit of emanation.

In the proceeding exposition I have taken it for granted that the relation between the emanation contained in the ionisation chamber and the ionisation factor a_m is constant. But this only holds good when the testings are carried out at even density of the atmosphere. A change in the density of the atmosphere causes a corresponding change in the relation between the emanation and the ionisation produced. If alterations in the ionisation called forth by small variations in the atmospheric density are assumed to be proportionate to the alterations of the density, I have

$$\frac{E - E'}{E} = \mu \frac{d - d'}{d},$$

where E and E' represent the ionisation produced by the same emanation, i. e. when the density of the air is d and d' respectively, and μ a factor of proportionality. Setting aside the moisture of the air, I refer all the measurements to the pressure of 760 mm. mercury, and 18° C., so that $d = 0.001213$.

By direct measurements of a given quantity of emanation, I determined the leakage due to the emanation, at 766 mm. pressure and 20° C., to 889 arbitrary units. The same emanation caused the leakage to be 852, at a pressure of 618 mm. and 20° C. The density of the air at 766 mm. and 20° is $d = 0.001215$, and at 618 mm. and 20° C., $d' = 0.000980$. Then we have from the experiments mentioned,

$$\mu \frac{0.001215 - 0.000980}{0.001215} = \frac{889 - 852}{889}$$

or $\mu = 0.215$. From the formula,

$$\frac{E - E'}{E} = \mu \frac{d - d'}{d}$$

¹ Amer. Journ. Sci. **22**, 1, 1906..

² Comp. rend. **138**, 1180, 1904.

we get,

$$E = \frac{E'}{1 - \mu \frac{d-d'}{d}}$$

which with sufficient accuracy may be transformed into

$$E = E' \left(1 + \mu \frac{d-d'}{d} \right)$$

inasmuch as the quantity $\mu \frac{d-d'}{d}$, in the experiments in question, never exceeds 0.02. All the measurements of emanation are corrected according to the last formula. After having thus determined the amount of emanation, E , introduced into the ionisation chamber, the emanation, C_t , contained in 1 ccm. spring gas at 760 mercury and $20^\circ C.$ is computed by simple proportion, when the reduced volume, V , of the gas employed in the experiment, is known.

Therefore,

$$C_t = \frac{E}{V},$$

C_t denoting the emanation contained in 1 ccm. of spring gas at the moment the gas was introduced into the ionisation chamber.

Supposing that the gas has been t seconds in the collecting tube, the emanation C_0 contained in 1 ccm. of spring gas at the time the gas was collected, is given by the formula

$$C_t = C_0 e^{-2.16 \times 10^{-6} t}$$

or

$$C_0 = C_t e^{2.16 \times 10^{-6} t}.$$

When C_t and t are known, C_0 can be calculated by means of this formula. Of course, the formula is not applicable except when the gas contains only radium emanation. C_0 is the emanation per gram of uranium per second contained in 1 ccm. of spring gas at the moment the gas was collected from the spring. From the foregoing it is obvious that the ultimate determination of the emanation contained in the spring gases is only to be obtained by somewhat prolonged calculations. As examples showing how these calculations are carried out, I cite here in extenso the measurements of the emanation of two samples of Icelandic spring gases, with the necessary calculations.

Reykir No. 5, Skíðastaðalaug.

Sample of gas collected on 16th. August 1906 at 5 p. m. Barometer: 746 mm. mercury. Temperature: $11^\circ C.$ The volume of the collecting bottle, 102.2 ccm.

The sample was introduced into the ionisation chamber on the same day at 8.30 p. m. Barometer 746 mm. Air temperature $6^\circ C.$

Measurements of the ionisation:

Time.	Leakage. $\frac{1000}{\left(\frac{t}{n}\right)}$	Leakage due to the emanation in the gas.
8 ^h 24 p. m.	26.1	0.0
8 ^h 34 »	87.0	60.9
8 ^h 36 »	90.9	64.8
8 ^h 40 »	102.0	75.9
8 ^h 43 »	108.7	82.6
8 ^h 58 »	113.6	87.5
9 ^h 02 »	108.7	82.6
9 ^h 24 »	116.3	90.2
9 ^h 28 »	123.5	97.4

Hence we get, by means of the curve, the values of $\frac{10000}{\left(\frac{t}{n}\right)}$:

10 minutes	$a_{10} = 76.5$
20 »	$a_{20} = 82.4$
30 »	$a_{30} = 86.2$
40 »	$a_{40} = 89.1$
50 »	$a_{50} = 92.2$
60 »	$a_{60} = 95.0$

showing an average of $86.9 = a'_m$.

The density of the air at 746 mm. and $6^\circ C.$ is $d = 0.001242$. The corrected value of a_m is therefore

$$a_m = 86.9 \left(1 + 0.215 \frac{1213 - 1242}{1213} \right) = 86.5.$$

The amount of emanation in question is thus

$$E = 86.5 \times 1.347 = 116.5$$

while the reduced volume of the spring gas investigated is

$$V = \frac{102.2}{1 + 0.00367 \times 11} \frac{736}{760} = 95.1 \text{ ccm.}$$

The spring gas contains therefore at the time of examination, an amount of emanation which is expressed by:—

$$C_t = \frac{E}{V} = 1.225.$$

Multiplying 1.225 by $e^{2.16 \times 10^{-6} t}$, t being 12600 seconds, we obtain the amount of emanation contained in 1 ccm. of the spring gas at the time of collection. Therefore

$$C_I = 1.225 \times e^{2.16 \times 10^{-6} \times 12600} = 1.26 \text{ per gr. uranium per second.}$$

Hveravellir No. 27, Bláhver.

Sample of gas collected on 23rd. August 1906 at 8.30 p. m. Barometer 696 mm. Temperature 37°. The volume of the collecting bottle, 198.7 ccm.

The sample was introduced into the ionisation chamber on 27th. August 1906 at 6.00 p. m. Barometer 703 mm. Air temperature 11° C.

Measurements of the ionisation:

Time.	Leakage.	Leakage due to the emanation in the gas.
5 ^h 50 p. m.	28.0	0.0
6 ^h 05 »	568	540
6 ^h 06 »	588	560
6 ^h 09 »	658	630
6 ^h 11 »	645	617
6 ^h 26 »	699	671
6 ^h 30 »	714	686
6 ^h 31 »	714	686
6 ^h 48 »	754	726
6 ^h 52 »	780	752

Hence we get, by means of the curve, the values of $\frac{10000}{\left(\frac{t}{n}\right)}$:

10 minutes	$a_{10} = 612$
20 »	$a_{20} = 656$
30 »	$a_{30} = 686$
40 »	$a_{40} = 715$
50 »	$a_{50} = 740$
60 »	$a_{60} = 763$
<hr/>	
	$a'_m = 695$

Corrected according to the density of the atmosphere

$$a_m = 695 \left(1 + 0.215 \frac{1213 - 1150}{1213} \right) = 702.6,$$

$$E = 702.6 \times 1.347 = 946.4,$$

$$V = \frac{198.7}{1 + 0.00367 \times 37} \times \frac{649}{760} = 149.1 \text{ ccm.},$$

$$C_t = \frac{E}{V} = 6.34.$$

The emanation, C_{II} , from the spring gas is therefore:

$$C_{II} = 6.34 \times e^{2.16 \times 0.3366} = 13.1 \text{ per gr. uranium per second},$$

t being 336600 seconds.

As many investigators, especially German, have employed of late the unit of emanation in spring gas proposed by MACHE and MEYER, it is important to be able to compare this unit directly with the one employed in these experiments.

This may be done in the following manner. According to equation (7) on page 207 the relation between the leakage in the ionisation chamber and the emanation expressed in the units of Mache and Meyer is given by

$$A = 4.74 \times 10^{-6} a_0.$$

In some experiments I made special efforts to measure the ionisation immediately after the introduction of the radioactive gas into the ionisation chamber. From these experiments I deduced

$$a_0 = 0.6 a_m$$

consequently

$$A = 2.84 \times 10^{-6} a_m.$$

If, in measuring a_m , v ccm. is used instead of 1 litre of the spring gas, the above equation is transformed to

$$A = \frac{2.84 \times 10^{-6}}{\frac{v}{1000}} a_m = 2.84 \times 10^{-3} \frac{a_m}{v}.$$

On the other hand, I calculated the emanation in accordance with the formula

$$C = 1.347 \frac{a_m}{v}.$$

Hence it is clear that my unit may be transformed to the unit of Mache and Meyer by multiplying the amount of emanation expressed in my units, by the factor

$$\frac{2.84}{1.347} \times 10^{-3} = 2.11 \times 10^{-3}.$$

Accordingly, the emanations of the two samples quoted, expressed by the units of Mache and Meyer, are

$$\begin{aligned} \text{Reykir No. 5} &\dots\dots\dots 2.66 \times 10^{-3} \text{ (E. S. E.)} \\ \text{Hveravellir No. 27} &\dots 27.6 \times 10^{-3} \text{ (E. S. E.)} \end{aligned}$$

It was important to ascertain how far the radioactive emanation contained in the Icelandic spring gases is due exclusively to radium, and whether the gases contain some other radioactive emanations. I shall now mention two methods by which I endeavoured to ascertain this point, viz. (1) by examining the ionisation curve, which shows how the ionisation in the ionisation chamber increases during the first hour after the introduction of the active gas; (2) by determining the coefficient of decay for the emanation contained in the spring gases. A third method, especially applicable to the investigation of rapidly changing emanations, will be mentioned later.

If, in determining the nature of the emanation, one bases one's observations only on the ionisation curve, great care must be taken in the filtration of the gas before introducing it into the ionisation chamber. The slightest quantity of disintegration products of the emanation, escaping into the ionisation chamber with

the emanation, will cause a perceptible alteration in the ionisation curve. On this account this method is always a little unreliable, and I therefore laid particular stress on the second method.

In order to determine the coefficient of the rate of decay of the emanation, I took two samples of every spring gas to be examined, one sample about 100 ccm., the other about 200 ccm. As soon as possible, (after t_1 seconds), the 100 ccm. of the gas were examined to ascertain the emanation contained, whilst the 200 ccm. of the gas were examined after about four days (t_2 seconds).

By means of the measurements above described, the emanation contained in 1 ccm. of the spring gas under examination, at the moment when the gas was introduced into the testing vessel, was then calculated. Let A_{t_1} and A_{t_2} represent the emanations calculated per 1 ccm. of spring gas, while the indices t_1 and t_2 signify the time in seconds that the testings took place after the collection of the gas, then A_{t_1} is the emanation in 1 ccm. of the spring gas after having been

t_1 seconds in the collecting bottle, and A_{t_2} has an analogical significance. Therefore A_{t_2} is the remainder of the emanation A_{t_1} after $t_2 - t_1$ seconds.

In order to calculate the rate of decay (α') of the emanation by means of the two experiments, it is necessary to suppose that the emanation decays in accordance with a known law. By supposing that the emanation decays according to an exponential law I get

$$A_{t_2} = A_{t_1} e^{-\alpha'(t_2 - t_1)}.$$

Hence I have

$$\alpha' = \frac{\log A_{t_1} - \log A_{t_2}}{t_2 - t_1}.$$

The values of the rate of decay entered in Table I are calculated in accordance with this formula.

The examination of the radioactive substances in solids, i. e. mud and sediments, was done by measuring their ionising power. The apparatus for measuring the ionisation produced by solids was, in principle, the same as that employed in examining the emanation. The same electroscope was used, but the ionisation vessel had different dimensions. The vessel I in Fig. 6 is 12 cm. high and 26 cm. in diameter. A circular, horizontal plate of zinc, Z , 16 cm. in diameter, is connected by a brass rod 6 cm. in length to the rod, g , in the electroscope. The brass rod is attached to the centre of the plate. The substance to be examined is pulverized finely and spread in a thin layer over the bottom of the vessel, which is easily removed from the upper part. The radium rays emitted by the substance will then ionize the air in the testing vessel and consequently augment the leakage.

One can form an estimate of the sensitiveness of the apparatus from the following measurements. I dissolved 0.201 gram of nitrate of uranyl, $(UO_2(NO_3)_2 + 6H_2O)$,

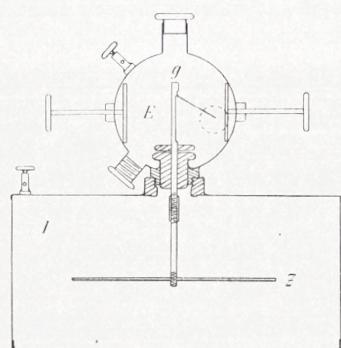


Fig. 6.

in water, and mixed the solution with 31 gram of dry mud powder which I had previously proved to be quite inactive. After desiccation and pulverisation the mud, which has now become active on account of the uranium contained in it, is again examined.

In the case of inactive mud the leakage $\left(\frac{1000}{(t/n)}\right)$ was 13.9. With the active mud the leakage was 153. Hence the increase in leakage was 139. Under ordinary conditions I could perceive an increase in the leakage corresponding to $\frac{1}{10}$ of the natural leakage, or 1.4 of the arbitrary units before described. Hence I conclude that, by means of this apparatus, it is possible to detect 0.00201 gram of nitrate of uranyl contained in the mud sample, or, as I usually in every experiment examined about 30 grams of the desiccated mud, I was thus able to detect radioactive substances in the sample, provided they produced the same ionising effect per gram of the examined matter as 0.00067 gram of the nitrate of uranyl.

The nitrate of uranyl contains 47.6 % uranium. Therefore 31.9×10^{-5} gram of uranium per gram of the mud is the smallest amount of uranium to be detected by this method.

According to McCOY¹ 1 gram of radium, in equilibrium with its disintegration products, is equally as active as 3.8×10^6 gram of uranium, while SODDY and MACKENZIE² found 1 gram of radium as active as 14.6×10^6 gram of uranium. Taking the average of these measurements, and estimating the activity of radium at 9×10^6 times the activity of uranium, I must have been able to detect, by means of the above described apparatus, 3.5×10^{-11} gram of radium contained in 1 gram of dry mud.

According to STRUTT³, and EVE and MCINTOSH⁴, the rocks on an average contain 1.4×10^{-12} gram of radium per gram of the mineral, i. e. $\frac{1}{25}$ of what I was able to detect.

At each of the hot spring groups investigated by us, I examined for radioactivity 5—10 different samples of mud, silicious sinter and other deposits from the hot springs, but without detecting any trace of radioactive substances. On this account I must conclude that the amount of radium contained in the sediments, mud etc. of the hot springs examined, does not exceed 25 times the amount of radium contained in common rocks.

2. The collection of spring gases.

The spring gases were preferably collected from springs where the gas evolved bubbled through water or mud, because we judged that the gas collected here was less likely to be mixed with atmospheric air than that collected from

¹ Phil. Mag. **11**, 185, 1906.

² Phil. Mag. **14**, 272, 1907.

³ Proc. Roy. Soc. **77**, 472, 1906.

⁴ Phil. Mag. **14**, 231, 1907.

from vents in the dry, porous soil. In every case the method employed in collecting spring gases was the same as that described by TRAVERS, as shown in Fig. 7.

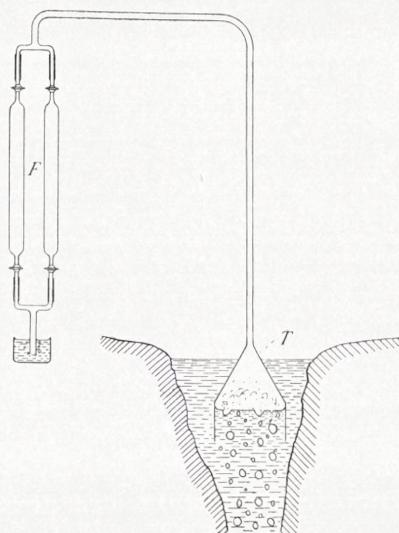


Fig. 7.

the spring gas, so that we were sure that the pressure of the gas above the water in the collecting bottle was never lower than the atmospheric pressure; had this been so, it would have caused the water from the funnel to be sucked up into the conducting tubes.

Fig. 8 A shows the kind of bottle in which the spring gas to be examined for radioactivity was collected. Every bottle is provided with two tubes capable of being closed airtight by means of the stop-cocks *a*. I took with me on the journey 8 sets of these bottles, each set consisting of two bottles, one containing 100 ccm. and the other 200 ccm. The bottles were provided with etched numbers, and before the journey they were measured by weighing them filled with water.

As already mentioned two samples of spring gas, 100 ccm. and 200 ccm., were collected from each hot spring investigated. In order that the gas in the samples might be as homogeneous as possible, the two samples were collected simultaneously by connecting the collecting tubes parallel to the conducting tube, by means of *T*-tubes, as shown in Fig. 7 *F*. Before closing the stop-cocks, we took care that the spring gas, by passing slowly through the tubes for a time, had assumed the pressure and temperature of the surrounding air.

On closing the collecting bottles, we observed the temperature of the air in

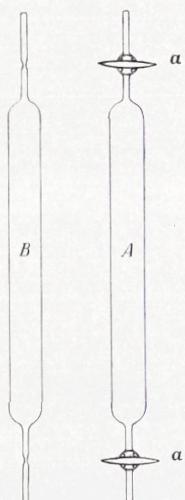


Fig. 8.

The gas emanating from the spring was gathered up by the enamelled funnel, *T*, and conducted through a tin tube into the collecting bottle. The pressure acting upon the gas collected in the funnel was great enough to force the gas through the connecting tubes and the collecting bottle. Care was taken that the gas, after having passed through the collecting bottle, always bubbled through water, in order to make sure that atmospheric air could not by any means be introduced into the collecting bottle. In order to facilitate the exclusion of atmospheric air from the collecting bottles in the beginning of the experiment, they were filled with water and then connected with the conducting tubes, out of which the atmospheric air is driven beforehand by the current of spring gas. The flow of the water from the bottle was regulated by means of stop-cocks according to the evolution of

the immediate vicinity of the bottles, the standing of the barometer and the exact time.

The samples of gas for the quantitative analysis were collected in the same way, in bottles (Fig. 8 *B*) containing about 150 ccm. These bottles were of a similar shape to those containing the gas to be examined for radioactivity, but the tubes had no stop-cocks, being closed by melting. The samples taken to determine inactive gases contained in the spring gas were at first collected in the sheet iron vessel *B* in Fig. 9. The volume of the vessel was about 5000 ccm., and the collection of the gas was performed in the usual way. The vessel was then brought to the tent, where the sulphuretted hydrogen, the carbon dioxide, the oxygen and hydrogen were for the most part withdrawn from the spring gas. The arrangement of the apparatus is shown in Fig. 9. The circuit *P, F, M, O, C, K* consists of the Prytz pump¹ *P*, the collecting bottle *F*, the glass tubes *M, O* and *C* containing respectively peroxide of manganese, oxide of copper, and metallic copper filings, and the absorption bottle *K* containing hydroxide of potassium to absorb the carbon dioxide. The vessel *B*, containing the spring gas, is attached to the circuit by means of the T-tube between *F* and *M*, while the lower end of the vessel *B* is connected by an indiarubber tube to the water reservoir *N*. By lifting *N* to the necessary height, the gas in *B* was continually submitted to a slightly greater pressure than that of the atmospheric air. The gas in the circuit could find an outlet through the T-tube *T* inserted between the pump and the collecting bottle.

We began operations by filling the collecting bottle, *F*, with water, and then closing it by clipping the two indiarubber tubes forming the inlet and outlet of the bottle. Keeping the T-tube *T* open, we pumped out the rest of the circuit by means of the Prytz pump, and washed it out a few times by refilling it with gas from the vessel and pumping it out again with the pump. Finally this part of the circuit was filled with spring gas up to the pump. The clips over the entrance tubes of the bottle *F* were then unscrewed and the bottle being in a slanting position, the water ran out of it through *T*, the bottle being filled at the same time with spring gas from the vessel *B*. As soon as the bottle is full of spring gas, the tube *T* and the connecting tube between the vessel *B* and the circuit are

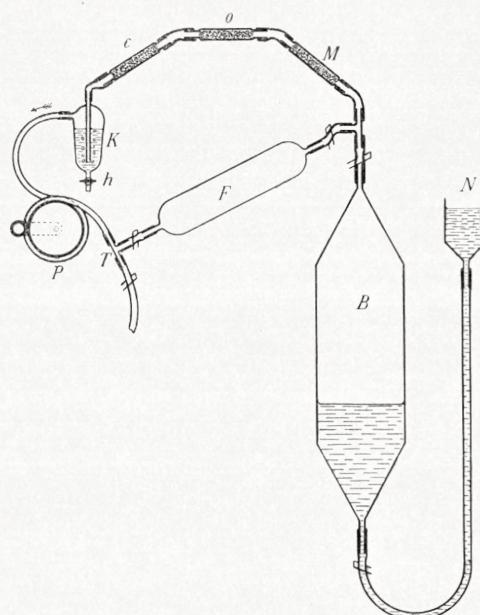


Fig. 9.

¹ K. PRYTZ: Zeitschr. f. Instrumentenkunde. 1905, p. 193.

closed. By pumping the gas in the circuit in the direction shown by the arrow, the sulphuretted hydrogen and the carbon dioxide are absorbed. The gases absorbed in the circuit are soon replaced by fresh spring gases introduced by opening the tube connecting the vessel with the circuit.

When the continued circulation of the gas does not further reduce the pressure in the circuit, showing that the absorption of the sulphuretted hydrogen and the carbon dioxide is nearly completed, the oxide of copper and the copper filings are heated, in order to destroy the free hydrogen and oxygen. When the spring gas contained carbon dioxide in exceptional quantities, it might happen that the caustic potash in the absorption flask *K* would not be sufficient to absorb the carbonic acid gas completely. Then the used solution of caustic potash was removed from *K*, by compressing a little of the gas above the solution, and then opening the stop-cock *h*. When the solution had mostly run out, the stop-cock was turned off. A fresh solution of caustic potash was then sucked into *K* by reducing the pressure in the flask.

After having in this way freed the gas in the circuit of its contents of sulphuretted hydrogen, carbon dioxide, oxygen, hydrogen and other combustible gases, the pressure in the collecting bottle was reduced a little, and the bottle closed by melting. The volume of the bottles used to collect these gas samples was 500—800 ccm.

After the journey the sealed bottles were brought to the Physical Laboratory of the Polytechnic Academy, Copenhagen, where I undertook a closer examination of the gases contained in the bottles. Of course, this investigation naturally came under two heads, viz. an ordinary quantitative analysis of the gases contained in the bottles of 150 ccm.; and an attempt to trace and partly to determine the amount of the rare inactive gases collected in the larger bottles containing 500—800 ccm.

3. Analysis of the gases.

In the quantitative analysis I aimed at a determination of the relation between the following gases contained in the spring gas: sulphuretted hydrogen, carbon dioxide, oxygen, hydrogen, methane, and nitrogen, plus the inactive gases.

In the analysis work I employed a Pettersson analysis apparatus² from the firm of Franz Müller (Dr. H. Geislers Nachf.) Bonn a/R.

The measuring tube contained 35 ccm., and the smallest divisions corresponded to $\frac{1}{10}$ ccm. so that I could with considerable accuracy read $\frac{1}{100}$ ccm. In connection with this apparatus I used absorption pipettes for absorbing sulphuretted hydrogen, carbon dioxide, and oxygen, and an explosion pipette.

To transport the gas to be examined conveniently and safely from the collecting bottle to the measuring tube, I proceeded in the following way: The end of the sealed tube of the collecting bottle was knocked off while held under the surface of mercury, and a short indiarubber tube, which could be closed by a clip

was pushed on the rest of the glass tube, while it still remained under the mercury, in order to prevent atmospheric air getting into the bottle. Then the other end of the bottle was immersed in the mercury, and knocked off in the same way. This end of the bottle was then connected, by means of an indiarubber tube, with a mercury reservoir that could be raised and sunk to adjust the pressure of the gas in the bottle. Of course, care was taken that the indiarubber tube was quite filled with mercury before it was pushed on the glass tube. The other tube of the collecting bottle, that which was first broken, was then connected, by means of the above mentioned indiarubber tube, with the entrance tube of the measurer, and we were ready to conduct the gas under investigation from the bottle into the measuring tube. I endeavoured, by keeping the mercury reservoir in a suitable position, to avoid rarefaction of the gas in the bottle, so that possible small leakages in the indiarubber connection could not result in a mixture of atmospheric air with the gas examined. As it was a very difficult matter to force the air completely out of the measuring tube and the accompanying inlet tube by means of mercury, the remaining atmosphere was excluded by washing the measurer a few times with small quantities of the gas, before the gas to be used for analysis was introduced.

The subsequent conduct of the analysis was roughly as follows. The sulphuretted hydrogen was first absorbed by a small globe of pure peroxide of manganese moistened by thick phosphoric acid. The absorption took place above mercury in an absorption pipette. Then the carbon dioxide was absorbed by a strong solution of caustic potash, and the oxygen was destroyed by a solution of pyrogallic acid in a solution of caustic potash. This solution was made according to a prescription of HEMPEL¹, by mixing 5 grams of pyrogallic acid dissolved in 15 ccm. of distilled water with 120 grams of hydroxide of potassium dissolved in 80 ccm. of distilled water.

After having measured the volume of the remaining gas, a known amount of oxygen or air, and if necessary a mixture of 2 volumes of hydrogen and one volume of oxygen, was admitted, and the gases mixed brought to explosion in the explosion pipette. After the explosion the remnant gas was examined for carbon dioxide and oxygen in the same way as before. Of course the gas after every absorption was drawn back to the measuring tube and its volume determined. By repetition of the test I made sure of a complete absorption in every case.

4. Investigation of the rare inactive gases contained in the spring gases.

The bottles containing the gas collected for investigation of the rare, inactive gases, were opened in the same way as the other collecting bottles, except that in this case I employed water instead of mercury to shut out the air.

I used the arrangement shown in Fig. 10 in the subsequent treatment of the

² HEMPEL: Gasanalytische Methoden, 3. Aufl. 1900, p. 133.

gas. The measurer *A*, volume 800 ccm., is connected, by means of the hard glass tube *C*, to the collecting bottle *F* containing the gas under investigation.

The gas is cut off from the surrounding air by water. The hard glass tube *C* contains, in three separate compartments, reduced copper, copper oxide and solid hydroxide of potassium. The part containing the copper and the copper oxide is heated, and, by conducting the gas several times through the tube, possible small remnants of combustible gases, oxygen and carbon dioxide in the gas are destroyed.

At last all that remains now consisting only of nitrogen and rare, inactive gases, is left behind in the measuring tube *A*, where its volume is determined. In the meantime I have, by means of the mercury air pump, exhausted the hard glass tube *M*, containing a mixture¹ of 1 part of magnesium powder, 5 parts of

freshly burned lime (CaO) and 0.1 part of metallic sodium; the tube is kept at red heat for about two hours, while the mercury pump works constantly to remove the gases evolved by the hot $\text{Mg}-\text{CaO}-\text{Na}$ mixture. When the mixture has been heated so long that the gas evolution has for the most part ceased, the communication to the pump is interrupted by closing the stop-cock *K*, and then the gas in the measurer *A* is admitted

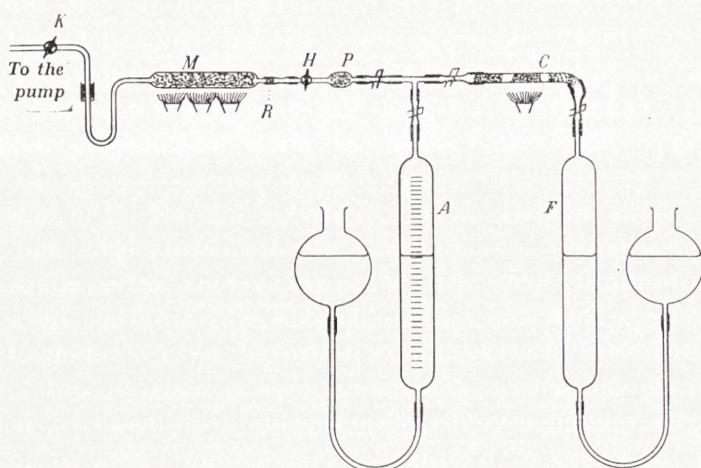


Fig. 10.

to the absorption tube by opening the stop-cock *H*. On its way to *M* the gas is desiccated by phosphorus pentoxide in the tube *P*. Then the gas is passed through the porous plug *R*, which is inserted in order to avoid too violent entrance of the gas into the empty tube *M*. After the absorption of the nitrogen the tube *M*, while still hot, is emptied by means of the mercury pump, and the remaining gas is collected above mercury in a collecting tube.

Although the remaining gases obtained as above described consist mainly of rare, inactive gases, yet small amounts of hydrogen and carbon monoxide evolved from the mixture, and perhaps even a trifle of nitrogen, are found.

The remaining work is to purify the rare, inactive gases from these impurities, and to separate the argon and helium.

As I had so many gas samples, (nearly 20), the following order of experimenting with these gas samples turned out to be the most practicable. First, all

¹ HEMPEL I. C. p. 150.

the samples were entirely purified from the small amount of nitrogen they contained, then the hydrogen and the carbon monoxide were destroyed, and at last, having determined the volumes of the remaining gases, — now only consisting of rare, inactive gases, — the argon and the helium were separated.

In these three different operations, viz. the absorption of nitrogen, the destruction of hydrogen and carbon monoxide, and the separation of argon and helium, I make use of an arrangement in all essentials similar to that shown in Fig. 11. One end of the tube connection R, K, P is attached to the automatic mercury pump, while the other end is closed by the porous plug C , which, together with the bend b of the tube R , is constantly covered by mercury in the glass vessel N . All the india-rubber connections between the tubes are made airtight by mercury. Having emptied the tubes up to the plug C by means of the mercury pump until a complete vacuum is attained, the gas is sucked into the system of tubes R, K, P through the porous plug C , by sinking the tube containing the gas into the mercury of the vessel N , until the plug is in contact with the gas. In the glass tube K , the form of which varies according to the purpose of the experiment, the gas is passed over the agent intended to react on it. The remaining gas can now very easily be collected again in the collecting tube by means of the pump, and in order to make sure that the reaction is complete, the gas is twice passed through the tubes R, K, P . It is evident that one could go on indefinitely in this way, but it was

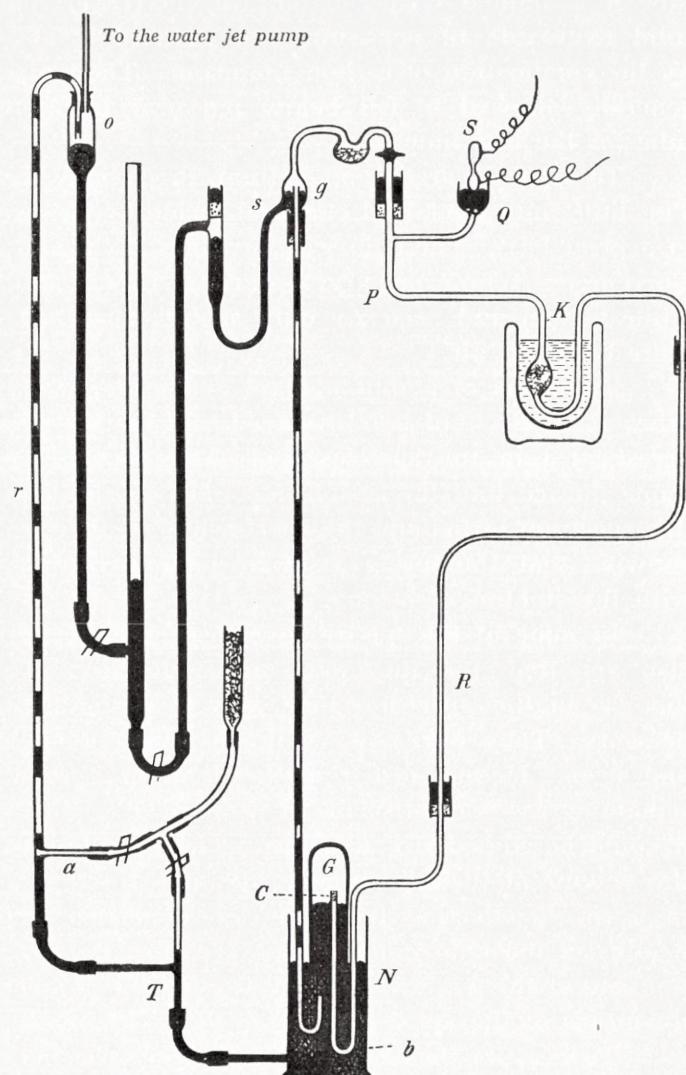


Fig. 11.

usually sufficient to pass the gas twice through the agent in order to obtain the result aimed at by the experiment.

With respect to the glass apparatus *K*, it was a hard glass tube containing the before mentioned Mg-CaO-Na mixture when nitrogen was to be absorbed.

When hydrogen and carbon monoxide were to be destroyed, the combustion tube *K* contained copper oxide; in this case, moreover a glass tube containing solid hydroxide of potassium was inserted to absorb the carbon dioxide formed by the combustion of carbon monoxide. The temperature of the copper oxide was generally allowed to fall below red heat before the gas was pumped out of the tube for the last time.

To separate argon and helium, the tube *K* had the form indicated in Fig. 11. The little bulb contained charcoal, made by bringing fragments of cocoanut shells to a great heat. The bulb was environed by liquid air before the gas was admitted. Then argon, xenon and krypton are, as DEWAR has found, retained by the charcoal, while helium and neon are only slightly absorbed by the charcoal at the temperature of liquid air.

By means of porous contact in the mercury cup *Q*, the gas contained in the tubes *P*, *K*, *R* could be introduced into the spectrum tube *S*, so that it could be investigated in the spectroscope. As expected, the investigation with the spectroscope showed that the gas not absorbed by the charcoal contained helium. Besides this spectrum of helium, the spectrum of neon was in many cases very conspicuous, showing that the spring gases in question contain neon in quantities comparable with the amount of helium.

In some of the spectra investigated, some lines due to mercury and hydrogen also appeared, but they were only visible in the beginning when the pressure of the gas in the spectrum tube was very small, and disappeared under increased pressure. They were always much fainter than the strong lines due to helium and neon. I concluded from this that the amount of hydrogen contained in the remaining gas was so small, in proportion to the amount of helium and neon, that it could be considered as a negligible quantity in the consecutive measurement of the volume of the helium-neon mixture. Having collected the helium-neon mixture in a small collecting tube, the liquid air was removed, and by the consequent heating of the charcoal the greater part of the gas absorbed became free. The last remnant of the gas was freed by heating the charcoal to some two hundred degrees by means of the spirit lamp.

To measure the small volumes of the gases in question, I employed a volumenometer, — originally designed by Professor K. PRYTZ, — in a slightly modified form. The apparatus as I used it is illustrated by Fig. 12. The two vertical glass tubes *A* and *B* are provided with divisions, and communicate underneath; but their upper ends are closed by the porous plugs *M* and *N*, which are covered by mercury. By raising the mercury reservoir *Q*, which is connected by the indiarubber tube *L* to the measuring tubes *A* and *B*, the air is expelled from the tubes. The remaining

air is drawn out through the porous plugs *M* and *N* by means of the mercury pump. The exhausted tube *B* is now used as a barometer tube, while the volume of the gas under examination is gauged in tube *A*.

To introduce the gas into the measuring tube *A*, the uppermost part of the latter is narrowed, the outward diameter being only 6 mm., so that the collecting tube *G* may be pushed over it. By sinking the collecting tube *G*, the gas contained in it is sucked through the porous plug into *A*, provided that the pressure in *A* is less than that of the atmosphere. The apparatus has turned out to be exceedingly convenient for rapid and accurate measurements of small volumes of gas, which are collected by means of the mercury pump in the collecting tubes. This method ensures that the gas is quite safely transported into the measuring tube. Besides this, the measurements of the volume can be performed at a suitably low pressure, so that considerable accuracy can be obtained in spite of the volumes to be measured being extremely small.

In order to prevent impurities of air being carried by the mercury through the indiarubber tube into the tubes *A* and *B*, the glass tube connecting the indiarubber tube with the measuring tubes is provided with an air receiver *F*. This receiver is shown in section in Fig. 12. The air carried by the mercury through the inlet *b*, is collected in the space beneath the porous plug *k*. There is usually great pressure in this space, and the gas collected is therefore forced up through the plug, and escapes into the atmosphere. On the other hand, the mercury resting above the plug prevents the air from penetrating into the plug. When the apparatus is arranged in this way, the small amount of gas under ordinary pressure contained in the porous plug is seldom rarified, and never to such an extent that it cannot be contained in the bulb of the receiver, without any danger of the air escaping into the measuring tubes.

Before abandoning this section on the apparatus and methods employed in this investigation, I shall briefly describe the mercury air pump I used. It is an air pump with falling mercury. The construction of the glass tube through which

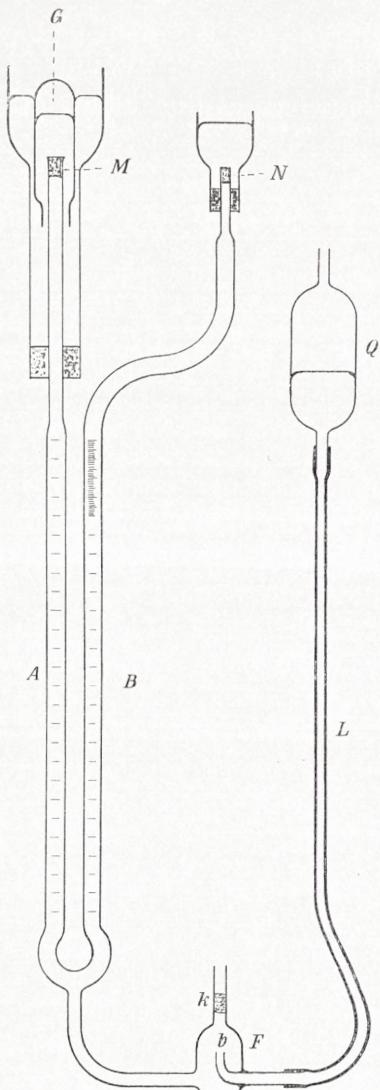


Fig. 12.

the mercury falls, and the manner in which the mercury falls into the tube, are distinguishing features of this pump.

The outer diameter of the fall-tube is 8 mm., the inner diameter 4.5 mm. at the top, but it rapidly narrows so that the inner diameter, 5 mm. from the top, is only 4 mm. The fall-tube consists of many capillary tubings of different inner diameters, as the following table shows.

Inner diameter	Length of the tube reckoned from the top
4 mm.	0.5— 5 cm.
3 »	5 — 20 »
2.5 »	20 — 42 »
2 »	42 — 55 »
1.3 »	55 — 76 »
2 »	76 — 152 »

Of course, care was taken that the passage from one dimension to another should be as even as possible. The fall-tube is consequently conical and the advantage obtained with this form, will presumably appear with sufficient clearness from the following description of the working of the pump.

The uppermost end of the fall-tube is situated in the middle of a concentrical glass bulb *g*, Fig. 11, with a diameter of 2.5 cm. The mercury is conducted through the side tube *s* into the bulb *g* and fills the space around the fall-tube. On account of the surface forces the mercury can stand higher in the space round the tube than the brim of the tube, without flowing into it. By continued influx of mercury, however, the surface forces cannot resist and the mercury suddenly falls from all sides into the tube, and at the same time cuts off the gas contained in it. As the mercury flows many times more rapidly away through the fall-tube, widened at the top, than it enters through the side tube *s*, the influx of the mercury in the fall-tube is soon interrupted. Then the mercury in *g* is raised again and after a short time a new volume of mercury falls, as just now described, into the tube.

All the mercury that falls into the tube forms a coherent column, forcing the gas by its weight down the tube. Owing to the conical form of the fall-tube, the mercury column becomes longer the farther it comes down the tube, and therefore it has still more power to drive the compressed gas downwards, and at the same time there is less probability that the gas can escape back through the mercury. At low pressure the resistance of the gas to the falling mercury is quite infinitesimal, and the latter would therefore gain a great velocity, and consequently be liable to disintegrate into small drops, unless the friction in the tapering tube diminished the speed. The conical form of the tube also is conducive to keep the mercury together in one body, for the friction is greater at the lower end of the column. The mercury at the upper end of the column will therefore exert a pressure on the mercury beneath. In my opinion, it is also necessary that the tube should be narrow in the spot where the falling mercury coincides with that standing in

the tube, so that the small gas bubbles collected in this spot may be pushed down the tube together with them mercury. The lower part of the tube becomes wider again, so that the mercury can flow with sufficient rapidity out of the tube. The width of this part of the tube is so adjusted that the mercury in the lower part is still moving downward when the consecutive portion coincides with it, provided that the tube is a vacuum, and that the intervals between the two bodies of mercury are suitable. In this way the fall-tube is exempted from violent concussions of the mercury, and the spot in which the portions of mercury coincide still remains covered by mercury when the succeeding body of mercury closes the upper end of the tube. Thus the pump is entirely without detrimental space. The theory of the working of this pump is the same as that of the Geisler pump. In both cases a known volume of the gas is cut off and then expelled. The sole difference is that the gas volume cut off is greater in the Geisler pump than in the pump just described, but on the other hand the strokes of the pump are much more frequent. With the dimensions above mentioned, the gas volumes cut off in the tube by the falling mercury were about 4 ccm., and the strokes of the pump were, as a rule, about 80 per minute.

The working of the pump is probably as efficient at high as at low pressure, and although it does not perhaps work so quickly as a large Geisler pump, yet I think it may be used with advantage especially in analytical work; amongst other reasons, because it is very cheap and it does not require specially cautious handling.

After working a long time, however, the tube becomes more fragile and at last breaks, but in my experience it is sufficient to attach the fall-tube to the glass bulb *g*, by means of indiarubber tubing, rendered airtight by mercury, the fall-tube can then be easily replaced. I have, however, used the same fall-tube for a year, and many times during this period the pump has worked incessantly for 7 hours. On the whole, the same tube has sustained the working of the pump during many hundred hours without breaking. By fastening the fall-tube to the wood-work of the pump special care must be taken that no tension arises in the glass for it will inevitably cause a premature fracture of the tube. It is sufficient to fasten the tube in two places to the wood-work.

A great advantage is that this air pump with falling mercury is especially suitable for automatic working. I have used a water jet pump for raising the mercury to the height required. The mode of proceeding is the same as usual, and is illustrated by Fig. 11. The air sucked by the jet pump enters the tubing *r* through the side tube *a*, but as the air passage through *a* is made narrow, which is most conveniently done by means of an indiarubber tube and a screw clip, the air in *r*, is rarified so that the mercury in the vessel *N* is raised into *r*. The air entering at *a* divides the mercury into small drops which are carried by the air current into the reservoir *O*, where the mercury is collected, while the air is passed on to the jet pump. The mercury is conducted from the reservoir through the

glass tubings shown in Fig. 11, to the glass bulb *g*, whence it falls through the fall-tube, and in this way comes back to the vessel *N*, where it started. The T-tube *T* is inserted, so that the mercury is not drawn into the tube *r* when its surface in *N* is lower than the T-tube. For this reason, the porous plug *C* is never exposed to the air.

III. On the results.

In the accompanying table of analyses, Table I, the name and number of the springs, in the first column, refers to the designation given in the description of the surroundings of the springs, (Part I), where particulars of their position and appearance will also be found. In the column headed "Calculated Boiling Point", is given the boiling point of distilled water calculated from the atmospheric pressure at the spring at the time of investigation.

The integral parts of the spring gas are expressed in their percentage to the volume of the gas; thus, the statement that the sample of the spring gas "Krafla No. 1" contains 12.6 % sulphuretted hydrogen, signifies that 100 ccm. of the spring gas in question contains 12.6 ccm. of sulphuretted hydrogen. The volumes are reduced to 760 mm. pressure and 0° Centigrade. Column "R" gives the percentage of the volume of the gas not absorbed by the agents usually employed in analysing gas, i. e. nitrogen, plus rare, inactive gases.

The radium emanation contained in 1 ccm. of the spring gas is expressed in the before-mentioned unit, (cf. p. 30), and is to be found in columns C_I and C_{II} of the table. C_I is calculated from the emanation measured in 100 ccm. of the spring gas a few hours after the gas was collected, while C_{II} is calculated from the emanation measured in 200 ccm. of the spring gas after standing about four days in the collecting bottles.

Probably the first point which strikes one on considering the accompanying table, is the great heterogeneity in the composition of the spring gases. Even samples taken from springs in the same locality sometimes show a considerable lack of uniformity in their composition. As a rule, however, springs in the same group evolve gases of almost the same composition. In cases where there is great incongruity in the gases, it will generally be found that there is a corresponding incongruity in the appearance of the springs. On the whole, the outward conditions and appearance of the springs seem to be to a great extent dependent on the composition of the spring gases. Springs which evolve gas containing sulphuretted hydrogen have generally a most unpicturesque appearance. The spring water becomes turbid through dark mineral particles being suspended in the water. If

there is plenty of water, these particles are constantly washed away, the water consequently attaining a grayish colour. Most of the hot springs at Kerlingarfjöll, and some at Hengill, are of this description. On the other hand, where the small particles find an opportunity of accumulating around the springs, they mix with the spring water, forming a thin pulpy kind of mud. In this way the mud pools and mud volcanoes at Námafjall, (Hlíðarnámur), Hveragerði, etc. have been formed. It is an obvious conclusion that the small particles are produced by the action on the rocks of sulphuretted hydrogen, or of sulphuretted hydrogen and carbonic acid gas combined.

The case is quite different in springs where nitrogen is the chief constituent in the composition of the spring gas. The water is then as clear as ordinary spring water, and only slight sediments are to be found deposited around the springs.

In the warm soil in the immediate vicinity of the springs a vegetation flourishes which is quite luxuriant for the climate, not being checked by the poisonous sulphuretted hydrogen, as is the case in the neighbourhood of the solfataras. Where the temperature of the springs is not very high, as for instance at Reykir, the vegetation has advanced almost to the immediate edge of the spring, leaving only a small outlet for the hot spring water.

Practically the only thing which distinguishes these springs from ordinary well springs is the bluish-gray cloud produced by the condensation of the vapours arising from the hot spring water.

The hot springs at Laugarás are similar, but owing to their intense heat and the consequent violent ebullition of the water, the vegetation has retired to a greater distance from the springs.

With the exception of two geysers, the hot springs at Grafarbakki are of the same nature as those in the two places already mentioned. There is a particularly close resemblance between them and the hot springs at Laugarás.

Although there are, as already shown, only infinitesimal deposits of sediment at the three places mentioned, the spring water nevertheless contains a considerable quantity of dissolved salts.

For instance, we filled an enamelled saucepan with water from a hot spring at Laugarás, and placed it in the water at the edge of the same spring. In this manner the saucepan was kept hot, and after a few hours the water in it had evaporated, leaving behind a considerable amount of white salts, partly crystallized. All the hot springs investigated at Reykir, Laugarás and Grafarbakki were likewise proved by direct test to contain carbonates and chlorides, and most of them also traces of sulphates. At all these places the water was alkaline.

A peculiar feature of the Laugarás and the Grafarbakki "hvers," distinguishing them from the hot springs at Reykir, is that the spring gas contains traces of sulphuretted hydrogen. At Laugarás the sulphuretted hydrogen could only be detected on the spot by means of the most delicate tests, while one of the gas samples from Grafarbakki contained 0.1 % of sulphuretted hydrogen when it was analysed in Copenhagen. That no sulphuretted hydrogen was found in the other

gas samples from Grafarbakki is probably due to the fact that these samples contained a little oxygen. While the gas was in the collecting bottle the small amount of sulphuretted hydrogen became oxidized and consequently disappeared.

According to the analysis, the spring gases at Grafarbakki contain a small percentage of carbonic acid gas, and it is not inconceivable that the presence of this gas and the larger volume of sulphuretted hydrogen in the spring gas are to some extent attributable to similar causes.

Around the hot springs at Grafarbakki a slightly larger deposit is to be seen on the stones than at Laugarás or Reykir. At Reykir the deposit is infinitesimal.

That there is a greater deposit at Grafarbakki is, I think, partly due to the carbon dioxide contained in the gas; I can see no other reason why the deposits should be larger here than at the other two places mentioned.

As far as the carbon dioxide contained in the gas and the silicious sediments around the springs are concerned, the "hvers" at Grafarbakki more resemble the third type of hot springs, i. e. hot springs with considerable silicious sediments, silicious sinters. Of the hot springs I investigated in the summer of 1906, the "hvers" at Hveravellir are the most important representatives of this class. The beautiful, cream-coloured silicious sinters here form two eminences of considerable height and of great extent.

The spring gases given off by these springs are characterized by a great amount of carbon dioxide, though they contain very little sulphuretted hydrogen. As before mentioned, the carbon dioxide contained in the spring gases probably tends to the production of silicious sediments. The gas sample Reykjafoss No. 1 is of a similar composition. This spring must therefore be considered amongst the springs of this third type, in spite of its very small deposits.

The spring gas from Hveravellir contains more oxygen than that from Reykjafoss No. 1, and perhaps this has some influence on the solution of the silicious compounds in the boiling spring water, although there are probably other more decisive factors.

In this connection it is worthy of mention that the alkaline springs at Reykjafoss seem to be very changeable. A good example of this is "Litli Geysir," which was previously a very active geyser, but which has now been inactive for a long time.

A similar example is to be seen in the great basin from which I collected gas samples in the summer of 1904. It was then a very energetic hot spring, but the basin is now filled with clear, tranquil water, and no gas is evolved.

The changes in the hot springs at this place seem to have been closely connected with the earthquakes which have taken place, no doubt on account of this group of hot springs being situated just on the outskirts of the district most subject to earthquakes.¹ In such districts comparatively large displacements must take

¹ In connection with the influence of earthquakes on the hot springs of Iceland, see J. THORODDSEN's paper in *Geogr. Tidsskr.* 15, 109, 1899—1900.

place during an earthquake. One has therefore good ground for supposing that the changeability of the hot springs at Reykjafoss is to some extent responsible for the insignificance of the silicious sinters around the existing springs, as the deposit of these sediments is a very slow process. The spring water must work in the same place for a long period before leaving any visible signs of its activity.

In contrast to the spring water with absorbed sulphuretted hydrogen, which in Iceland breaks down all the rocks with which it comes into contact and causes them to crumble, the alkaline spring water with absorbed carbonic acid gas seems to smooth out its course and enclose it with a crust of silicious sinter. This process possibly begins a little below the surface of the earth. If that be so, we can still better understand why the alkaline springs at Reykjafoss have such small stratifications, for by reason of the frequent changes in the course of the water, the silicious compounds dissolved in the spring water are used up in enclosing the course of the water through the crust of the earth. On the other hand, there is in the neighbourhood of Reykjafoss a large number of silicious sinters dating farther back.

A very common feature of the springs belonging to the last-mentioned type, is that most of them are periodic springs, and many of them are geysers. The same is the case with the alkaline hot springs at Reykjafoss and at Hveravellir, and very probably the thermal springs at "Stóri Geysir" are of the same kind.

There are only scattered and rather imperfect observations in existence concerning the periods of these springs, so that at present one cannot affirm more than that it is possible for springs belonging to the same group to have different periods. Many examples of this can be seen at Hveravellir. For instance ÞORVALDUR THORODDSEN¹ states that Nos. 15 and 16 have longer periods than the surrounding springs. According to our less studied observations, No. 12 has a period of many hours, while most of the other springs have periods of not more than a few minutes. I had no opportunity of making a closer investigation on this point. Most probably, however, the case is the same here as at the two geysers at Grafarbakki. In mentioning these geysers, P. THORODDSEN² remarks that they spout alternately, and that each eruption lasts for a minute. I made observations of the eruptions of these geysers on the 5th. August 1906. The barometer stood at 757.4 mm. and the temperature of the air was 13° Centigrade.

These observations (see Table II) show a very regular period on the part of the southern geyser. The pauses between the eruptions are very nearly equal, 60·8 seconds on the average. The measurements of the eruptions, on the other hand, seem to indicate that they have a double period lasting about 44 and 53 seconds alternately. But the measurements are too few to permit of a decision as to whether this is due to a fortuitous circumstance or not.

The figures for the northern spring do not show the same regularity, but as

¹ loc. cit.

² Geogr. Tidsskr. 10, 18, 1889—90.

Table II.
The Southern Geyser.

Eruption commenced	Eruption ended	Length of eruption	Pause	Period
	6 h. 37' 48" p. m.			
6 h. 38' 50" p. m.	39' 39"	49"	62"	111"
40' 42"	41' 24"	42"	63"	105"
42' 24"	43' 15"	51"	60"	111"
44' 15"	45' 00"	45"	60"	105"
45' 55"	46' 55"	60"	55"	115"
48' 00"	48' 45"	45"	65"	110"
Mean:—				109.5"
The Northern Geyser.				
6 h. 39' 00" p. m.	40' 35"	95"	35"	130"
41' 10"	42' 45"	95"	70"	165"
43' 55"	45' 38"	103"	42"	145"
46' 20"	47' 48"	88"	62"	150"
48' 50"				
Mean:—				147.5"

I made the two observations simultaneously, while standing near the southern spring, I consequently paid more attention to it than to the northern spring. The irregularities observed in the periods of the latter may therefore very easily be due to inaccuracy in the observations. The possibility of inaccuracy is enhanced by the fact that the beginning and ending of the eruptions of this spring are observed with difficulty, as the eruption rises very gradually to its full height, and falls likewise very slowly. It was therefore difficult at a distance to decide when the eruption should be considered as begun or ended. The following observations, made on the 7th. August 1906, seem to strengthen the conclusion that the irregularity is due to inaccurate observation. Barometer 754.3 mm. Temperature of the air, 16° C.

Table III.
The Northern Geyser.

Eruption commenced	Eruption ended	Length of eruption	Pause	Period
	11 h. 29' 27" a. m.			
11 h. 30' 35"	33' 05"	150"	70"	220"
34' 15"	36' 48"	153"	72"	225"
38' 00"				

These measurements show that it is possible for this spring also to have eruptions with very regular periods.

From the measurements made on the 5th. August, it appears that the southern geyser has four eruptions while the northern geyser has three, for $3 \times 147.5'' = 442.5''$ and $4 \times 109.5'' = 438''$. But this is probably quite fortuitous.

P. THORODDSEN¹ is of the opinion that these geysers had, in 1888, periods of equal length, but my observations show that this is no longer the case.

From what is known of the nature of the geysers, it is to be expected that the weather has considerable influence on the periods of the springs. This is confirmed by people who live in the neighbourhood of the springs. They have noticed that the eruptions of "Stóri Geysir" especially are greatly dependent on the weather. In this connection I can also refer to the observations made by GILBERT MAIR², showing that the weather has great influence on the thermal springs of New Zealand. The observations given above are an additional corroboration of changeability in the periods of the geysers, for on the 5th. August the period of the northern geyser was 147 seconds on the average, but on the 7th. it was about 222 seconds. This difference is remarkably great, especially when it is taken into account that only 41 hours elapsed between the two observations. Several hot springs in Yellowstone National Park³ are found to have more than one distinct range of periods. Nevertheless it seems to me hardly probable that the differences I observed are due to such a cause, amongst other reasons because the transmission from one range of periods to another is usually attended by a change in the energy of the eruption, whereas, as far as I could discern, the eruptions were equally powerful at the time of both observations.

There have been several theories advanced at different times to explain the activity of the geysers. A good idea of these so-called geyser theories can be formed from Peale's treatise on "The Thermal Springs of Yellowstone National Park".⁴ A. ANDREAE⁵ also mentions several geyser theories in his treatise on geyser models.

The best known geyser theory is that of R. BUNSEN⁶. As this theory, in spite of several serious objections to it, — that of H. O. LANG⁷, for instance, — seems still to be the geyser theory most generally recognised, it will be made the basis of the following remarks concerning the phenomena. All the later geyser theories are to some extent based on BUNSEN's theory and the materials acquired by his observations.

According to BUNSEN⁸, we must discern between hot springs with narrow

¹ loc. cit.

² New Zealand Trans. Inst. **9**, pp. 22—29, 1876.

³ Twelfth Annual Report of the U. S. Geological and Geographical Survey of the Territories. Washington, 1883. Vol. II.

⁴ Twelfth Annual Report of the U. S. Geological and Geographical Survey of the Territories. Washington, 1883; p. 417.

⁵ Neues Jahrbuch der Mineralogi. 1893. Vol. II, p. 1.

⁶ Liebigs Ann. **62**, 1. 1847.

⁷ Nachrichten v. d. Königl. Gesellsch. d. Wissenschaften zu Göttingen, 1880; p. 225.

⁸ loc. cit. p. 56.

channels and great heat energy supplied by hot water and steam, and hot springs with wider channels and less heat energy. The former are constantly boiling because the hot water cannot settle in the narrow channels on account of the hot vapours and water which pass through them with great force. The latter are periodic geysers. The wide and, (as at "Stóri Geysir"), perpendicular channels are filled with water which is almost stagnant. The temperature of the water at the surface is kept a little below boiling point, but the temperature increases in proportion to the depth of the water. The temperature is, however, always a little below the boiling point of water at the same pressure.

Immediately after an eruption, this difference is rather great, but it gradually lessens, until, just before the next eruption, according to measurements of the temperature made in the geyser channel itself, the difference is so small that a slight rising of the water column is sufficient to cause the water to boil.

The rising of the water is, according to BUNSEN, explained by the fact that many great basins with hot water, at "Stóri Geysir" as well as at Reykjafoss, do not give off air bubbles steadily, but periodically. Taking for granted that the same thing happens at the bottom of the geyser channel, it will then cause a periodic rising of the water, and thereby possibly an eruption.

As before stated, there are many objections to this theory. LANG¹, for instance, regards the Bunsen theory as unsatisfactory, and as conflicting with other geological theories, because it does not take into account the circulation of the water in the geyser channel caused by the hotter water lower down in the channel having less density than the colder water higher up. Neither does the Bunsen theory, in his opinion, explain the intensity and periodicity of the eruptions. In this last point I agree with LANG, though I have arrived at this conclusion on considerations somewhat different to his.

In accordance with BUNSEN's curves of the temperature in the geyser channel, a rising of the water column immediately before an eruption would only result in the temperature of the water in a small part of the channel becoming higher than the boiling point at the same pressure. Then, of course, the water in this part of the channel boils. But in ordinary circumstances this would by no means cause an eruption. If the Bunsen theory be correct there must be some particular causes at work in the geyser channel, but evidence on this point is entirely wanting.

Again, it is questionable whether Bunsen's method of dealing with the temperature measurements in the geyser channel, made by him and DESCLOIZEAUX, is absolutely correct. Of the five series of measurements they have made², BUNSEN only uses the 2nd., 3rd. and 4th., without giving any reason for omitting the first and the last series of observations. But these very observations omitted are of primary importance, in that they are the first measurements made after eruptions. Indeed, it seems as if the observers themselves do not have very much confidence

¹ loc. cit.

² Compt. Rend. 23, 934. 1847.

in these measurements, for the results of 3 out of the 7 measurements are given with a note of interrogation. But the 4 remaining measurements may safely be considered as reliable as those of the other 3 series.

I have made a graphic diagram of all the measurements, (Fig. 13), and con-

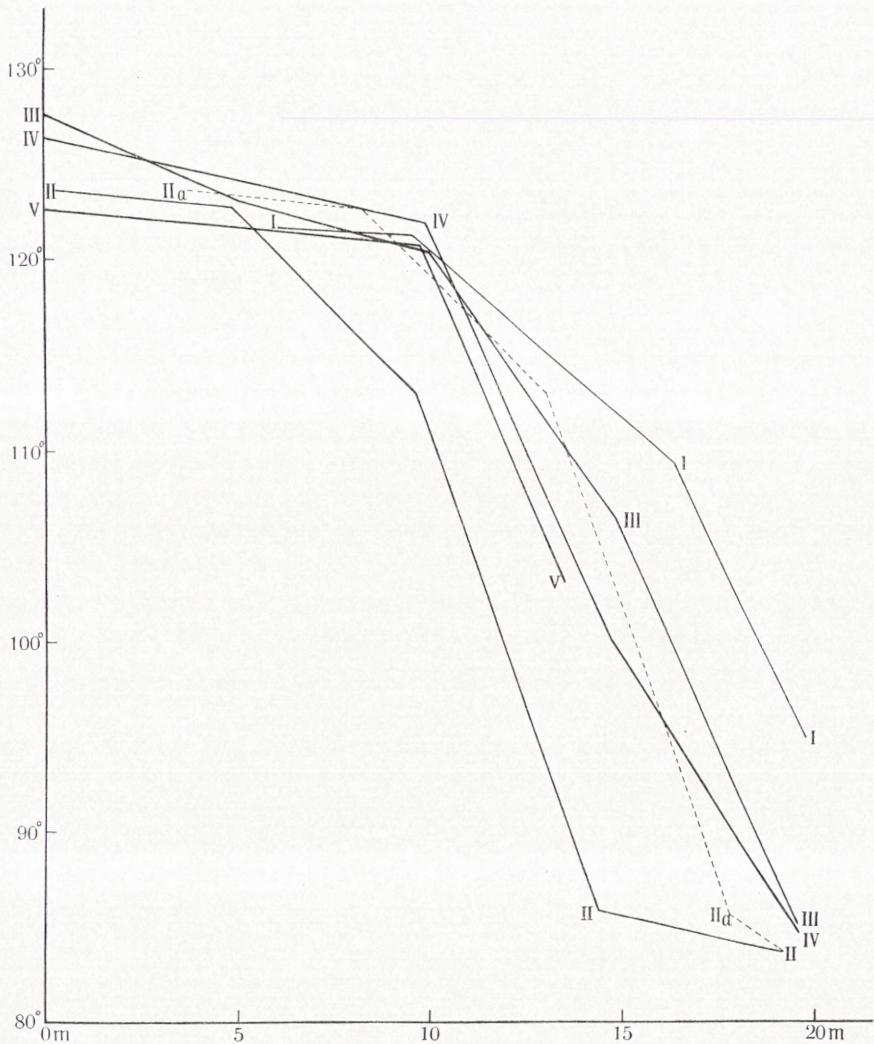


Fig. 13.

nected by means of straight lines the temperatures belonging to each series of observations. The roman figures denote the order in which the experiments succeeded each other. "I" shows the temperature immediately after a large eruption. IV shows the temperature a little before the subsequent eruption, and V the temperature after it.

From this diagram it is evident that the temperature measurements of the two experiments omitted by BUNSEN are in fair agreement with the other measurements. Two measurements in the first experiment, however, seem to be a good deal too high, but both these measurements are given with a mark of interrogation, and may therefore be regarded as uncertain. A glance at the diagram also shows that the measurements of the second experiment, (line 4 in BUNSEN's paper), does not agree with the other measurements. This would lead one to suppose that an inaccuracy has crept into this experiment. This suspicion is strengthened by the fact that if these measurements are correct, the temperature of the water must have risen about 2° C. from 19.2 m. to 14.4 m., and 17° C. from 14.4 m. to 9.6 m., which seems in the highest degree improbable. Such abnormalities are not to be found in the other experiments. This disagreement is readily explained by supposing that the thermometer measuring the temperature at 14.4 m. remained higher up the channel, at about 17.8 m., and as all the thermometers were hanging on the same string, the result would be that the thermometers which were farther down the channel measured the temperature 3.4 m. higher up than was assumed by BUNSEN and DESCLOIZEAUX. The dotted line, constructed on the basis of this supposition, now shows a fair consistence to the other lines. But the lines in this instance have a vastly different significance to that which BUNSEN assigned to them. In the first place, we observe that the lines form a well-marked angle at about 9 m. In this respect they resemble the temperature curves of Strokkur¹. The significance of this is evident enough. The heat supply is brought into the geyser channel in the neighbourhood of the spot corresponding to the angle in the temperature curve, i. e. about 9 m. from the bottom. Thus the temperature measurements are brought into harmony with direct observations by BRYSON². He has found that at a depth of 45 feet from the surface, there is a projecting rim in the geyser channel, and that very hot water and steam flow into the channel immediately beneath this rim. As it is known that Strokkur also has side channels, the manner in which the temperature in the channel of this spring varies with the depth must naturally be explained in the same way. BUNSEN's supposition that the lower part of Strokkur's channel must be full of steam, is therefore incorrect. It must be filled, as in the case of "Stóri Geysir", with stagnant or almost stagnant hot water.

BUNSEN reports several peculiarities in the eruptions of "Stóri Geysir", which in his opinion indicate the existence of fissures in the sides of the geyser channel supplying the channel with hot water and steam during the eruptions. But he considers this to be of secondary importance. But it is, however, of great importance in considering BUNSEN's objections against MACKENZIE's theory. BUNSEN proved, by actual experiment, that a thermograph could lie unmoved and unharmed at the bottom of the channel during an eruption of "Stóri Geysir". This, he contended,

¹ Liebigs Ann. **62**, 39, 1847.

² Frost and Fire. Vol. II, p. 417.

would not be possible if hot water and steam, according to MACKENZIE's theory, rushed into the channel with great violence. This objection cannot now be maintained, as we know that the inlet to the geyser channel is situated 9-10 m. from the bottom.

My explanation of the measurements of BUNSEN and DESCLOIZEAUX also shows that BUNSEN's theory that the temperature at a given spot in the channel continually increases from one eruption to another, can no longer be held in its entirety. For if we replace line II by the dotted line, then lines I to IV show that the temperature at a given point in the geyser channel does not rise appreciably from the cessation of one eruption to the commencement of the next.

The chief cause of the eruption is, therefore, to be sought outside the geyser channel. Of course the energy accumulated in the channel will increase the power of the eruption, but the calculations made by BUNSEN to show that the water in the channel is possessed of sufficient energy to sustain the eruption, do not, however, appear to me to be conclusive.

It is very difficult to form even an approximate estimate of the amount of energy required for an eruption, and besides this, the calculations do not provide for the diminution of the available energy, produced by the intermixture of hotter and colder water.

PEALE¹, who inclines perhaps most to BUNSEN's theory, supposes, however, that subterranean channels and cavities are of considerable significance in regard to the geyser phenomena.

BUNSEN himself inclines to the opinion that in the case of Strokkur, — which, as already pointed out, resembles "Stóri Geysir" in many particulars, — the motive power of the eruption is outside the channel. He has come to this conclusion through the following observations. One can cause Strokkur to spout by stopping up its channel with sods. This makes the jet of water at first discoloured, on account of the dirt the water in the channel has received from the stoppage. But after a short time the water becomes clear as a fresh supply of water flows into the channel from other channels deeper down.

In other respects BUNSEN has been quite clear on the point that the typical geyser channel is not the sole cause of the periodic eruptions. For instance, he remarks in describing "Litli Geysir", that the eruptions of this spring are not due to the same causes as those of "Stóri Geysir". He seems to incline to the opinion that the eruptions of "Litli Geysir" are most satisfactorily explained by MACKENZIE's theory.

MACKENZIE's theory is illustrated by Fig. 14. The cavity A is supplied with water (of atmospheric origin) through fissures in the walls of the cavity. The water in A receives heat partly conducted from the volcanic surroundings, and partly by a supply of highly heated steam. At last the temperature in A becomes so high

¹ Twelfth Annual Report of the U. S. Geological and Geographical Survey of the Territories. Washington, 1883, p. 421.

that the pressure of the steam can withstand the pressure of the water column in the channel. A sudden increase of the heat supply will then give rise to an eruption.

The principal fault of MACKENZIE's theory is that it does not explain the intermittence and periodicity of the geysers, which are the most characteristic features of the geyser phenomena.

Amendments of this theory, proposed by later scientists, have not, as far as I know, overcome these difficulties in a satisfactory manner.

In order to see in what way the existing theories need to be amended in order to agree with the existing facts, it will be very instructive to make a closer examination of an eruption of one of the small geysers in its different phases. I select as an example the southern geyser at Grafarbakki.

Immediately after an eruption the small shallow basin is quite empty. The dampness of the stones at the bottom of the basin is the only visible sign that boiling water has recently filled the basin. But the water soon begins to show itself between the stones at the bottom of the basin, and it rises steadily and rapidly. At last it fills the whole basin and begins to overflow the brim. Shortly after, the spring enters upon its next phase, when air bubbles commence rising through the water from the bottom of the basin. The water is not boiling, for real ebullition very seldom takes place in the Icelandic springs. The water is agitated by bubbles of spring gas, which, saturated with vapour, force their way up through the water. At first these bubbles are neither large nor numerous, but they increase rapidly until at last they rise with such violence that the water is thrown up a little into the air. The eruption has commenced.

At the height of the eruption the water column is fairly constant, but it sometimes happens towards the end, when the energy of the eruption is declining, that two or three water jets suddenly rise far above the others. It looks as if the motive energy pulls itself together for a last effort. At the close of the eruption the water in the basin sinks down again into the earth, preparatory to the next eruption.

The main points of the mechanism of the periodic eruptions seem to be included in the foregoing. I assume the supply of hot water, steam and spring gas from the interior of the earth to the lowest part of the spring channel, to be con-

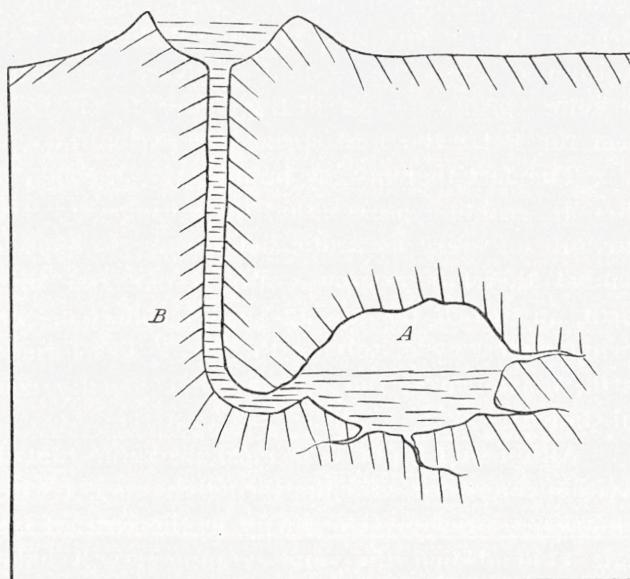


Fig. 14.

stant in all the hot springs, whether they be periodic or in a constant state of ebullition. For I am not aware of any reason why this supply should be periodic, and this assumption is rendered more plausible by the fact that both periodic and constantly boiling springs are often situated side by side in the same group of springs, as, for instance, at Grafarbakki. It is therefore only in the shape and position of the channel that one can expect to find the factors which cause the periodic springs, — as distinguished from the constantly ebullient springs, — to eject the hot water and spring gas periodically.

The fact that no gas bubbles rise through the water in the basin immediately after an eruption proves that the spring gas, — which appears to be an inseparable attribute of every Icelandic hot spring, is blocked up down in the spring channel. I must therefore assume, with MACKENZIE, that there are cavities down in the earth, in which the spring gas is collected. And it is highly probable that the spring water, by dissolving the rocks, has formed many such cavities down in the earth, inasmuch as the spring water usually contains great quantities of dissolved substances.

Although I think it is most probable that the majority of geysers have several cavities connected with the spring channel, I will, in order to simplify the following remarks, restrict myself chiefly to the case of only one cavity, as shown in Fig. 14. It is evident that the same argument will hold good when the spring has many cavities, although the whole subject then becomes more complicated. The water in the bend of the channel *B* cuts off from the atmosphere the spring gas accumulating in *A*. But as fresh spring gas is constantly coming from below, the gas accumulated in *A* is constantly expanding. Again, the loss of heat in the spring being comparatively small while the channel is stopped up, and the supply of heat to *A* being constant, the temperature in it must consequently increase. This causes an increase in the volume of the gas in *A*, on account of the expansion of the gas itself, and the augmentation of the steam pressure through the increasing temperature. This increase in the gas volume in *A* is at first counteracted by the increasing pressure produced by the rising of the water in the channel *B*. At last the volume of the gas in *A* increases so much that bubbles of spring gas, saturated with vapour, begin to force their way through the channel *B*. The volume of the first bubbles is, however, very much diminished on the way up, on account of the condensation of a great deal of the vapour through contact with the colder water in the channel. A considerable difference is possible in the temperature of the water in different parts of the channel, especially when the channel is so narrow that the water cannot circulate freely enough to distribute evenly the loss of heat in the spring water which takes place in the upper part of the channel, through the lower temperature of the surroundings. The condensation of the vapours from the gas bubbles increases the temperature of the water, so that subsequent bubbles are not so much diminished.

In ordinary circumstances a state of equilibrium will eventually ensue, in

which the bubbles will force their way up through the water in the channel of the spring without producing any disturbance in the pressure in the channel. This is the case with the continually ebullient springs. But if the channel is at any point so narrow that the gas bubbles can fill it entirely, then the water column resting on the gas volumes below becomes shorter. The decrease of pressure thus produced will give rise to a more intense ebullition and emission of gas from the cavities and adjacent side channels. The current of gas bubbles through the channel becomes therefore more intense, and increasingly displaces the water from the channel. Consequently the emission of gas and the ebullition increase still more, as the pressure of the water diminishes.

At last the water columns barring the passage of the gas bubbles through the channel become so few and so small, that the steam pressure from below can easily overcome them. They are then forced through the channel with great speed, and thrown to a considerable height when expelled. The eruption of the spring is then in full activity. The length of the interval from the moment when the first bubbles appear, until the eruption takes place, is to a great extent dependent on the shape of the spring channel.

In springs with a simple form of channel, the eruption may commence suddenly, almost simultaneously with the appearance of the first gas bubbles. This is most readily explained by the experiment of forcing air up a narrow perpendicular glass tube filled with water. The air pushes the water column before it up the tube, and expels the water almost all at once. On the other hand, where the spring channel is irregular, being in some parts very wide and in others very narrow, some time may elapse before the water is thrown so high above the basin that a real eruption may be said to have begun.

The length and character of the eruptions also depend very much on the shape of the channel, but in this respect the conditions under which evaporation and ebullition take place down in the cavities is also of great importance. In the interval between the eruptions, during which the spring is at rest, a large supply of energy, in the form of highly heated water, is accumulated down in the cavities. The duration of the eruptions seems to indicate that this reserve energy of the spring has some resistance to overcome before it can properly develop itself. Of course, some of the hot water is accumulated in recesses and side channels leading to the principal cavities, and can only take effect gradually during the eruption, because very probably it has first to pass through narrow channels into the principal cavities.

During the eruption itself it is possible that the passage of the spring exhalations through the principal spring channel may frequently be hindered by small water columns, formed in the bends or narrow passages of the channel by the water which the vapour carries from below, or which is conveyed to the principal channel from the side channels.

While the eruption is at its height these stoppages only last a very short

time, because the pressure of the steam from below drives them along as soon as they are formed, but they are, however, of sufficient duration to account for the intermittent character of the eruptions.

When the eruption is on the decline and the evolution of steam decreases, the water barricades can remain in the channel a little longer. The spring must have time to gain strength to expel them, but when at last it is able to master them, it will eject them from the channel with great velocity. This will doubtless account for the extraordinarily high water jets which we noticed so often at the end of the eruptions of the two geysers at Grafarbakki.

During the eruption the great water pressure usually prevailing in the spring cavities becomes almost nil. The accumulated energy of the spring is therefore liberated. But when this is exhausted, and the steam evolution is only sustained by the heat energy continually supplied from beneath, the steam current through the channel is so much weakened that it is not able to keep the passage through the channel free.

The barriers of water formed as described, in bends and narrow passages of the principal spring channel, can then remain stationary, as long as there is a perceptible stoppage of the steam current through the channel. But as soon as the steam current is stopped, the water will also fill other parts of the channel, from which water has previously been excluded by the steam. The increase of the water pressure then becomes greater than the increase of the steam pressure from below. As a result the water column recedes downwards through the channel, enters the cavities of the spring, and fills up the whole of the space formerly occupied by the steam. The steam is unable to resist, on account of the pressure of water being so great and the tension of the vapour becoming less through the decrease in temperature caused by the entrance of colder water from above into the cavities. The eruption is now ended, which event is marked by the water from the basin rushing down into the channel.

We have noticed that the spring gas, saturated with steam, which is continually supplied to the spring from below, cannot force its way in the form of bubbles through the water in the spring channel, without producing a decrease in the pressure of the water, and thus causing an eruption. In exactly the same way, the eruption is brought to a close through the steam current kept up by the constant supply of energy to the spring becoming insufficient to keep the spring free of water stoppages, which block the passage of the steam current through the channel.

This is, in my opinion, the principal cause of the periodic eruptions of the thermal springs. Of course, very hot water, by suddenly boiling, may also cause an eruption, as many of the geyser models show, but it occurs very seldom in nature. On the whole, it is hardly probable that the spring water can be superheated to any extent, because it is, in almost every case, impregnated with spring gas. In those cases where hot springs are found with a temperature a little higher than

the boiling point at that elevation, it is more probably due to the substances dissolved in the spring water and too strong a heat supply from heated steam, than to the tendency of the spring water to become superheated.

That the channels be crooked, can no longer be regarded as a necessary condition of the intermittence or periodicity of the springs, for the latter, as already mentioned, could easily be in a constant state of ebullition, even though their channels are crooked. On the other hand the irregularity of the channels may in several different ways influence the progress and character of the eruptions of the periodic springs; they tend especially to shorten the eruption, as the water is collected in the bends, and forms stoppages to the steam current through the channel.

It is evident that special circumstances in the individual springs may greatly influence the character and period of the eruptions. In most of the springs there is a cup-shaped hollow at the place where the spring channel reaches the surface. Owing to the rapid loss of heat at the surface, the spring water gathering in this hollow is kept considerably cooler than the water deeper down in the channel. The rapidity of the loss of heat at the surface is evidenced by the temperature measurements made by BUNSEN and DESCLOIZEAUX at "Stóri Geysir" and Strokkur. This is also borne out by our measurements of the temperature of the water at the surface and at the bottom of Básahver and Vaðmálahver at Grafarbakki.

During the eruption, the steam current from the orifices in the bottom of the basin is generally so strong that the channel below is kept free from the cold surface water in the basin, but if the steam current is stopped for a moment, or weakened to any extent, the surface water runs down into the channel.

In many cases this will result in the entire cessation of the eruption, because the pressure produced by the water is increased, at the same time as the tension of the vapour is decreased on account of the temperature in the channel being lowered by the cold water.

At Grafarbakki and, generally speaking, in most of the spring groups that contain periodic geysers, there are constantly boiling springs and periodic geysers side by side. Hence it is evident that two entirely independent channels are often found side by side in the earth. It is therefore quite possible that two or more really independent channels may be united to one channel beneath the surface of the earth. Only one of these channels being capable of causing periodic eruptions, suffices to render the spring itself periodic.

In the case of several geysers, the eruption takes place in all the channels at once, for as soon as the eruption in one of the channels has relieved the pressure due to the water column in the common channel, the decrease of the pressure will give rise to an eruption in the other channels. With other geysers the decrease of the pressure is not sufficient to cause an eruption in the remaining channels, and as an interesting medium between these two extremities, we have geysers where the eruption in the remaining channels only takes place when the eruption

in the first channel is extraordinarily intense, while they remain passive when the eruption is less intense. This is undoubtedly the case with many geysers which have two kinds of eruptions. They must be provided with two or more channels beneath the surface of the earth.

Another reason for two different kinds of eruptions taking place in the same geyser will be mentioned later, in the dissertation on the eruptions of "Stóri Geysir."

Where violent eruptions take place the spring gas and the vapour in the channels are subjected to great pressure previous to the eruption. The walls of the channels must therefore be very strong, in order to sustain this great pressure. Where the soil is loose and disintegrated, the spring gas makes new passages as soon as the old ones are stopped up. In these localities therefore no great eruption can take place. This is evidently the principal reason for the scarcity of geysers where the spring gas contains large quantities of sulphuretted hydrogen. For the soil surrounding the sulphurous springs is always disintegrated.

In some geysers, Grýla for instance, the real eruption is succeeded by a steam jet period. This is most readily explained by assuming that the form of the spring channel is comparatively regular, so that the steam can easily drive the whole of the water out of the channel. Besides this, the supply of hot water which produces the steam cannot enter into the channel during the eruption. When the spring has spent its accumulated energy, and the steam power is consequently on the decrease, the vapours in the channel become condensed and stop the flow of steam out of the geyser.

Finally, I will mention somewhat more exhaustively a particular type of periodic spring, namely, the great hot water basins, which evolve gas periodically. The periodicity of these springs is not easily apparent on the surface. The steam and gas bubbles which are periodically ejected from the small holes at the bottom of the basin, diminish very rapidly as soon as they come into contact with the water in the basin, which is kept cooler on account of the evaporation from its large exposed surface.

These eruptions may therefore appropriately be termed subterranean eruptions, inasmuch as their energy is exhausted before they reach the surface.

The periodicity of these springs is easily explained in the same way as in the previous instance. The steam flow is not strong enough to keep the water in the basin out of the channels, and by the time the water has entered the channels and hindered or completely stopped the outflow of spring gas, the spring has accumulated sufficient energy to expel it again.

This class of hot spring claims more attention, inasmuch as "Stóri Geysir" must be considered as belonging to it. For besides its characteristic large eruptions, "Stóri Geysir" has also small eruptions with regular periods. These small, or as BUNSEN has called them, unsuccessful eruptions, are, like the larger eruptions, accompanied by subterranean detonations. Water and spring gases flow with such

velocity through the geyser channel, that it causes the water to rise in the shape of a cone on the surface. These small eruptions are called "flóðs" in Icelandic, owing to the increase in the amount of water flowing away. These "flóðs" are subterranean eruptions, only much more powerful than similar eruptions in the large hot water basins. The geyser channel, with its large funnel-shaped basin, plays a similar part to the water basins in choking the eruptions. The circulation of the water in the geyser channel is generally able to keep the temperature sufficiently low, so that the bubbles of steam condense on coming from the side channels. Occasionally, however, either on account of the subterranean eruptions being more powerful, or because the loss of heat is less than usual, the steam bubbles are able to fill up the whole width of the channel and raise the entire water column, thus occasioning a large eruption.

The pressure of the water column in the geyser channel is for the most part suspended during the larger eruptions. The energy accumulated in the side channels has then more freedom to spend its strength than in the smaller eruptions ("flóðs"), where the subterranean forces have to work under the pressure of the water in the channel.

One can now understand that the period of inaction after a large eruption is about twice as long as after a small one.¹ For, after a long eruption, a far greater supply of energy and spring gas must be conveyed to the side channels and their cavities in order to enable them to produce a new eruption, than after a small one.

At Öskurhóll we noticed that the steam emissions varied in strength. We could not make a closer investigation of the periodicity of the steam emissions, but there is little doubt that Öskurhóll must be reckoned amongst the periodic springs. Small subterranean eruptions, either in the principal channel or, more probably, in one of the side channels, would be sufficient to account for the periodicity of the steam emissions. But it is nevertheless not impossible that Öskurhóll is in communication with one of the adjacent geysers, so that the variations in the steam emissions might be due to influences from another spring.

Many attempts have been made to construct models to show in miniature the mechanism of the geyser phenomena.² It seems to me, however, hardly probable that we can with these apparatuses make even an approach to the actual conditions. In my opinion, the only thing which the geyser models have proved with sufficient clearness, is that the relation of the width of the channel to the steam evolution on the one hand, and the loss of heat in the channel on the other, is one of the chief causes of the intermittence or periodicity. But as to the part the spring gases play in the eruption, very little information is to be gathered from the geyser models. However, as stated, the relation between the spring gases and the width of the channel is evidently the chief cause of the periodicity.

¹ DESCLOIZEAUX: Ann. d. Chem. 3rd. Series, 19, 456, 1847.

² Full details of previous papers on Geyser Models are to be found in a paper by J. A. ANDREAE in "Neues Jahrbuch der Mineralogie", 1893, Vol. II, p. 1. Many models are described in this paper.

On the basis of the preceding remarks we can sum up the conditions of the periodic eruptions as follows.

A mixture of hot water and spring gases saturated with vapour is conveyed through the spring channel, which we must assume to be situated in solid strata, and to be well defined, at least in the upper part, i.e. near the surface of the earth.

If the gas bubbles, while a state of equilibrium rules, do not cause the water pressure to decrease on their way up the channel, we have then a continually ebullient spring.

If, on the other hand, the gas bubbles, while the spring is in a state of equilibrium, would produce a decrease in the pressure, especially by filling out parts of the channel, the spring is periodic.

In the latter instance, the surface tension, and adhesion, will be of considerable consequence, especially in regard to the size of the gas bubbles.

The constantly boiling springs are therefore hot springs with a fixed equilibrium, while the periodic springs have no fixed equilibrium. I understand that a spring has attained its state of equilibrium, when the flow of water, steam and spring gases, passing through the channels of the spring, becomes constant, and the temperature in all parts of the channels has also become constant.

We have assumed that water is conveyed through the spring channels, for that is a necessary condition of the periodic springs. Where no water is to be found in the spring channel, an eruption can hardly take place. But it is sufficient if there is water in the upper part of the spring channel. In this connection it matters little if there is only steam farther down the channel, for the cause of the eruption is only to be sought in the parts of the channel where there is water.

In the theory of the periodicity of the hot springs, it is immaterial whether we assume that the heat energy is supplied by steam or by highly heated water which, on account of the great pressure to which it is subjected, cannot boil and evaporate. But, in my opinion, the heat energy is most probably supplied by highly heated steam and spring gas. Direct proofs of this are not forthcoming, but there are many things that seem to indicate that it is correct: amongst others, that I have never been able to detect any radium worth mentioning in the sediments or mud of the springs; and since radium emanation is always found in the exhalations of the springs, either the spring water or the steam must have been in contact with radium. If it were the spring water, it would dissolve a little radium, and carry it in this manner up to the earth's surface, where it ought to be found in the deposits of the springs, as is the case with many springs in Italy and France.

But this is not the case with any of the hot springs I have investigated in Iceland. This is most probably on account of the spring water having, somewhere down under the earth's surface, passed into a state of vapour, and thus being hindered from conveying any radium. On the other hand the vapour must con-

dense again at a considerable depth, for otherwise the spring water would hardly be able to convey such large quantities of dissolved substances as it actually does.

The surface temperature of the spring water is dependent on several different factors. Some of these are of a more individual character, in that they are controlled by the form and nature of the spring. The loss of heat to the surroundings, — whether it is produced by heat conduction from the spring channel or by evaporation from the surface of the water, can be considered among these. The differences in the temperature of springs situated in the same group are chiefly due to these circumstances. There are two other factors likely to be of importance with regard to the temperature of the spring water, which may be supposed to be almost identical in springs belonging to the same group. These factors are the heat supply from below and the loss of heat caused by boiling.

At Reykir in Skagafjörður the first of these is the most important factor. The intensity of the heat supply is evidently much less there than at the other places explored. As the highest temperature measured at Reykir was only 68° C., the water in the depth of the earth cannot possibly have as high a temperature as at the other places.

At the other places investigated, the temperature down in the earth is undoubtedly considerably higher than 100° C. We know that the temperature in the depth of the earth must be over 100° C., otherwise the steam in these springs would not possess sufficient power to consummate an eruption. The highest temperature measured by BUNSEN and DESCLOIZEAUX at the bottom of a geyser channel was 127° C.

When the temperature of the spring water is nearly at boiling point, which is the case at most of the places we explored, the surface temperature is very little influenced by variations in the supply of heat energy. In such cases, the circumstances of cooling, and, foremost among these, the ebullition, are of the greatest importance with regard to the temperature of the spring.

The ebullition of the springs is dependent on the standing of the barometer, on the amount of substances dissolved in the spring water and on the volume of the spring gases. The dissolved substances raise the boiling point of the water. It cannot yet be decided how much this amounts to in the case of spring water, as no measurements to this end are available, but probably it only amounts to a small fraction of a degree. Setting this aside, we calculate, in the fourth column of Table I, the boiling point of distilled water, corresponding to the respective height of the barometer. It appears from this table that the boiling point thus calculated is higher throughout than the temperature of the spring.

The bubbles rising up through the water are not filled only with vapour, as by ordinary boiling, but with a mixture of vapour and spring gas, and it is the combined pressure of the vapour and the spring gases that withstands the atmospheric pressure. Assuming that the bubbles are saturated with vapour having the same temperature as the spring, the relation between the spring gases and the

vapour can easily be calculated, provided that the height of the barometer and the temperature of the water are known. Hence it follows that, in the case of two springs with the same temperature and at the same pressure of the atmosphere, the spring that evolves the greater volume of gas in proportion to the volume of water, will lose the greater amount of heat by ebullition. For in this case the evaporation is proportional to the volume of the spring gases.

As a rule, the spring gas augments the evaporation of the spring water, and thus contributes to keep its temperature below boiling point. The loss of heat consequent on boiling is therefore greater in springs evolving much gas than in springs with slight gas evolution.

A glance at the temperature of the hot springs investigated, shows that springs in the same locality have practically the same temperature. In most cases where considerable divergencies from this rule occur, a direct observation of the springs on the spot will show that these divergencies are due to some special peculiarities in regard to the process of cooling.

Springs in the same locality not only resemble each other as regards their temperature, but in the composition of their spring gases, as Table I shows. The same may be said in regard to the amount of emanation contained in the gas.

All this seems to indicate that springs in the same locality have a common source, or at least originate under similar conditions. The well-known fact, that the hot springs are always found in fissures in the earth's crust confirms this. At Reykir, (Plate II b), at Grafarbakki, (Plate VII b), and at Reykjafoss, (Plate IX a), it is noticeable that the principal springs are situated almost in a straight line, showing the direction of the fissures. Where the surface of the earth is much disintegrated, as it is around the solfataras, it is not so noticeable that the hot springs are confined to fissures. Every visible sign of the fissures is destroyed by the disintegration of the surface, and the hot springs find their outlets at the lowest places possible.

Our knowledge of the processes taking place in the depth of the earth, where the real source of the energy of the springs is situated, is very slight, and the available methods of investigation very limited, in that we are almost exclusively confined to the study of the exhalations of the springs, viz. the steam, the spring gases and the radioactive emanations.

As far as I know, no analyses of spring gases from the places I investigated have been made, except BUNSEN's¹ and O. T. CHRISTENSEN's² analyses of spring gases from the hot springs in the vicinity of Mývatn. I have already pointed out that many hot springs have changed in the course of time. The mention of these changes served particularly to illustrate the action of the hot springs on the outer crust of the earth, and the influence of meteorological conditions and earthquakes on the thermal activity of the springs.

The matter has another aspect, if one considers the change in the composition

¹ Pogg. Ann. 83; p. 238. 1851.

² Tidsskrift for Physik og Chemie. 10, p. 225. 1889.

of the gases from the same spring. If the composition of the spring gases is changed in the course of time, then we have reason to suppose that a corresponding change has taken place in the depth of the earth, where the spring has its origin.

For the purpose of comparison, I quote here CHRISTENSEN's analyses of samples of spring gases collected by JOHNSTRUP at Krafla in the summer of 1871.

Table IV.

	I	II	III
$SH_2 \text{ } \%$	5.89	13.94	14.55
$CO_2 \text{ } \%$	68.80	63.52	71.99
$H_2 \text{ } \%$	15.59	11.71	9.30
$N_2 \text{ } \%$	9.72	10.83	4.16

We see at once that the last of JOHNSTRUP's gas samples, (III), has almost exactly the same composition as one of mine. The other two have a somewhat more divergent composition, which is chiefly due to a comparatively large increase in the amount of nitrogen. This suggests that these samples originate from springs where the soil is particularly porous, and that a little atmospheric air has therefore mingled with the spring gas.

Unfortunately, however, there is no detailed description of the springs from which the gas samples originate, in JOHNSTRUP's and CHRISTENSEN's papers. Any conclusions drawn from a comparison of my analyses with those of CHRISTENSEN may therefore be to some extent uncertain. My two samples of gas show a considerable divergence in their composition, although they originate from two very similar hot springs, the distance between them being only about 20 m. Nevertheless it is confirmed with sufficient accuracy by the analyses quoted, that the spring gases at Krafla have undergone very little change, if any, in the period 1871—1906.

We might expect that the gases evolved by the hot springs at Námafjall, situated about 10 km. south of Krafla, would very closely resemble the gases evolved by the hot springs at Krafla. The outward appearance of the springs is in many respects similar, and the geological conditions indicate that the springs originate from the same source.

It was during the long period of volcanic eruptions 1722—1729, when Helvíti was a very active ash-crater, and when the great line of craters at Leirhnjúkur, a short distance west of Helvíti, emerged and threw up an immense quantity of lava, that the active craters in Bjarnarflag, west of Námafjall, also came into existence, (see Fig. 2).

All this seems to indicate that the hot springs at Krafla and at Námafjall must be in connection with each other. Nevertheless the composition of the spring gases at Námafjall differs essentially from that of the spring gases at Krafla. The great amount of hydrogen in the former is especially conspicuous.

These gases have also some interest in other respects.

In the following table I have collected the analyses within my knowledge of spring gases from Námafjall.

Table V.

	BUNSEN	CHRISTENSEN				TH. THORKELSSON	
	(1845)	1. (1876)	2. (1871)	3. (1871)	4. (1876)	1. (1906)	2. (1906)
$H_2S\text{ }^{\circ}/\circ$	24.12	26.32	15.78	19.26	21.75	2.2	18.4
$CO_2\text{ }^{\circ}/\circ$	50.00	59.24	44.97	52.00	48.25	37.5	30.0
$H_2\text{ }^{\circ}/\circ$	25.14	7.94	25.49	27.02	28.03	54.4	49.0
$N_2\text{ }^{\circ}/\circ$	0.72	6.50	13.76	1.72	1.97	5.9	2.6

It appears from this table that a slight change in the composition of the gas took place between 1845 and 1871, the amount of hydrogen becoming a little greater. This change seems to have developed along the same lines with surprising rapidity during the years 1871 and 1906. My gas samples from Námafjall show the greatest amount of hydrogen that has been found in gases evolved by the hot springs of Iceland. As already emphasized, one must exercise great care in drawing conclusions from changes in the composition of the spring gases, but as the mud pools at Námafjall are grouped together within three well-defined areas, one of which it is not possible to approach, and the spring gases in each of these three groups of springs have in all essentials the same composition, we shall not be far wrong in assuming that the alterations in the composition of the spring gases, shown in the above table, correspond fairly well to the actual conditions.

Of course the few results given cannot help us to determine whether the alterations have taken place suddenly or as the result of a gradual process.

Assuming that BUNSEN's theory regarding the process of the formation of hydrogen and sulphuretted hydrogen in the springs is correct, CHRISTENSEN¹ expresses his opinion that the increase of hydrogen must be regarded as a sign that the spring gases have been highly heated. If this be so, we must suppose that the terrestrial heat at Námafjall is on the increase. However, comparing my observations of the terrestrial heat at Námafjall with previous descriptions of the locality, I have been unable to find the least sign of such an increase in the thermal activity on the earth's surface.²

With regard to their composition, the spring gases from Kerlingarfjöll and Hengill most closely resemble the gases evolved by the hot springs at Mývatn, especially on account of the large quantities of hydrogen. The analyses of the gases from the hot springs at Kerlingarfjöll and Hengill harmonize very closely

¹ loc. cit. p. 242.

² I have since learnt that the inhabitants of the district at Mývatn are of the opinion that the thermal activity really is increasing.

with each other, having on an average a volume of about 71 % of carbon dioxide and 26 % of sulphuretted hydrogen plus hydrogen gas. One of the gas samples from Hengill has a slightly greater percentage of carbon dioxide but the spring from which this sample was taken differed in other respects also from the surrounding springs. The gas sample Krafla No. 2 is also consistent with spring gases of this type, and as one of CHRISTENSEN's gas samples is of a similar composition, one has reason to suppose that spring gases with about 71 % of carbon dioxide and about 26 % of sulphuretted hydrogen plus hydrogen gas, are common among the Icelandic solfataras and mud pools.

In spring gases of this type, the amount of sulphuretted hydrogen and of hydrogen gas, taken separately, may each vary considerably, but taken as a whole, the percentage of the volume of these two gases is fairly constant. In his remarks on the spring gases from Krafla, CHRISTENSEN mentions that an increase in the amount of sulphuretted hydrogen is attended by a decrease of the amount of hydrogen gas. It appears thererfore that the sulphuretted hydrogen and the hydrogen are closely related to each other in the spring gases. CHRISTENSEN is of the opinion that an easy explanation of this is found in BUNSEN's theory of the process of formation of hydrogen and sulphuretted hydrogen in the hot springs, viz. that the sulphuretted hydrogen originally formed disunites according to the formula $SH_2 = H_2 + S$. Thus, a molecule of hydrogen gas is formed by the decomposition of every molecule of sulphuretted hydrogen.

The hydrogen liberated by the decomposition of the sulphuretted hydrogen does not therefore combine with other substances. As the relation between the volume of the carbon dioxide and the sum of the volumes of hydrogen gas and sulphuretted hydrogen is practically constant in this kind of spring gases, it appears probable from the above that there is a certain connection between the carbon dioxide and the sulphuretted hydrogen before its dissociation.

Taking into account the laws of chemical equilibrium, we perceive that the cause of the relation which exists between the two gases is either that they are produced in the same place, and consequently under the same chemical and physical conditions, or else that the one gas has liberated the other by acting on its chemical compounds. For it is highly improbable that two gases produced independently in two different places should be found mixed in the same proportion in several separate localities. The possibility that sulphuretted hydrogen, more or less dissociated, should always liberate carbon dioxide in the same proportion to the sum of the volumes of hydrogen gas and sulphuretted hydrogen, can hardly be considered, as it does not harmonize with the laws of chemical equilibrium.

In my opinion, the foregoing experimental data seem to indicate that the three gases, carbon dioxide, hydrogen and sulphuretted hydrogen, are produced at the same time and by the same physical and chemical processes.

The conditions of the production of these gases must consequently be the same over vast stretches of Iceland. Most probably the source of gas evolution is

to be found in the flowing mass, the fluid lava or magma in the interior of the earth, the gas evolution being either the result of the action of the mass on the solid crust of the earth, or else being produced through the gases originally absorbed in the mass being released as the pressure lessens.

It is evident that when the conditions of the gas evolution are fixed, the gases evolved must have a fixed proportion to each other. At the moment of production, the carbon dioxide, the hydrogen and the sulphuretted hydrogen appear to be in the proportion 71 : 11.5 : 14.5. As these three gases are very liable to combine with other substances, it is not surprising that the proportion between them is not very constant at the earth's surface. Sulphuretted hydrogen particularly is a very unstable gas, and this is doubtless the reason why the volume of this gas is more liable to variation than that of the two other gases, (carbon dioxide and hydrogen).

In this class of spring gases carbon dioxide, hydrogen gas and sulphuretted hydrogen constitute nearly 97 % of the whole volume. Hence it follows that a decrease in one of these gases must be attended by a corresponding increase in the combined volume of the other two.

The remainder of the spring gas, amounting to 3 % of the entire volume, consists chiefly of nitrogen, and is undoubtedly mostly due to the intermixture of foreign gases of atmospheric origin. The real spring gases in the solfataras and similar hot springs, i. e. the spring gases of which the production is so closely connected with the thermal activity of these springs, are therefore almost exclusively composed of hydrogen gas, carbon dioxide and sulphuretted hydrogen, the remaining gases being treated as a negligible quantity, their percentage being so small. A rise in the percentage of one of these three gases is therefore not so much due to an absolute increase of the gas in question, as to a decrease in the other two gases on account of destruction and absorption.

The analyses of the spring gases from Kerlingarfjöll and Hengill show that these gases contain some traces of methane, and differ in this respect from the spring gases at Mývatn, which contain no hydrocarbon. The gas samples from Hveravellir, Grafarbakki, Laugarás and Reykjafoss also contain a little methane.

According to my analyses methane must be a rather common constituent of the Icelandic spring gases, although it is nowhere found in large quantities. This does not, however, agree with the results obtained by other analysts. BUNSEN in particular states emphatically that he has not been able to find hydrocarbon in any of the spring gases, although he considers that with his instruments he would have been able to detect even a tenth per cent of methane, had it been in any of the samples. The apparatus I used for the analysis being provided with stop cocks, it was not absolutely impossible that the methane came from the grease used for lubricating. I therefore made, in the middle of my analysis work, some experiments with atmospheric air, treating it in the same way as the gas samples under investigation. But in this case no methane could be traced. Another proof experiment was carried out in the following manner. After having proved that a

gas sample from Laugarás only contained nitrogen, inert gases and methane, I mixed a known volume of the same gas sample with a little atmospheric air and a suitable amount of oxygen and hydrogen in chemically equivalent proportions and then exploded the gas mixture. A subsequent examination of the gas remaining from the explosion showed the same result as regards the methane. Immediately after this I treated an equal volume of atmospheric air in exactly the same manner, without detecting the slightest trace of methane. The view that the methane found in the spring gas samples is not entirely due to erroneous methods in the analysis work is further confirmed by the fact that the investigation of the gas samples containing methane was twice interrupted by the examination of the gas samples from Reykir. In these samples I could never find any traces of methane. The gas samples from the hot springs at Mývatn, on the other hand, were examined in the beginning of the analysis work. When one considers that several of the gas samples investigated were proved to contain no methane, it can hardly be contended that the methane found in the remaining samples is due to awkwardness in collecting the gas, or in fusing the collecting bottle.

On the other hand, the method I employed is under a disadvantage, as compared with that used by BUNSEN, in that the gas under investigation often comes into contact with organic substances, the indiarubber tubing, and the grease on the stop-cocks. It is therefore, in my opinion, more probable that where very small quantities of methane are found, — i. e. only a few thousandths of the entire volume of the gas examined, — it is on account of erroneous treatment of the gas sample, rather than that methane is really a constituent of the original spring gas. But where methane is found in larger quantities as, for instance, in the gas samples from Hveravellir, I consider it quite impossible that this should be due exclusively to errors in analysis. In these cases methane is really contained in the spring gases.

The existence of methane may be explained as follows. The spring water, or at least a part of it, comes from swampy ground, and it is a well-known fact that methane is produced in such places by fermentative processes in organic matter. In this way the water conveys the methane to the interior of the earth, where it is mingled with the other spring gases.

Three of the gas samples from Reykjafoss are, as regards their composition, most closely allied to the class of spring gases represented by the gas samples from Hengill, Kerlingarfjöll and Krafla. But this might have been expected, for the hot springs at Reykjafoss and Hengill may really be considered as one group of hot springs, which stretches from Reykjafoss right through to Hengill. The small quantity of nitrogen found in the spring gases from Reykjafoss indicates that they are only slightly mixed with atmospheric nitrogen and other gases of atmospheric origin. The amount of hydrogen gas and, to some extent, of sulphuretted hydrogen, is less than at Hengill, while the percentage of carbon

dioxide naturally becomes greater. This has probably some relation to the fact that the thermal activity at Reykjafoss is not so intense as at Hengill.

The gas sample Reykjafoss No. 1 is quite different to the three others, and shows clearly that the spring gas in question is mixed with atmospheric air. Calculating how much air is mingled with the original spring gas, we find that about $2\frac{1}{2}$ volumes of air are mixed with one volume of the original spring gas. In this calculation I have assumed that the spring gas has originally had the same composition as the three other gas samples from Reykjafoss, and also that no carbon dioxide has been lost by intermixture or on its way to the surface of the earth. One observes that the proportion between the nitrogen and the oxygen is very different from that in the atmosphere, in that the greater part of the oxygen in the spring gas has disappeared, i. e. entered into chemical combinations in the interior of the earth.

As the spring from which the gas sample Reykjafoss No. 1 comes is also a periodic alkaline spring, it is very probable that the intermixture of atmospheric air with the spring gases has some connection with the periodicity of the hot springs. The spring gases from Hveravellir supply evidence to confirm this. For one is doubtless quite safe in concluding that the oxygen and the comparatively large amount of nitrogen in these spring gases are of atmospheric origin, while the carbon dioxide and the small quantities of sulphuretted hydrogen and hydrogen gas may be regarded as remnants of the original spring gas, which has probably had a similar composition to the spring gases from Kerlingarfjöll and Hengill.

According to the analyses before us, the spring gases from Hveravellir may be divided into two groups.

One is represented by the two gas samples: Hveravellir Nos. 2 and 25, which come from hot springs apparently not periodic, situated in the north-west part of the spring district. The three other samples, i. e. Nos. 10, 27 and 16 belong to the second group, all coming from periodic springs.

These gas samples are distinguished from the two first mentioned by the great amount of nitrogen they contain in comparison with carbon dioxide and by a considerable quantity of oxygen. Taking it for granted that the oxygen and the nitrogen are of atmospheric origin, this shows that the spring gas in periodic springs has received a greater contribution of air than that in the non-periodic springs. The connection between the periodicity of the springs and the amount of atmospheric gases in the spring gas is here shown very clearly. It is most probable that the periodicity of the springs is a direct cause of the intermixture of air with spring gases.

The hot spring No. 12 at Hveravellir will perhaps be the means of throwing considerable light on this subject. When P. THORODDSEN visited Hveravellir in the summer of 1884, this spring was found to be periodic. In the summer of 1906 the basin was occasionally filled with tranquil water, but generally it was quite dry, and showed no signs of activity. As far as I know, this spring did not once spout

during our stay at Hveravellir. If this be so, the spring water must have found another outlet. The water standing in the old channel would then rise or sink according to the pressure prevailing in the water in the earth below. It is quite possible that similar channels are found in many places in the neighbourhood of the periodic springs, although they are not yet discovered, as the water in such channels does not necessarily reach up to the surface of the earth.

It is not difficult to perceive that a natural channel of a similar form to that shown in Fig. 15 may suffice to explain how the air is mixed with the spring gases, provided that the channel has suitable dimensions.

We may assume that the channel *b* is at the beginning entirely filled with water. When the pressure down in the earth is reduced, the water recedes down the channel, and as soon as the surface of the water has fallen as low as the bend, the atmospheric air, forcing its way through the water, enters the reservoir *B*, where it is stored up, and also in the upper part of the channel *c*. When the pressure below increases again, the water rises in the channels *b* and *c*, and expels the air from them; but the air remains in the reservoir *B*. By the subsequent reduction of the pressure in *d*, the air in *B* is forced down the channel *c* by the pressure of the water column in the channel *b*. Supposing *d* to be in communication with the channel of a geyser, the periodic variations of the pressure in the geyser channel will be sufficient to produce the required variations in the pressure in the channel *d*.

Inasmuch as channels similar to that shown in Fig. 15 are undoubtedly very common, especially in periodic springs, one can readily understand that when such a channel falls into inactivity on account of the spring water finding an outlet on a lower level, it is very likely that the vacant channel serves as a kind of pumping

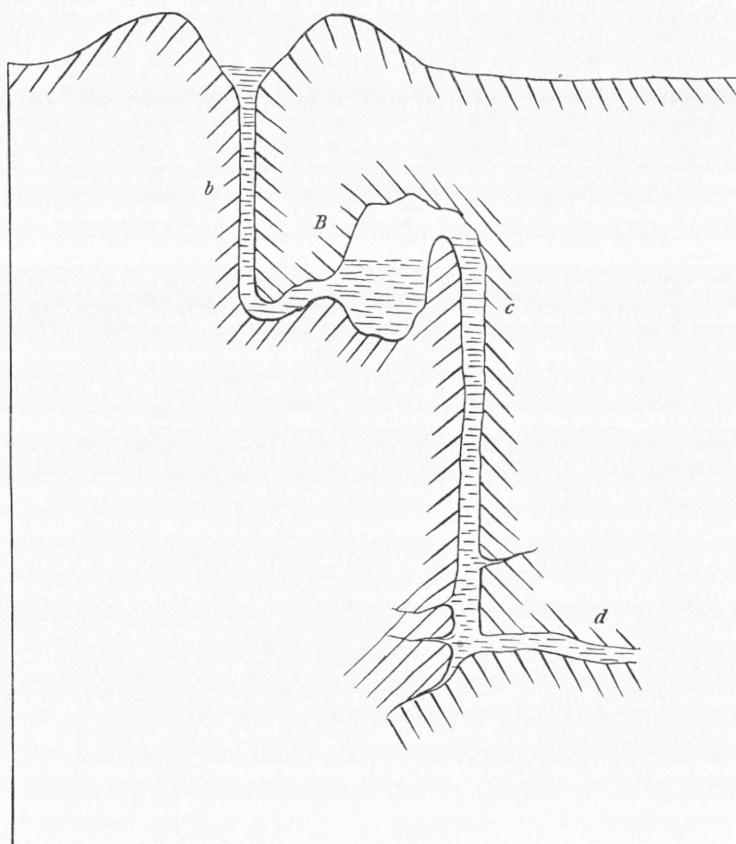


Fig. 15.

apparatus to pump the air down into the subterranean cavities, where it mixes with the original spring gases.

The air decomposes the sulphuretted hydrogen in the spring gases, and thus prevents the destructive effect of this gas on the rocks. In this way the intermixture of the air with the spring gases perhaps serves to uphold the periodicity of the springs. On the other hand, the oxygen will doubtless affect the solubility of the rocks in spring water containing carbonic acid. The characteristic deposits of silica at Hveravellir have possibly some connection with the comparatively large quantity of oxygen in the spring gases there.

I have assumed that the relatively large amount of nitrogen in the spring gases from Hveravellir and in Reykjafoss No. 1 is of atmospheric origin. I cannot, however, adduce direct proofs of this supposition, but it seems to me that the presence of nitrogen in the spring gases is readily and naturally explained in this manner; and the oxygen in the spring gases bears evidence to the same effect.

BUNSEN went still further.¹ It was his opinion that the nitrogen in the Icelandic spring gases was entirely of atmospheric origin. But when we take into consideration the fact that the spring gas at several places, (at Reykir, at Laugarás and, generally speaking, at Grafarbakki) consists solely of nitrogen, it is open to question whether all this nitrogen really originated from the atmosphere, and by what means the soil is enabled to retain the atmospheric oxygen so that not a trace of it is to be found in the spring gases.

Before my journey to Iceland, I did not know that such nitrous springs existed in that country.² However, I considered the question of the origin of nitrogen in the spring gases of so great importance, that I decided to make a closer investigation on the point. I thought that a determination of the proportions in which argon and nitrogen are found in the spring gases would most probably give a decisive answer to this question, because it was very improbable that these gases would combine with other substances. But Ramsay's³ investigations have since indicated the probability of argon being produced by radio active substances under certain conditions, and the determination of the proportion between argon and nitrogen in the spring gases can therefore only give reliable information concerning the origin of the nitrogen, in the event of the amount of argon being smaller, in comparison with the nitrogen, than in the atmosphere. In this case, however, it is most probable that some of the nitrogen is due to chemical processes down in the earth, for at present we know no instance of argon combining with other substances.

¹ Liebigs Ann. **62**, 5. 1847.

² I have since noticed that BUNSEN, (*Gasometrische Methoden*, 2. Aufl. 1877, p. 78), has made an analysis of an Icelandic spring gas which consists chiefly of nitrogen, (99·48 % nitrogen, 0·52 % hydrogen). As this spring gas is stated to have come from a small group of hot springs to the north of "Mælifell", it probably originates from the spring group "Reykir in Skagafjörður".

³ Nature. 1907. p. 269.

In the following table, the volume of the argon in some spring gases is referred to in the second column in the percentage of the entire volume of nitrogen plus argon. In the 3rd. and 4th. columns the percentage of helium plus neon is given respectively in proportion to the nitrogen plus argon and to the argon plus helium.

Table VI.

Gas sample	Argon, in percentage of Nitrogen + Argon	Helium, in percentage of Nitrogen + Argon	Helium, in percentage of Argon + Helium
Reykir No. 1	1·50 %	0·0132 %	0·88 %
Reykir No. 2	1·63 -	0·0140 -	0·87 -
Reykir No. 5	1·64 -	0·0146 -	0·97 -
Hveravellir No. 2 ...	1·75 -	0·0298 -	1·67 -
Hveravellir No. 25 ..	2·10 -	0·0302 -	1·42 -
Grafarbakki No. 1 ..	1·83 -	0·0114 -	0·62 -
Grafarbakki No. 2 ..	2·30 -	0·0110 -	0·48 -
Laugarás No. 1	1·94 -	0·0105 -	0·55 -
Laugarás No. 3	2·11 -	-	-
Reykjafoss No. 1 ...	1·96 -	0·0148 -	0·75 -
Hengill No. 1	0·63 -	0·0326 -	4·76 -
Hengill No. 3	2·21 -	0·0511 -	2·31 -

As could be expected, this table throws little light on the origin of nitrogen in the spring gases. The proportion $\frac{\text{volume of argon}}{\text{volume of nitrogen} + \text{argon}}$ is, as the table shows, with one exception always greater in the spring gases examined than in the atmosphere. The gas sample Hengill No. 1 proved to have only half as much argon in proportion to nitrogen as the atmosphere. From this fact one deduces that a great deal of the nitrogen in the hot spring in question originates from the soil, or from the seat of the thermal activity of the spring. Another gas sample from the same district, i. e. Hengill No. 3, shows, however, quite a different proportion between argon and nitrogen. But unfortunately this gas sample was mixed with the atmosphere. I corrected the final result by determining the amount of oxygen in the gas sample used in the investigation, and calculated from this how much atmospheric nitrogen and argon corresponded to the oxygen found. The volumes of nitrogen and argon thus calculated were then subtracted from those directly measured by the experiment, in order to find the volumes of argon and nitrogen originally in the spring gases. Of course all this tended to make the final determination of the volume of argon in this sample rather uncertain. I therefore attach less weight to this result, especially as it is not in harmony with the measurements of the gas sample Hengill No. 1, which are, in my opinion, quite trustworthy.

In other respects the measurements of argon and helium-neon show considerable harmony in gas samples from the same spring group, and this may be considered as a guarantee of the accuracy of the methods employed.

Table VI shows that the relation between the argon and the nitrogen contained in the spring gases is fairly constant in the samples from Reykir, Laugarás, Grafarbakki and Hveravellir, and in the sample Reykjafoss No. 1, being in each case a little greater than in the atmosphere.

I have already shown that it is probable that the nitrogen contained in the gas samples from Hveravellir and Reykjafoss No. 1 is of atmospheric origin; one is, therefore, well within the bounds of reason in concluding that in the spring gases from Reykir, Grafarbakki and Laugarás it is also of atmospheric origin. The surplus of argon in the spring gases may therefore be ascribed partly to the greater absorption of argon in water, and partly to the destruction of nitrogen in the soil.

The fluctuations in the amount of helium-neon in the spring gases are much less than I had expected. One can hardly form a true conception of the amount of helium in the spring gases from the table, for the proportion between the helium and neon varies considerably. For instance, the spectroscopic examination of the helium-neon mixtures from Reykir, Laugarás and Grafarbakki showed a fairly intense spectrum of neon as compared with the spectrum due to helium, while no lines due to neon were visible in the spectrum of Hengill No. 1. The fluctuations in the amount of helium are doubtless much greater, therefore, than Table VI shows. On the other hand the measurements do not indicate any parallel between the amount of radium emanation and helium.

I have also endeavoured to trace xenon and krypton in argon gas from the spring gases. For this purpose I used the same apparatus as for the separation of the helium-neon from the argon, but in this case I cooled the charcoal to -80°C . by means of liquid carbon dioxide. As VALENTINER and SCHMIDT¹ have shown, it is possible in this way to detect xenon and krypton in argon, the xenon and krypton being retained by the cold charcoal, while the argon is removed by means of the pump. As I expected to find only minute quantities of these gases, I mixed together all the argon that originated from the same spring group, before examining it. But I was unable to detect any trace of these rare gases. I then mixed the last distillates of the argon gases from Reykir, Laugarás and Grafarbakki, and examined this gas mixture in the above-described manner for xenon and krypton, but without success. If, therefore, the spring gases contain any xenon or krypton, it must be in very small quantities.

Thus the study of the rare inert gases has not given a decisive answer as to the origin of nitrogen in the Icelandic spring gases, but it is most probable that the nitrogen found in springs such as those at Reykir, Laugarás and Grafarbakki, which are rich in nitrogen, is chiefly of atmospheric origin; while the small quan-

¹ Ann. d. Phys. IV Folge. **18**, 187. 1905.

ties found in the solfataras at Hengill and Kerlingarfjöll are partly due to chemical processes in the interior of the earth.

The exhalations from Bjarnarflagshraun, (the lava field east of Mývatn), and the northern part of Kjalhraun, (south of Hveravellir), differ from those of the other hot springs in that they contain little or no radium emanation. The composition of the outflowing gases coincides closely with that of the atmosphere, so that there is no doubt whatever that it is atmospheric air that we have to deal with. Similar exhalations of warm, damp air are fairly common in the hot lava fields of Iceland.

In 1846 BUNSEN¹ collected some gases exhaling from the crater of Hecla and the surrounding lava, the latter having been produced by the eruption of 1845, and having not then become cold. These gases proved to be of similar composition to the atmosphere. JOHNSTRUP² collected a similar gas sample in some lava in Mývatnsöræfi, east of Mývatn, which had been ejected about a year previously. CHRISTENSEN³ also finds that the gases emanating from a fumarole at Krisuvik have the same composition as the atmosphere, and he explains the presence of air in these exhalations on the hypothesis that the steam, rushing out through the spring channel, sucks the air into the channel through the side walls. He considers the feasibility of this much increased by the fact that lava and other volcanic rocks are exceedingly porous. I think it more probable, however, that the atmospheric air and water are in such a case in actual circulation, similar to the circulation of water in hot water pipes. The air and the water ooze down, in cooler parts, through small channels and fissures in the soil. In the heated interior of the earth the air becomes hot and the water evaporates, and their density consequently decreases. They now rise again up to the earth's surface through channels which are kept hot by the current of hot air and steam.

A most interesting point in connection with these atmospheric exhalations is that they do not appear to come into contact with the real seat of thermal activity, for this would at once be marked by a change in the composition of the spring gases. The heat energy necessary to maintain these exhalations must be conveyed to them in a special manner. The exhalations studied by BUNSEN and JOHNSTRUP, from Hecla and Mývatnsöræfi respectively, provide a ready explanation of the heat energy. The lava from recent eruptions had not become cold throughout, and although the surface was cold, there was sufficient heat in its depths to produce the circulation of air and water as above described. The same explanation is not, however, applicable to the exhalations we investigated from Bjarnarflagshraun and Kjalhraun. Bjarnarflagshraun was formed by the volcanic eruptions which took place during the years 1724—1729, and is thus about 180 years old. Kjalhraun is, however, older than the settlement of Iceland, i. e. at least 1100 years old. These stretches of lava would doubtless therefore have become cold throughout, if

¹ Pogg. Ann. **83**, 242. 1851.

² Festschrift, p. 180; or Tidsskrift for Physik og Chemie, **10**, 232. 1889.

³ loc. cit. p. 233.

particular causes had not been at work to keep the bulk of the lava hot. Bearing in mind that there are hot springs in the immediate neighbourhood of the atmospheric exhalations both in Bjarnarflagshraun and in Kjalhraun, it is very probable that the high temperature of the lava is maintained by heat conduction from hot springs beneath the lava. They have not been able to break through the hard crust at the bottom of the lava, but have been compelled to find an outlet at the edge of the lava field. The atmospheric exhalations may therefore be correctly characterized as secondary hot springs, as distinct from the real hot springs, in that they derive their heat energy from the latter.

The exhalations from the above-mentioned secondary hot springs contained very little radio active emanation. It was therefore out of the question to determine the character of the emanation. But the ionizing effect of the radio active emanations from the other hot springs was so great as to render this possible. As to the methods employed, I refer to page 35. The investigations showed that the ionisation in the ionisation chamber increased immediately after the introduction of the spring gases, in such a way as might be expected if the gases contained no other emanations than radium emanation.

The coefficient of transformation calculated from the experiment, and referred to in Table I under the head of α' is of the same magnitude as the coefficient of transformation for radium emanation (2.16×10^{-6}) found by Rutherford. The divergences seldom exceeded probable experimental errors, the latter of course being rather great owing to the difficult conditions under which the experiments were carried out.

Taken as a whole, the divergences of α' for spring gases from the same group appear to be to some extent of a systematic nature, in that α' for the same group is generally either too great or too small. But bearing in mind that the ionisation in the ionisation chamber apparently made the same progress whether the spring gas was examined immediately after the gas was collected, or after it had stood three or four days in the collecting bottles before it was investigated for radioactivity, it seems rather improbable that these small divergences, even though they are systematic, should be due to different radio active emanations. They are more

likely to be due to small systematic errors in the treatment and investigation of the gases. The Icelandic spring gases may therefore for the present be regarded as not containing any slowly decaying radio active emanation except radium emanation.

Rapidly changing radio active emanations such as, for instance, thorium and actinium emanation, cannot of course be examined in the same way. I therefore endeavoured to examine them in the following manner.

The spring gases were conducted from the collecting funnel, which was placed in the spring, through the tube *a* (Fig. 16) into the tin vessel *B*. From *B* the spring gases were passed

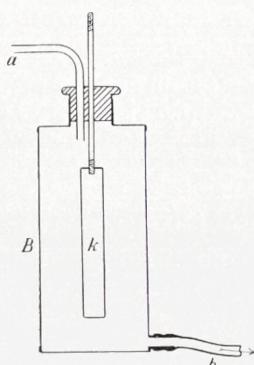


Fig. 16.

through the tube *b*, about 1 m. in length, out into the atmosphere. The cylinder *k* is, as the illustration shows, placed in the middle of the vessel *B*. The whole was arranged so that the gases evolved by the spring were spontaneously and without supervision passed through the vessel in the manner described. The apparatus thus arranged was left untouched for about 12 hours, when the cylinder *k* was brought to the tent, where its ionizing effect was measured in the ionisation chamber. The rate of decay of the induced activity was then investigated.

In these experiments the induced activity due to Ra-emanation was so predominant, that I was not able in the time at my disposal, and with the apparatus I used, to decide with certainty whether other kinds of emanation might not be present in the spring gases.

If, therefore, the Icelandic spring gases contain thorium emanation or other similar rapidly decaying emanations, they must be present only in very small quantities in comparison with the radium emanation. In support of this view, I will mention that we were unable to trace radio active substances in the sediments or mud of any of the springs. For if the spring gases contained a large amount of rapidly decaying emanations, one would reasonably expect to find in the spring water the radio active substances responsible for these emanations, and therefore also in the sediments and mud of the springs, and it is hardly possible that we should have failed to detect them.

The amount of radium emanation in the spring gases varied greatly in the different groups of springs. The greatest amount of emanation in the gas samples from Kerlingarfjöll, was about 43 times as large as in one of the gas samples at Reykir, although the secondary exhalations from the lava fields of Bjarnarflagshraun and Kjalhraun gave quite an insignificant amount of emanation compared with the above-mentioned gas samples from Reykir.

In springs belonging to the same group one also meets with considerable variations in the amount of emanation, but these variations are, however, much less than those between one spring group and another. We observe particularly that when the springs in a group are similar in other respects, the variations in emanation are also comparatively small. When, therefore, BOLTWOOD¹ on the occasion of his investigations of some hot springs in America states that the amount of emanation in a spring cannot be deduced from the emanation in a neighbouring spring, this only holds good, in the case of many Icelandic spring groups, with regard to the smaller variations. As a rule, the amount of emanation in the springs of a group is known approximately when one has determined the amount of emanation in one of the springs.

On the other hand, in the case of springs in the same group belonging to different types, the variations in the emanation may be comparatively large. This is the case with the hot springs at Hveravellir and at Reykjafoss. Acetous, sul-

¹ Americ. Journ. Sc. **20**, 128. 1905.

phurous springs and alkaline springs containing free oxygen are found at each of these places.

The measurements of the emanation in the spring gases apparently contribute very little to an elucidation of the nature of the hot springs. The comparatively large variations in the emanations indicate that the emanation is affected by several factors which have little importance in connection with other properties of the springs. In this regard it is certainly very important to note that the emanation is distinguished from the other gases evolved by the springs, on account of its gradual decay. In two spring gases, originally of the same composition and undergoing similar treatment on their way to the earth's surface, there will be less emanation in that which has been longer on the way, owing to the decay of the emanation. This latter factor will therefore doubtless contribute to increase the difference between the amounts of emanation contained in the gases.

The emanation in springs situated on the same fissure in the earth's crust often increases the nearer one comes to one end of the fissure. This is the case with the three hot springs at Reykir, (Reykir Nos. 1, 2 and 3), the springs at Grarfakki and those at Hengill. At the first-named place the springs with the greatest emanation are situated at the south end of the fissure, and in the two other places at the north-east and north ends respectively. The decay of the emanation will possibly account for this, as the spring gases take less time to reach the surface at the end of the fissure where the emanation is greater. This may either be because the subterranean seat of the spring is nearer this end of the fissure, or because the gases, for some unknown reasons, pass more rapidly through the subterranean channels. The great variation in the amount of emanation from the alkaline springs at Hveravellir is probably to a great extent due to similar causes, in that the spring gases often stand for a considerable time in the subterranean cavities which, according to the geyser theory I have advanced, are to be found in this locality. The fact that the whole of the emanation does not come from the subterranean seat of the spring would have considerable bearing on the variations in the amounts of emanation. A considerable part of the emanation from the springs is often due to radium contained in the superficial strata. The atmospheric water, sinking through the ground, receives a great deal of the emanation produced in these strata, and conveys it to the spring channel. A comparison of the radio activity of the alkaline and acetous springs at Reykjafoss and at Hveravellir seems to confirm this. The acetous springs at these places are in my opinion more closely connected with the real subterranean seat of these spring groups than the alkaline springs, which contain gases of atmospheric origin and consequently also atmospheric water in considerable quantities. But the alkaline springs are nevertheless often more radio active than the acetous springs, which is certainly to be regarded as a proof that atmospheric water and air supply the springs with radium emanation from the strata the water has passed through. It is possible that this could be demonstrated experimentally, for there is good reason to suppose

that, provided the water which rushes into the upper part of the spring channel carries with it an appreciable amount of emanation, a parallel could be shown between the quantity of emanation and the amount of water in the springs. An exhaustive investigation of the amount of water and of the emanation would therefore doubtless give a decisive answer to this question. On our journey, we were so much occupied with other investigations, that time did not permit of our measuring the volume of the water, but our observations on the spot indicate that an increase in the volume of water is generally attended by a corresponding increase in the radio activity. Mud pools with little water, as for instance those at Hveravellir and at Reykjafoss, often seemed to exhibit a surprisingly slight radio activity in comparison with the other springs of the same group.

Of course these experiments throw no light on the question as to what extent the radio activity of the springs is due to emanation conveyed by atmospheric water into the upper part of the channel. But there is no doubt that a great deal of the emanation in the springs must come with the other exhalations from the interior, where all the springs in the same group have a common channel, or perhaps even all the way from the seat of the heat energy of the springs, for otherwise it is difficult to understand why the amount of emanation in proportion to the other gases is usually of the same magnitude in the same group.

I have already shown, (page 63) that spring channels may often extend deep down into the earth before joining the main channel of the group. Even two springs situated side by side may have channels independent of each other deep down in the earth. But it is evident that the longer the individual channels are, and the deeper they extend down in the earth, the more probable it is that the decay of the emanation and the supply of fresh emanation from the side channels will cause the amounts of emanation from the two springs, originally equal, to be finally quite different. When, therefore, we find that the three springs Námafjall Nos. 1, 2 and 3 have practically an equal radio activity, it must undoubtedly be attributed to the group in question having a common channel which divides into three not far from the surface.

The same is probably the case with the two hot springs in Vestur-Hveradalir, i. e. Kerlingarfjöll Nos. 1 and 2.

Inasmuch as the Icelandic hot springs are all radio active, and as radium spontaneously produces heat, it seemed quite reasonable to conclude that the heat energy of the springs is due to radium. I therefore expected that my measurements of the radio activity of the hot springs would render valuable information on this point. But this has not been the case. There are no definite proofs that the heat energy of the springs is directly connected with their radio activity. The fact that the nitrous springs at Reykir are both colder and less radio active than similar springs at Laugarás and Grafarbakki, is probably due to other causes. And on the other hand, although they are apparently quite as vigorous, the hot springs at Hengill are less radio active than those at Hveravellir and Kerlingarfjöll.

The radio activity is therefore more likely to be dependent on other properties of the springs, and curiously enough, it seems to increase with the height of the springs above sea-level.

Again, if the heat energy of the springs is produced by radium accumulated around the subterranean seat of the springs, a greater amount of emanation would probably be found in the spring gases than is the case. Of course, the emanation takes a considerable time to pass through the channels of the spring from the interior of the earth up to the surface, so that it is difficult to calculate how great a fraction of the original emanation reaches the surface without being transformed.

The radio activity of the German and Austrian mineral springs¹ seems to be about the same as of the Icelandic springs. A few, for instance Grabenbächerquelle, which contains emanation amounting to 564×10^{-3} ESE = 267 per gram of uranium per second, are even more radio active than the Icelandic springs. This is generally the case in springs containing appreciable quantities of radioactive substances in the spring water or in the sediments. It does not, however, preclude the possibility of radium being an indirect cause of the thermal activity of the hot springs. STRUTT's² researches have rendered it probable that the internal heat of the earth is sustained by the radium contained in common rocks. It is true that no measurements have yet been made of the radium contained in the Icelandic rocks, but there is no reason to doubt that they are similar in this respect to the same sort of rocks in other lands.

We examined the water from two cold springs in the neighbourhood of Akureyri for radio activity. They turned out to be more radio active than the tap water in Copenhagen. This example shows that the superficial rocks of Iceland may contain radium, but our measurements of the emanation in the hot springs may also be considered as a proof of the presence of radium in the Icelandic rocks. I have already pointed out that the radium contained in the superficial rocks may have considerable bearing on the radio activity of the hot springs. But the radium in the lower strata has also considerable significance, in that some of the emanation evolved in these rocks is carried by water, steam and other spring exhalations to the main channel of the spring group. This has no little influence on the activity of all the springs in the group, for the average radio activity of a spring group depends on the amount of emanation supplied to the spring channel deep down in the earth where the springs of the group have all a common channel, or where the different spring channels are so near to each other that they are subject to the same influences. The emanation thus received by the channels originates chiefly in the surrounding rocks, which are of course very deep down, although some of it may be carried by the water all the way from the superficial strata.

¹ See, for instance, H. MACHE u. ST. MEYER: Phys. Zeitschr. **6**, 693. 1905; and H. W. SCHMIDT u. K. KURZ: Phys. Zeitschr. **7**, 209. 1906.

² Proc. Roy. Soc. **77**, 472. 1906.

When one considers that the supply of the emanation is thus evolved from rocks ranging over a large area, one can readily understand that the amount of emanation contained in the spring gases is not dependent solely on the amount of radium contained in the rocks, but also on the facility with which these rocks give off the emanation. As already mentioned, the decay of the emanation will also tend to increase the uncertainty of deducing from the emanation contained in the spring gases the amount of radium in the rocks, for it is difficult to say how much time has elapsed since the gases were in contact with the rocks producing the emanation.

A peculiarity of the hot springs is that they are generally found gathered in groups, being of course confined to fissures in the crust of the earth, (see p. 68). The reason for this is, that it is only where fissures are found in the crust that water can penetrate sufficiently deep down into the earth to become hot. In my opinion, one has no ground for expecting to find any special agents which produce the heat necessary for the thermal activity of the springs, inasmuch as this activity is undoubtedly occasioned by the fact that the heat present in the interior of the earth can be transmitted without difficulty to the earth's surface at the places where the hot springs are situated.

But the transmission of heat from the interior of the earth takes place almost exclusively by means of convection of hot water and steam through fissures in the crust of the earth.

It will readily be seen that, at the places where the thermal springs are, the earth must suffer an extraordinary loss of heat. An estimate of this loss of heat can be obtained by means of a simple calculation. The temperature gradient of the earth is generally estimated at 0.000304° per cm., and the earth's coefficient of heat conductivity at 0.0041. Hence we get the loss of heat through each square cm. of the earth's surface per second as 0.0000125 gram calories, or through a square km. 12500 gram calories. It is sufficiently accurate to reckon the mean temperature of Iceland at 0° C., and assuming that the thermal activity of the springs will raise the temperature of 1 litre of water to 100° C. in one second, the heat consumption amounts to 100000 gram calories, which, according to the above calculation, corresponds to the loss of heat from 8 square km. of the earth's surface. But in reality the loss of heat from the spring groups explored by us is undoubtedly much greater. For these spring groups deliver on an average more than 1 litre of water at 100° C. per second, and the spring water has already lost a great deal of its heat energy on its way up to the earth's surface, partly from heat conduction from the spring channel to the surroundings, and partly on account of evaporation. I presume therefore that the loss of heat on the part of the earth through the thermal activity of the springs is not exaggerated when we reckon it, at each of the spring groups we investigated, at from 5 to 10 times as great as calculated above, or as great as the loss of heat due to conduction from about 60 square km. of the earth's surface.

Apart from the possibility of the loss of heat occasioned by the thermal activity of the springs being compensated for by heat produced by special agents or reactions on the spot, such an extraordinary loss of heat within such a limited area must apparently lead to extraordinary temperature gradients in the surroundings, if the heat energy is only supplied by means of conduction. The consequent gradual cooling of the surrounding strata would probably, after a short time, be attended by a corresponding decline in the activity of the springs. In my opinion, however, the thermal activity of the springs does not decrease as rapidly as the above might lead one to expect, whence it follows that special causes must be present, and the prominent cause is that the heat supplied to the hot springs is chiefly by means of convection and not by conduction.

Sulphurous springs usually come into existence immediately after volcanic eruptions, and on this account it is probable that their channels extend deep down into the earth; I have already adduced reasons which seem to indicate that these springs are directly connected with the fluid interior of the earth (magma). In this case there seems to be no reason why the heat should not be transmitted by convection, by means of the spring exhalations coming from the fluid magma up to the surface. Through the circulation of the fluid magma, the loss of heat is distributed over a wide area.

In the secondary hot springs in the lava fields, the heat is conveyed by the exhalations from the bottom of the lava up to the surface. But from the fluid magma up to the bottom of the lava the heat is undoubtedly conveyed through the lower spring channels.

The nitrous hot springs apparently do not communicate directly with the fluid magma, for, as I have already pointed out, it is highly probable that the nitrogen and argon contained in their exhalations are of atmospheric origin. It is therefore obvious that they belong to a kind of secondary hot spring similar to the lava exhalations, only with this difference, that their channels go much deeper down than those of the lava exhalations. In both cases atmospheric water and air are caused to circulate in the channels by means of the heat energy supplied to the bottom of the channels. In the case of the nitrous springs it is not very likely that the heat energy is conveyed through other channels from the magma up to the actual spring channels. One has more reason for assuming that the channels of these springs go down so deep that the necessary heat energy is easily supplied to them by conduction from the lower strata of magma. It is not altogether impossible that these springs may to some extent communicate with the magma. The small quantities of sulphuretted hydrogen (and carbon dioxide) found in the spring gases from Laugarás and Grafarbakki might perhaps be looked upon as the last remnants of sulphurous exhalations from the interior of the earth.

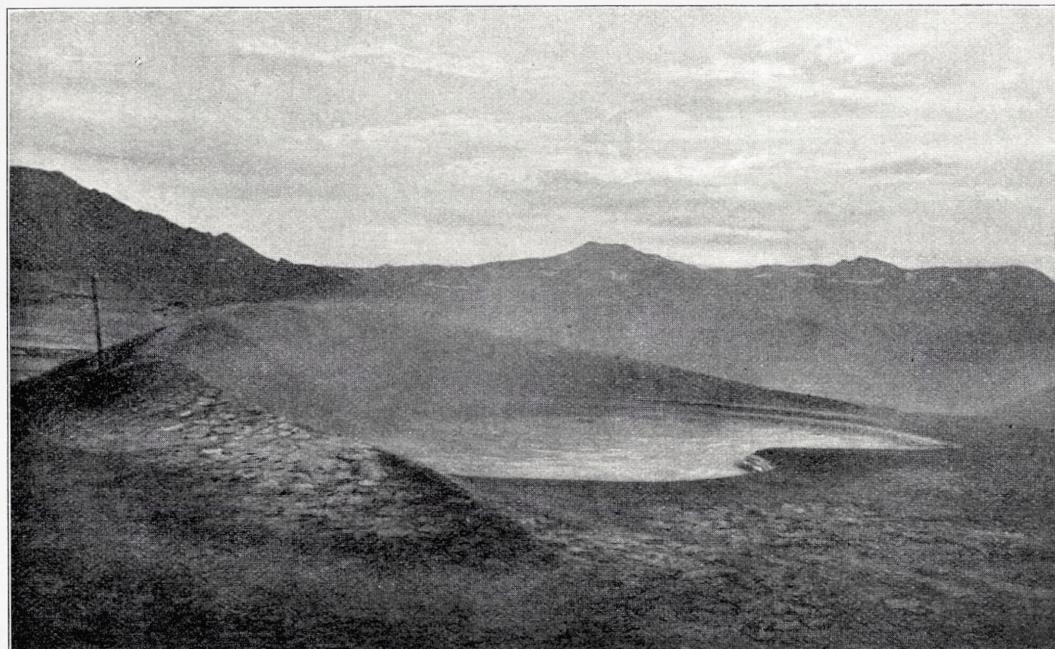
Corrigenda.

Page 18, line 31, for spouting-spring read spouting spring.

- 24, — 34, for is altered read is then altered.
 - 26, — 29, for ganged read gauged.
 - 30, — 11, for used by unit is read unit is used by.
 - 38, — 1, omit from.
 - 49. In Table I against Námafjall No. 1 in column H₂ 49,0 ‰ should be 54,4 ‰, and against Námafjall No. 4 in the same column should stand 49,0 ‰.
-



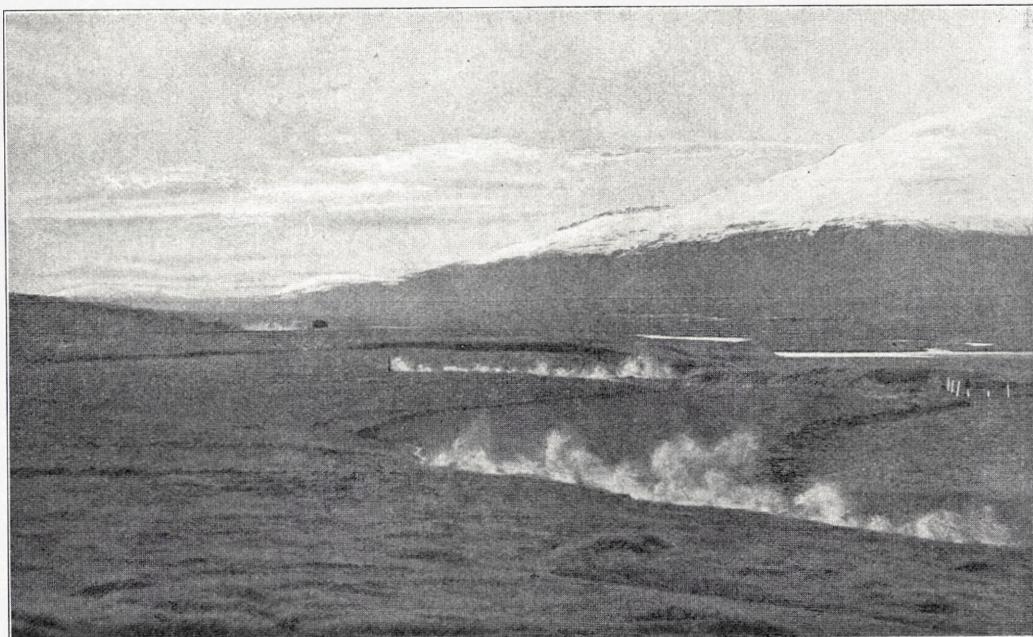
a. The twin lakes on the western slope of Krafla, looking north. The solfatara are seen in the light-coloured sections on the north-eastern slopes of the two lakes. A man is standing at the spot where the two lakes join.



b. The hot springs at Námafjall, looking north. Gas sample No. 1 originates from the slough seen in the foreground. The rod standing to the left of the slough is about 1 m. high. Krafla is seen in the background, near the centre.



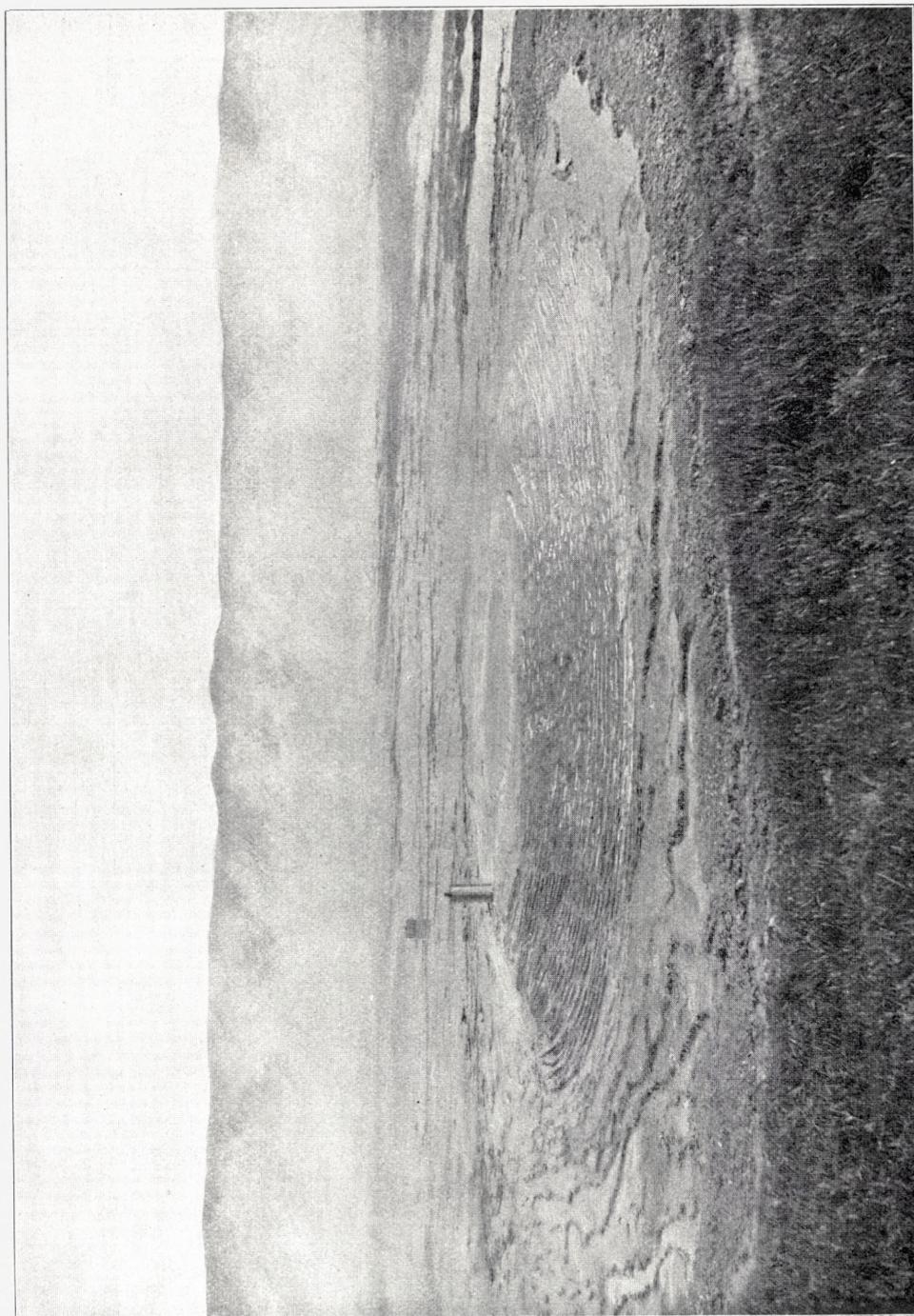
a. Bjarnarflagshraun and Jarðbaðshólar. The hill in the background (to the east), is Jarðbaðshólar. In the foreground (to the west), a small part of Bjarnarflagshraun with a row of three craters is seen.



b. Reykjalaugar. At the "Sundlaug", which is farthest away, a small black house is visible. A man is standing at the middle spring, Hornahver.



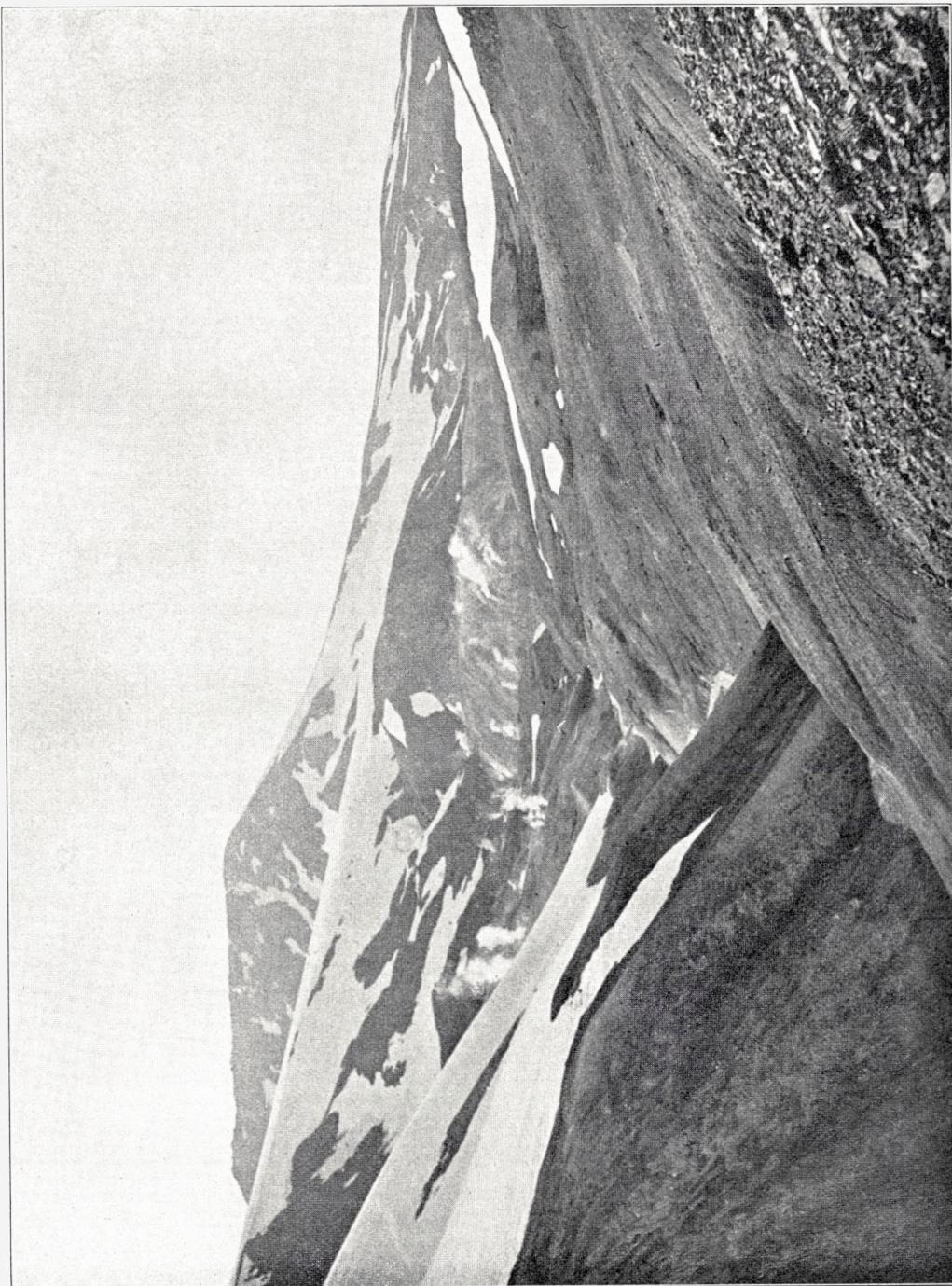
Hveravellir, looking east. The isolated spring to the right (south) is Öskurhöll. In the right background is the mountain Dútfell, and farther to the left is the glacier Hofsjökull.



Fagríhver. The tin standing on the brink of the spring is 20 cm. high.



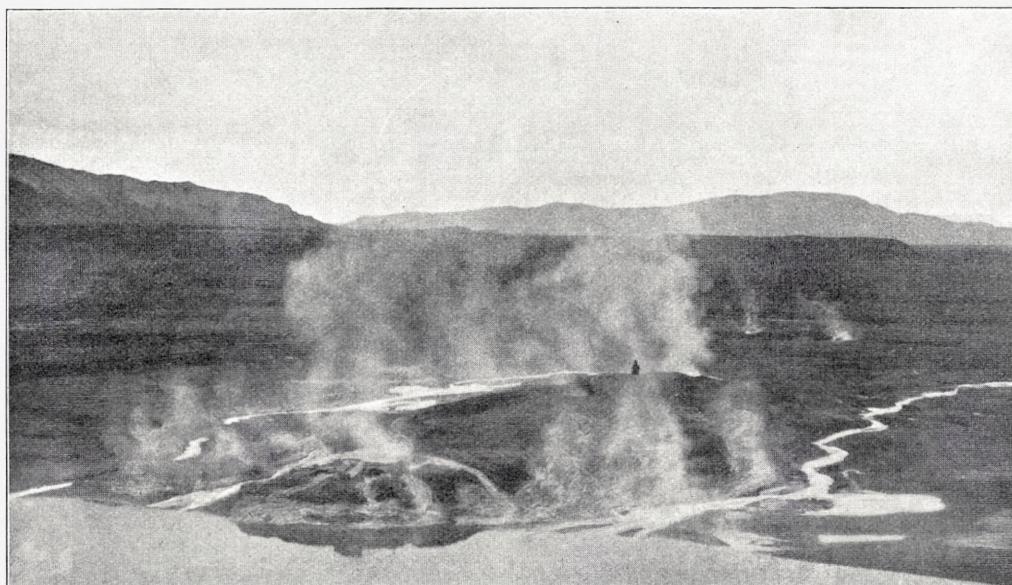
Vestur-Hveradalir, Kerlingarfjöll. The illustration shows two ravines in the western slope of the main valley. The two gas samples Kerlingarfjöll No. 1 og No. 2 were collected in the ravine to the left. There are several hot springs in this ravine, the mist produced by them almost hiding it from view. Higher up, the slope is covered with snow, which is in many places undermined by the action of the hot springs.



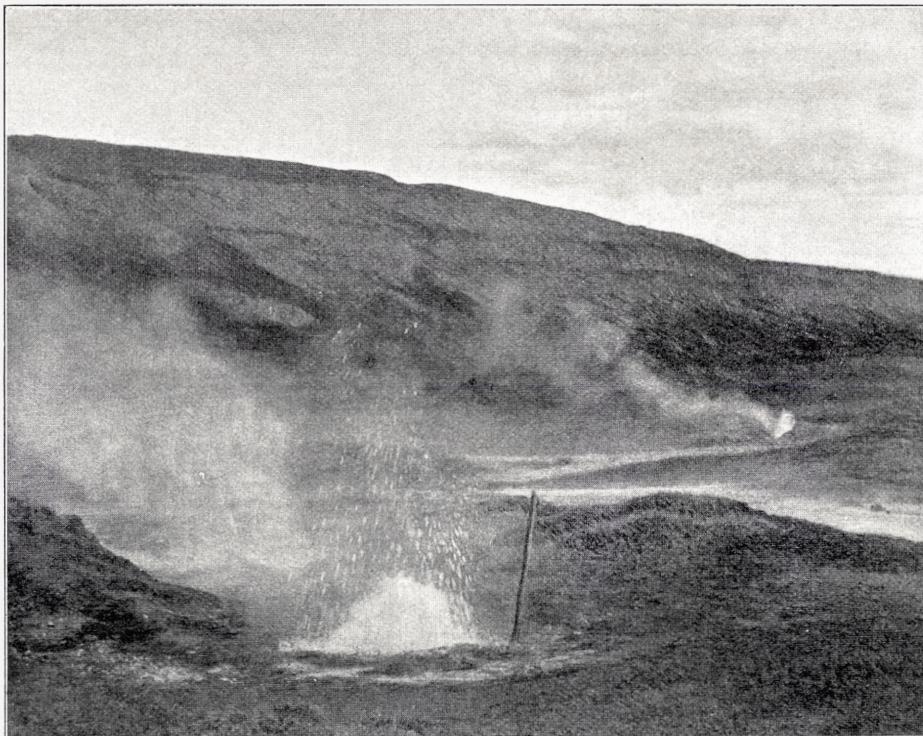
Mið-Hveradalir, Kerlingarfjöll. The photograph is taken from Austur-Hveradalir, looking west. The hot springs (in the centre of the illustration) are distinguished by the white columns of mist rising from them.



a. Austur-Hveradalir, Kerlingarfjöll, looking east. The steam from Öskrandi and another steam vent fills the valley with a thick mist. Most of the solfataras in Austur-Hveradalir are situated in ravines to the left (north) of the main valley shown in this illustration.



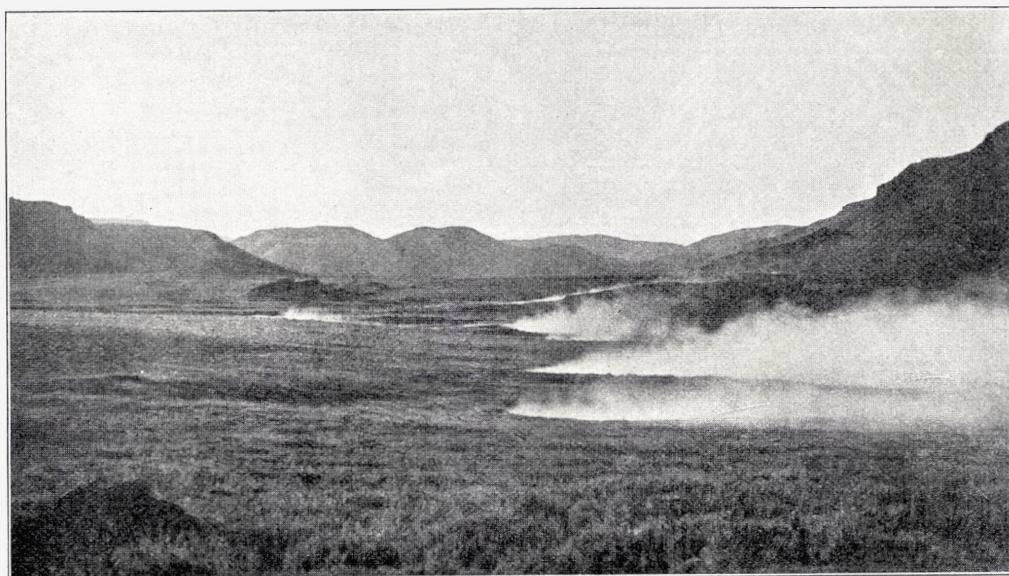
b. Grafarbakkahverir, with the river Litla Laxá in the foreground. Váðmálahver is nearest the river; the reflection of the little dome-shaped eminence around the spring may be seen in the sheet of water. A man is standing in the immediate neighbourhood of the larger geyser.



a. The geysers at Grafarbakki. The rod standing by the southern geyser is nearly 1 m. high.



b. Grýla, showing the steam period of the spring.



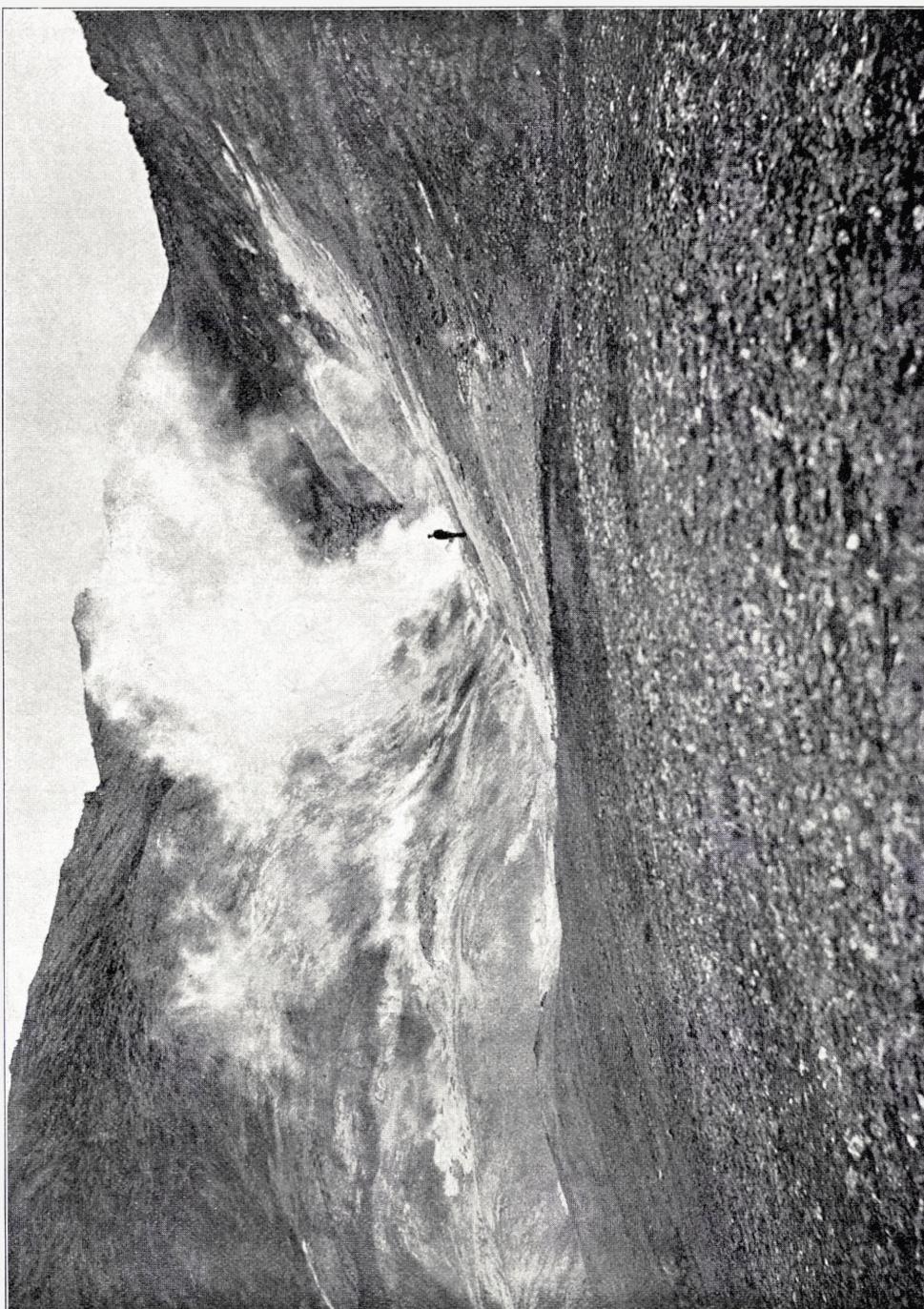
a. Hveragerði at Reykjafoss, looking north. Only the alkaline springs in the northern part of Hveragerði are visible.



b. A mud volcano at Hengill. The rod shown is about 1 m. high.



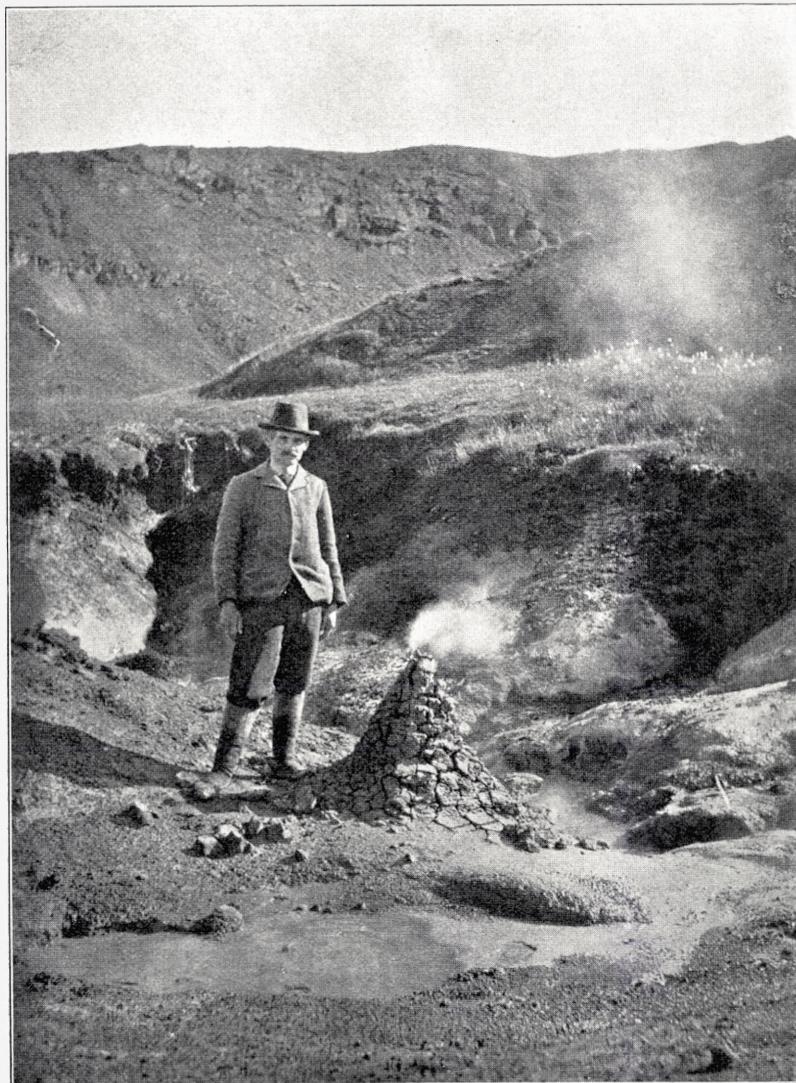
The eastern slope of the mountain Hengill, with two groups of hot springs. A man is standing on the ridge to the left (south) of the lower group.



A group of solfataras in a hollow on the eastern slope of Hengill.



A large isolated mud volcano at Hengill. The column of white mist in the background indicates a group of hot springs to the south-east of the mud volcano.



A fuming mud cone at Hengill. A traveller is standing to the left
of the spring.

ICHTHYOTOMICAL CONTRIBUTIONS

II. THE STRUCTURE OF THE *AULOSTOMIDÆ*, *SYNGNATHIDÆ* AND *SOLENOSTOMIDÆ*

BY

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D. KGL. DANSKE VIDENSK. SELSK. SKRIFTER, 7. RÆKKE, NATURVIDENSK. OG MATHEM. AFD. VIII. 5



KØBENHAVN

BIANCO LUNOS BOGTRYKKERI

1910

In the contribution published in 1908 (23 b) and in the present contribution I have endeavoured to give a fuller and more thorough account of the structure of the members of the old Cuvierian family "Bouches-en-flûte" and the old Cuvierian order "Lophobranchii" than it would be possible to gather from the previous literature; and in giving a broader base of facts than hitherto possessed, especially concerning their osteology, I hope to have settled the question, how far these forms are really related, and thus to have laid down a sound and reliable foundation for their future systematic arrangement. That previous knowledge of the structure of these fishes must be said to have been defective and that a thorough reexamination of their osteology was justified, is, I think, proved in the descriptive part of my papers and in the notes which I have added. The latter I have made so full and extensive, that any reader may be in the position to verify to what extent the descriptions given by me contain really new information, and to realize the confusion which on several points has been brought about, partly by defective observations, partly by ignoring facts already settled before.

The bulk of the present paper is merely descriptive; but in a concluding chapter I have set forth the systematic arrangement of the fishes under consideration which seems to me most in accord with the anatomical facts obtained.

Aulostomidae.

Aulostoma.

The following account is based on specimens of *Aulostoma coloratum* M. and Tr. As far as I have seen the other species *A. chinense* (L.) does not show any differences of importance.

Exoskeleton.

Aulostoma is covered with scales; only on the head (including the posttemporal), and on the anterior part of the back are scales wanting; through the naked skin of the back is seen, more or less distinctly, the sculptured surface of three longitudinal, median, bony nuchal shields. The scales embrace basally the anterior margins of the second dorsal fin and anal fin and cover part of the caudal fin. Most of the scales are ovoid, with truncate hind margin, along which is a single row of large teeth; the latter are independent structures, separated from the

scale-plate, dropping off when macerated. The largest scales are found along the sides of the body, above and below the lateral line; their number of teeth, in specimens of about 50 ctm. length, is 33—37. In each row the middle teeth are largest, the size evenly decreasing towards the margins. The lateral, smaller teeth show basally a small extension, which appears to vanish on the larger and older ones towards the middle. On a scale of about 3 mm. length one of the longest teeth measures 0,352 mm., one of the shortest 0,112 mm. In another specimen of ca. 40 ctm. length, one of the lateral body-scales carries 28 teeth, a scale from near the middle line of the back 14 teeth, and one from the caudal fin 7. In a young specimen of 110 mm. length, scales from the sides of the body show 7 teeth; the scale-plate is $0,336 \times 0,304$ mm., the middle tooth 0,096 mm. in length; a scale from the middle of the belly in front of the anus carries only 3 teeth, one median and two lateral; the scale itself is $0,282 \times 0,192$ mm., the median tooth 0,096 mm. The median tooth apparently is the oldest, and new teeth are formed in pairs, one on each side of the first etc. in a similar way as G. WINTHER (58) has shown the scale-teeth to originate in *Gobius*. It would be of some interest to have for examination still younger specimens which might decide if the development begins with a simple scale-plate without any teeth, on which, later, a single, median tooth, appears, next the first pair of lateral ones and so on; or if perhaps one single tooth is the first to be formed, the appearance of a scale-plate the next step etc. In the latter case some light might be thrown on the origin of the dermal asperities found in two species of *Fistularia*; but it has to be remembered that in the latter genus the small hooklets or denticles form one piece with their basal enlargement (cfr. below).

The large scale-plates of *Aulostoma* are provided with a great number of concentric striæ, parallel to the margin; the number seems to be about double that of teeth present; in the small scales of young specimens only 2—3 striæ are found running along each margin¹.

The canal of the lateral line is not inclosed in the scales, but in a system of free, thin, bony tubes; these tubes are uncovered by scales from the postfrontal to about the level of the posterior margin of the ventral fins; from here and further backwards the tubes are sunk between the scales and more or less covered by these, but the tubes will never be found combined or coalesced with the scales.

Immediately below the skin, in the most superficial part of the muscles, is found a most richly developed system of long, narrow and flat ossifications, probably formed in the outermost layer of the intermuscular ligaments. Corresponding to the arrangement of the lateral muscles these ossifications appear in a double row on each side above the lateral line, from the head to the tail; below the lateral line the trunk shows two double series, the tail only one, as dorsally to the lateral line. In each double row the upper and lower members converge towards the tail, meeting at a very acute angle. In the dorsal row the upper anterior member is by far the largest, very much surpassing in size any of the others; it

is fastened by ligament to the epiotic of the skull and reaches backwards about as far as the anterior coalesced part of the vertebræ. Its upper surface is flat, and more or less observable through the skin, laterally to the median nuchal shields; the lower surface carries a thin vertical lamella, originating from its posterior half, to enlarge the face of muscular attachment. Much smaller, but still of considerable size, is the anterior member of the uppermost ventral row; it is in front connected by ligament with another separate ossification, which, passing over the branch given off from the posttemporal to the first vertebra, is fastened to the pterotic of the skull; thus it is from the outside covered by the posttemporal. The "inscription" itself lies below the plate representing the coalesced transverse processes of the anterior vertebræ and dissolves behind into a bundle of long fibres. Generally the anterior members of the whole system of "inscriptio[n]es tendineæ" are the stoutest. Into the lowermost ventral double row project parts of the endoskeleton, viz. the posterior ends of the postclavicle and the coracoid; while the former bone ends as a needle, the latter forms a bundle of threads. In a similar way most of the ossified tendons, or "inscriptio[n]es", are split up at both ends — more or less irregularly dichotomously².

Endoskeleton.

The vertebral column consists of 60 vertebræ, 24 (25) abdominal and 36 (35) caudal. The four anterior abdominal vertebræ (Pl. I, figs. 9, 10, Pl. II, fig. 10) are elongated and coalesced into one piece; but distinct sutures show the composition of originally separate elements. This part takes up about one-fifth of the whole length of the vertebral column. Seen from below (Pl. I, fig. 9) the corpora do not show much of the usual type; only the posterior one is more like a normal vertebral body, otherwise the combined neural arches and the coalesced transverse processes constitute the dominant part of the whole. The spinous processes form one vertical crest (Pl. I, fig. 10), the combined transverse processes a similar one on each side, sloping somewhat downwards and narrowing posteriorly. The single elements are immovably joined through sutures.

Closer examination of the lower surface will show that the bodies of the second and third vertebra are longer, the first and especially the fourth shorter; (in a specimen, where the whole coalesced part is 61 mm. in length, the first body is 14 mm., the second 17 mm., the third 18, and the fourth 12 mm.). The front end of the first corpus has partly preserved the usual type, but the posterior part, behind the openings for spinal nerves and blood vessels (n), is elongated and modified; the two following have both their ends elongated and modified to about the same extent, as will be evident on looking at the position of the nerve-openings; of the last vertebra only the anterior part is elongated and modified: here the nerve-openings n are found at the posterior end, and the posterior part of the transverse process appears separated as an independent process, as is the case with the following free abdominal vertebræ. The transverse processes on the second

and third vertebræ possess an elongated part, directed forwards (Pl. I, fig. 10); that of the second vertebra projects a little (Pl. I, fig. 9, 10*) and is connected by a strong ligament with the posterior end of the posttemporal.

On examining the lateral aspect of the coalesced vertebræ (Pl. I, fig. 10, Pl. II, fig. 10) we find the sutures partially repeating the features characteristic of the following free vertebræ: in the small bend (a) looking forwards we recognize the part lettered in the same way on the following free vertebræ (Pl. II, fig. 10) and on the front end of the first of the fused vertebræ; further, the process (b) of the latter, which is connected with the skull, will be found to correspond with the process (b) on the free vertebræ, that is to say, it must be regarded as an articular process, not as a transverse one, and the first vertebra has thus only developed the posterior part of the transverse process (t).

The nerve-openings observable in side view (n') are in a position about corresponding to that of the ventral ones (n, Pl. I, fig. 9).

All the following, free, abdominal vertebræ possess double transverse processes (Pl. II, fig. 10), i. e. there is an anterior and a posterior process on each side (or it may be put in this way: there is one transverse process of the same length as the whole vertebra but divided through a deep incision into an anterior and a posterior part). A posterior process on one vertebra joins with its hind margin the front margin of the anterior process on the following vertebra etc.; the two adjoining processes, belonging to two different vertebræ, are almost of the same length on the foremost vertebræ; but about from the 17th vertebra the posterior element (i. e. the anterior process of the 17th vertebra) grows a little longer than its fellow (the posterior process of No. 16), and on the 20th—24th vertebræ the difference is still more marked. On the foremost vertebræ these “double processes” are nearly horizontal and directed straight outwards but farther back they gradually pass into a position directed downwards and a little backwards, still, on the 24th vertebra (sometimes on the 25th) the long anterior transverse process does not unite with its fellow from the opposite side; but on the next the anterior processes join from opposite sides and form an inferior arch, terminating in a long, backwards directed, lower spine. This vertebra (No. 25 or 26) I therefore count as the first caudal vertebra. On the preceding, the last abdominal, vertebra the posterior transverse process is already much shortened, on the first caudal it is very small, and on the following it gradually vanishes.

The spinous processes originate from the posterior part of the neural arches. On most of the abdominal vertebræ they are only low, and laterally compressed; from about the 17th they rise somewhat and from the 20—21st they grow long and slender as in most bony fishes. The anterior part of the neural arch is shaped like a rather large, rounded process, which, together with its fellow from the opposite side, embraces the base of the preceding spinous process; this part is larger on the foremost vertebræ, and diminishes gradually backwards. Below this part is found the proper articulation, formed by a triangular pit into which fits a small process from the preceding neural arch.

Ribs are wanting.

Interspinous bones are developed not only in connection with the dorsal and anal fin rays, but in front of the dorsal fin a row of 9 or 10 rayless interneurals is found, beginning immediately behind the skull. The three foremost of the latter (Pl. II, fig. 10, 1—3) are more or less distinctly seen through the skin, which is here naked as already mentioned above, but the following 6 or 7 are hidden below the scales. They all consist of a horizontal part, lying below the skin in the shape of a longitudinal shield or plate, and a vertical part; they correspond in position to the anterior 9—10 vertebrae, their vertical part being really interposed in front of the spinous processes of the latter. This fact is less evident in the case of the four elongated and fused vertebrae, but very easily seen in the following free vertebrae. The modified interspinous bones form a continuous row, in which not only the horizontal shields are joined (through sutures) but also the vertical parts. The anterior three* are much larger than the rest, which decrease evenly in size backwards, especially with regard to their shield-parts. The upper face of the latter is sculptured with quite regular longitudinal striae on the 3 anterior ones; feeble traces are seen on the fourth and still some faint and indistinct remnants may be observed on the following one or two. From the hind margin of the second passes out on each side a long, flat and slender splint of bone, looking like an ossified tendon fused to the shield; similar, but much shorter ones proceed from the posterior margin of the following shields, except the last, and are concealed below the plate of the next shield, while the long "cornua" from the second nuchal shield diverge among the muscles.

The vertical part (the main part or stem of the typical interspinous bone) is elongated longitudinally according as the upper edge is modified into a shield; it is most elongated and at the same time lowest in the 3 foremost interneurals (the "nuchal shields"), increasing in height backwards with decreasing length; its lower margin is cleft, thus embracing the crest formed by the fused arches and spinous processes. The foremost as well as the fourth to the tenth interneurals show most distinctly that the position is originally in front of the corresponding spinous processes as is usually the case in fishes. The foremost is connected with the supraoccipital by ligament. Immediately behind the row of rayless interneurals appear those supporting the (9—)10 isolated rays, which together constitute the first dorsal fin; each ray of the latter is a spine having a small separate fin-membrane. These interneurals are considerably smaller than the preceding and of a different shape (Pl. II, fig. 10, 10—16); they do not form a closed row nor do they reach to their corresponding vertebrae. The foremost corresponds to the 11th (or 10th) vertebra, between each of the following is an interspace with one or two spinous processes.

* Only these three "shields" have been mentioned previously. GÜNTHER (16a p. 537) says: "A long narrow bony shield, half as long as the snout, is joined to the occiput and extends along the neck." But l. c. p. 538 he says (*A. chinense*): "the three single plates of which the nuchal shield is composed are more distinct."

Like the preceding modified interneurals they all consist of only one single piece (are "unisegmented"); in position they are about horizontal. The interneurals supporting the second dorsal fin number 26 or 27; except the foremost and hindmost they are "bisegmented", a small ossicle (with a median cartilaginous centre) occupying the cleft base of each ray and connecting through cartilage with the main part or stem. The foremost interspinous bone is small and rayless, the next two support quite rudimentary rays. The two anterior are together interposed between two spinous processes (of the 34th and 35th or 35th and 36th vertebrae), but only the second almost reaches the spine; the following ones are interposed singly or in pairs (somewhat irregularly); from the sixth they reach almost to the base of the neural arch, from the twelfth almost to the corpus; the hindmost again are shorter.

The anal fin is supported by 26 interspinous bones, likewise bisegmented. The anterior bones slope forwards, the foremost is about horizontal in position; the fourth reaches the spinous process of the 35th (or 36th) vertebra, lying close behind the tip of its inferior spine³.

The fin-rays of the unpaired fins. The isolated dorsal rays are spines (Pl. II, fig. 10, s), made up of one piece, without any joints; they are rather blunt, flat and somewhat weak, basally with a transversely rounded head, articulating with a transverse pit in the interneural⁴.

The four anterior rays of the second dorsal are also pointed, unjointed like spines; the foremost two are rudimentary and both supported by the second interneural. The following rays are longitudinally cleft and jointed, but not branched distally.

Of the anal fin (29 rays) the 4 anterior similarly are short, spine-like, the rest like those of the second dorsal.

The caudal fin has 20 rays: $3 + 7 + 7 + 3$; the three upper and lower rays short, pointed and without joints, the rest jointed; No. 5 to No. 15 are distally branched.

Closer examination of the skeleton of the end of the tail shows that two separate bones are interposed, like interneurals, above between the last vertebra and the last but one, and in a similar way also two bones below; but of the two lower the hindmost seems to be fused with the lower hypural bone of the last vertebra. The rays are arranged in the following way: the foremost short ray is interposed between the spinous processes of the third and second last vertebra; the two following short rays and the first upper jointed ray are supported by the "interposed" bones; the upper hypural bone carries 6 rays, the lower 5 or 6; of the rest of the lower rays, two jointed and two unjointed are supported by the lower "interposed" bones, the anterior short ray is correspondingly situated to the anterior upper one. As mentioned above only the rays 5–15, i. e. those supported by the hypural bones, are distally branched; of these the two middle ones — one from each hypural — are somewhat longer than the rest, causing the rhomboid outline of the caudal fin (probably homologous to the caudal filament in *Fistularia*).

Cranial skeleton. The head (Pl. I, fig. 4) is laterally compressed, its facial part, in front of the orbit, much elongated, tubiform, with terminal mouth.

The skull (Pl. I, figs. 1—4) is rounded above, somewhat flattened between the orbits; the preorbital part is about three times as long as the rest, forming a slender beak with sharp edges, concave below, except at the anterior end, where the vomer projects into a blunt keel.

Viewed from above (Pl. I, fig. 2) by far the greater part of the beak will be found made up by the mesethmoid (mes). At the front end of the latter the palatines (pa) are seen, suturally united to the skull and meeting each other in the middle line; behind these, part of the vomer (vo) is seen on each side of the mesethmoid. Behind the mesethmoid are the frontals (fr), and, wedged in between the posterior part of these, the supraoccipital (so); on each side of the latter the epiotics (ep). Besides are seen the pterotics (sq), postfrontals (pf), alisphenoids (al), prefrontals (prf), and — below the nasal openings — the preorbitals (ao). Furthermore, the exoccipitals (eo) and the basioccipital with the large condyle are seen from above. As previously stated parietals and opisthotics are wanting.

The supraoccipital takes no share in the occipital foramen, the exoccipitals meeting above the latter. Behind, the supraoccipital is cleft and deepened into a triangular pit, filled out with the strong ligament which connects the skull with the first nuchal plate. Each epiotic is provided with a knob (*), close to the suture with the supraoccipital, for the attachment of the above-mentioned ossified tendons.

On each side of the beak a narrow furrow runs from the front margin of the nasal opening to the end of the snout; imbedded in this furrow is the continuation of the supraorbital canal for the lateral line. Immediately in front of the nasal opening the furrow encloses a small osseous tube (Pl. I, figs. 1, 4) (na), evidently a rudiment of the nasal bone; otherwise the walls of the whole canal are membranous from where it leaves the frontal at the posterior border of the nasal opening. The greater part of the furrow is lodged in the mesethmoid, only the anterior third part in the vomer.

On the lateral aspect of the brain-case the upper sculptured face overhangs the lower, smooth face with sharp edges, under which the two articular facets for the hyomandibular are found, the anterior made up by the postfrontal and the prootic, the posterior by the pterotic. Between the anterior facet and the opening for the 7th nerve the prootic is provided with a spine, pointing backwards. As already stated the large pterotic (sq) is interposed between the prootic and the exoccipital, reaching downwards to the parasphenoid and basioccipital. In the orbits the prootics from both sides meet each other with processes bridging over the excavated upper face of the parasphenoid; thus a kind of myodome is present. The upper lateral part of the bridge is formed by the adjoining alisphenoid (al); the latter bone is in a peculiar way (as far as I know quite unique among

teleosts) produced in front of the postfrontal, forming the inferior part of the postorbital process. I have not found any orbitosphenoid.

The basioccipital (ob) is laterally compressed, its occipital condyle broad, transversely ovoid, and convex. The parasphenoid (Pl. I, fig. 3) (pa) reaches far behind, where like the adjoining basioccipital it is compressed; between the prootics it broadens and in the orbits its upper margins send out a process in front of the opening for the 5th nerve in the prootics. The anterior part is situated between the prefrontals and its pointed front end stops on the mesethmoid without reaching the vomer, a peculiar feature also found in *Fistularia* and *Solenostomus*, but as far as I know in no other teleost. The greater part of the lower face of the beak belongs to the vomer (vo); the keelshaped front end of the latter carries a longitudinal strip of numerous small teeth.

Infraorbitals are wanting. The bone (ao) connecting the mesethmoid with the prefrontal I think represents the antorbital (preorbital), but it does not enclose any lateral line canal.

The opercular apparatus (Pl. I, fig. 4) shows the usual 3 elements; the interoperculum (io) is an elongated thin plate mostly covered by the preoperculum and reaching from the lower front end of the suboperculum to the mandibular articulation, connected with a short ligament to the angular.

The hyomandibular (hy) is obliquely directed forwards, its front face is concave, the inner margin of the concavity being somewhat produced, like a wing; the lower end is a thin cartilage connected with the proximal end of the symplectic (sy). The latter is extremely thin and so firmly joined with the preoperculum (pro), that it requires the utmost care to make out the boundaries; viewed from the inner face only the posterior end and the distal part are more easily seen, the preoperculum covering the rest so completely, that only an exceedingly narrow brim may be detected along the upper margin of the preoperculum; viewed from the outside (Pl. I, fig. 4) only the extreme proximal end is hidden by the preoperculum. The quadrate (qu) is very large, sculptured on part of the outer face with fine striæ radiating from the neighbourhood of the articular head for the mandible. The palatine (pa) is small, its anterior part, which sends out a prominent and relatively well developed maxillary process, meets its fellow from the other side at the front end of the mesethmoid (Pl. I, fig. 2); behind, the palatine bifurcates (Pl. I, fig. 1); the upper branch is wedged in between the mesethmoid and the vomer, the lower branch covers the pointed and slender anterior end of the entopterygoid (Pl. I, fig. 4) (ept). A separate ectopterygoid is wanting. Where this bone ought to be, the entopterygoid broadens into a plate firmly joining the oblique anterior margin of the quadrate. The rest of the entopterygoid is a thin plate the upper margin of which embraces the lateral edges of the cranial beak, formed by the vomer and the mesethmoid. Behind the entopterygoid follows the metapterygoid (mt), the narrow anterior part of which in the same manner embraces the edge of the mesethmoid, while the posterior broader part

has its somewhat thickened upper margin firmly fastened below the edge of the broadest proximal part of the mesethmoid, reaching with a slender splint to the preorbital.

On the inner face of the suspensory apparatus two oblique ovoid patches of teeth are present, the anterior one on the entopterygoid*, the posterior on the metapterygoid.

The short ascending part of the preoperculum covers not only most of the lateral face of the hyomandibular, but also the front face below the hyomandibular foramen; the long horizontal part is on the outer face ornamented with fine striæ and reaches almost to the articular head of the quadrate.

The premaxilla (Pl. I, fig. 4 i), which bounds the mouth slit, is slender and edentulous, provided with the typical processes, as also is the case with the relatively large, posteriorly broadening maxilla (mx).

The articulation for the lower jaw is situated at a distance rather far behind the end of the snout; the mandible therefore is fairly long, and the mouth opening is extensible to a considerable degree. The mandible is high and laterally compressed, composed of the typical three parts; the angular (an) is very small and therefore easily overlooked. Two patches of teeth are found on the dental, an anterior small one on the upper edge close to the symphysis, and a large posterior one covering the upper part of the inner face.

Branchial apparatus. The whole gill-bearing part lies behind the articulation of the hyoid to the skull. The hyoid (Pl. II, fig. 7, 8) is composed of the typical elements, but the epihyal (eh) and the lower hypohyal (hy^I) are unusually large in proportion to the other constituents. The stylohyal (st) is laterally compressed and broadens towards the upper end, the inner face of which plays against the thin cartilage interposed between the hyomandibular and the symplectic.

The branchiostegals are four in number, belonging to the outer face of the epihyal, the uppermost is the stoutest and longest, at its end divided into filaments. The glossohyal is long and slender, surpassing in length the hyoid and the urohyal, which is laterally compressed and higher behind, where it is broken up into filaments. The first copula (Pl. II, fig. 3 co^I) or basibranchial is represented by a short cartilage, the second (co^{II}) is slender, styliform and ossified; no further copulæ are developed.

The gill-arches (Pl. II, fig. 3, 4) are provided with rows of thin bony plates, densely beset with teeth, in the place of gill-rakers. Along the whole anterior border of the first arch plates of this kind are found, from the upper to the lower end, the first gill-slit being very wide; otherwise the plates are mostly confined to the margins of the ceratobranchials only, those on the anterior border always being somewhat larger. The first arch consists of three parts, having no pharyng-

* The anterior patch of teeth has been seen by GÜNTHER (16 a p. 536), but he ascribes it to the "palatine bones".

branchial; the second arch has all four parts developed, but the short and slender epibranchial (e^{II}) is widely separated from its ceratobranchial (c); it abuts against the hinder end of the flat pharyngobranchial (ph^{II}); the latter is on the pharyngial face beset with teeth, and reaches to the epibranchial of the first arch.

The third arch also has four parts; the hypobranchial (hy^{III}) has only a short cartilaginous part lying at the same level as that of the second arch, but a long, osseous process runs downwards, together with its fellow from the other side embracing the branchial artery; the epibranchial is still weaker than that of the preceding arch, almost rudimentary, and still farther away from the upper end of its ceratobranchial; its distal end articulates with both the third and fourth pharyngobranchial; the flat pharyngobranchial III is produced in front along that of the second arch; its under face carries an ovoid patch of teeth. The fourth arch consists only of two parts, the hypobranchial and epibranchial being absent; the pharyngobranchial IV is shorter than the preceding but like this provided with teeth. The fifth arch, as usually only one piece, carries the lower pharyngeal teeth, and on the anterior or outer border some tooth-plates along the hindmost gill-slit.

At the upper ends of all the ceratohyals the branchial lamellæ (Pl. II, fig. 4) are continued a short way upon the pharyngeal wall, supported by semicartilaginous strips of tissue, which appear as prolongations of the cartilage enclosed by the osseous sheaths of the ceratohyals.

Thus the branchial apparatus of *Aulostoma* foreshadows the condition found in the *Lophobranchii* as to the skeletal parts, in the fact, that the epibranchials II and III are reduced and separated from the rest of the arches, while the epibranchial IV is absent, and the basibranchials are reduced.

The shoulder-girdle (Pl. III, figs. 4, 5) has been so fully dealt with by STARKS (55 p. 629) that only some features have to be repeated here and a few new facts to be pointed out. The clavicular arch is composed of but two parts, the posttemporal and the clavicle, the supraclavicle being absent. The posttemporal is through ligament fastened to the somewhat serrated hind part of the pterotic (not also to the epiotic); its outer face lies in the skin and is sculptured; from the inner face, near the ventral margin, originates a flat branch, connected through ligament with the first vertebra; the posterior angle of the posttemporal further is bound by ligament to a blunt process on the transverse process of the second vertebra, and at the same time with the upper end of the clavicle. As is the case with all the members of the group treated here, the clavicle (cl) has a superficial sculptured plate, seen in the skin (Pl. III, fig. 4) and covering part of the fin-muscles. As in *Fistularia* the clavicle divides distally into two branches, the inner of which is united with the outer face of the scapular arch (Pl. III, fig. 4 i); but as the coracoid is produced forwards to unite also with the outer (or anterior) branch, the aperture between the branches, which is large in *Fistularia* (Pl. III, figs. 8, 9), in *Aulostoma* is reduced to a small foramen (Pl. III, fig. 5 f) (not visible from the outer aspect).

Inside the posterior upper angle of the clavicle is the postclavicle (pcl). In the scapular arch the scapular foramen is large; the coracoid (co), as shortly mentioned above, is broadly united to the clavicle, leaving only the small opening described; the lower edge, which is ventrally joined to its fellow from the opposite side, is thickened on the outer side and posteriorly produced into a flat bundle of osseous filaments, used for muscular attachments.

Of the four well developed pterygials (ba), the upper and smaller one is carried by the scapular.

The pectoral fin rays (15—16) are unbranched, but jointed except the uppermost (3—4).

The pelvic bones are not in contact; each is a triangular flat piece, with feebly pronounced muscular crest along its middle. The outer of the 6 ventral rays is unbranched, but jointed, the others branched and jointed. The position of the ventrals is about on the level with the 20th abdominal vertebra⁵.

Visceral anatomy.

There are four complete gills and a large pseudobranch; a slit between the 4th gill-arch and the lower pharyngeal. The alimentary canal is without mesentery, short, and quite straight; the anal opening is situated immediately behind the ventral fins, just behind the end of the ventral rays when these are lying against the body. The oesophagus passes without boundary into the stomach; the latter is spindle-shaped, narrowing behind into a pyloric part, sharply marked off from the intestine. The oesophagus and stomach together are about of the same length as the rest of the alimentary canal. The small intestine sends out from its anterior end two well developed appendices pyloricae, one on each side, the left being somewhat longer than the right; the intestine is wider anteriorly and tapers behind, where it is sharply bounded by a constriction from the short, wide rectum. In the stomach of one specimen from the West Indies (a medium-sized female) I found a wholly undigested herring 53 mm long and the vertebræ of another, otherwise completely macerated and digested small fish; in another (large, dried) specimen from the West Indies I also found the vertebræ of a small fish.

The liver encloses ventrally the oesophagus and part of the stomach, without reaching the pyloric part; to the right side it reaches higher up on the sides of the stomach than to the left; it is not properly lobed, but about in the middle of the right margin there is a deep incision leading to the gall-bladder; from the latter the long bile-duct passes backwards, lying close to the portal vein, and enters the front end of the small intestine between the two appendices pyloricae.

The right cardinal vein is strongly developed, passing along the right kidney and leaving the latter at its anterior end to unite with the ductus Cuvieri, the left cardinal vein is small and its anterior part completely hidden in the left kidney.

The aorta passes to the left side of the corpora of the coalesced anterior vertebræ and continues in this asymmetrical position. A short way behind the last branchial vein, coming from the 3rd and 4th gill-arches, it sends out a pair of strong branches; each for one of the pectoral fins, and ventrally between the origin of these, it gives off the *arteria coeliaca*, which passes to the right side of the oesophagus between the stomach and the liver, following the portal vein and giving off branches to both oesophagus and stomach and one branch running forwards to the lower face of the air-bladder, entering the "red-corpuscle".

The air-bladder is very thin-walled and reaches from the oesophagus, about at the level of the front end of the liver, or the scapular foramen of the shoulder girdle, to behind the ventral fins. At the anterior end it is provided with a large, ovoid *rete mirabile* or "red gland"; besides the branch from the *arteria coeliaca*, just mentioned, it has a branch from the portal vein, closely following the artery.

The kidneys are above the rectum fused to a thick mass, below which is a urinary bladder; anteriorly the kidneys separate and filling out the impressions between the vertebral corpora take on the shape of narrow bands, which under the front end of the coalesced part of the vertebral column on each side form a small, slightly swollen "head-kidney". The latter are asymmetrical, the left being the larger. Through the "head-kidneys" pass out the above mentioned arteries for the pectoral fins. The head-kidneys seem not to contain any urinary tubules, but such are to be detected in the narrow strands of kidney-substance filling the grooves on each side of the body of the last (the 4th) coalesced vertebra.

On the outer side of each kidney run the large vagus-nerves, which leave the skull through the anterior exoccipital foramen, while a large nerve for the pectoral fin leaves through the posterior (that nearest to the condyle); a deeper-lying nerve for the pectorals passes out through the nerve-openings in the front end of the first of the coalesced vertebræ; through the openings in the following coalesced vertebræ, besides nerves, pass branches from the aorta.

Genital organs. The ovaries are large, paired sacs, posteriorly uniting into a very short common oviduct, opening as usual between the anal and urinary orifices.

Also the testes are paired, provided behind with a very short common duct⁶.

Fistularia.

Exoskeleton.

In the 3 species examined: *F. tabacaria* L., *F. depressa* Gthr. and *F. petimba* (Lacép.) Jordan & Gilbert the equipment with dermal osseous structures is somewhat different.

I. In *F. petimba* the skin is rough to the touch (like sand-paper adhering to the fingers), the whole body being covered with minute hooklets. This I have found to be the case not only with quite small specimens from 130 mm. in

length* and larger ones from 170 to 385 mm., but in the largest specimens examined, surpassing 708 mm. in length. In *F. tabacaria* only the small and middle-sized specimens up to about 400 mm. in length show minute asperities of the same kind as in the former species. The smallest specimen at my disposal is figured on Pl. VII, fig. 1. It has a length of 43 mm.; the caudal filament exceeds the body, being about 52 mm. Most of the body is covered with proportionately large, hooked spinelets, only a longitudinal strip along the middle of each side, the head and the adjoining part of the body, being naked. The spinelets appearing on the crests of the head and on the nape are denticulations belonging to the deeper skeletal parts mentioned below. A much larger specimen (280 mm.) shows still a general coating with small asperities, most densely developed on the tail; but in two specimens of about 400 mm. the dorsal part of the body is to a great extent naked, whereas the lateral and ventral parts have their rugosity well developed. On the other side a third specimen, c. 350 mm., at first sight seems completely naked; but examined with a strong lens the tail ventrally to the lateral line shows very small asperities. In large specimens, exceeding 700 mm., I have not been able to detect any hooklets at all. Thus *F. tabacaria* in the fully adult state seems to be naked. The same is probably the case always with *F. depressa*, even in the youngest stages; but quite small specimens I have never seen. The six specimens examined by me, from 250 to 450 mm. in length, at all events show no trace whatever of asperities.

The spinelets in *F. tabacaria* and *F. petimba* are of the same type: a conical, sharply pointed hook, basally hollow and expanded into an extremely thin cup-shaped plate, generally with irregularly indented margins. In large specimens of *F. petimba* many of the asperities appear conical or blunt, having lost their hooked point, which has either been absorbed or worn away⁷.

The dimensions of the asperities in some of the specimens examined are the following:

		Diam. of basal plate	Height of spine	Diam. of spine at base
A.	c. 720 mm.	0,160 × 0,176 — 0,240 × 0,288	0,064	0,043
B.	c. 710	—	0,064 — 0,080	0,032
C.	c. 340	—	0,064 — 0,096	0,032
<i>Fistularia tabacaria</i>				
A.	c. 400	—	0,080 × 0,088 — 0,128 × 0,136	0,016 — 0,024
B.	c. 350	—	—	0,016 — 0,019
C.	c. 280	—	0,096 × 0,112	0,024 — 0,032
D.	c. 43	—	0,080; — 0,208	0,008

II. In *Fistularia tabacaria* longitudinal rows of short spindle-shaped ossicles (of 4—8 mm. length in adult specimens), imbedded in the deeper layer of the cutis,

* The length in all cases mentioned is measured from the tip of the snout to the base of the caudal filament.

form a strip between the posterior end of the coracoidal plate and the ventrals, and behind these running backwards, below and parallel to the lateral line, to the end of the tail. In the youngest stage figured (Pl. VII, fig. 1) I have not been able to detect these structures, but in a specimen of about 280 mm. they are discernible, at all events anterior to the ventrals, and in larger ones they always seem to be present⁸.

III. In *Fistularia petimba* a single median row of narrow longitudinally keeled scales, quite superficially imbedded, is found along the back, running from about the level of the ventrals to the base of the dorsal fin, and behind the latter to some distance from the end of the tail, where the hindmost scales grow shorter and finally take the shape of nodules; a similar row is found in the ventral median line, beginning in front of the ventrals at some distance behind the coracoids and, interrupted by the anus and anal fin, continuing on the tail, stopping at some distance from the caudal fin. In all large and medium-sized specimens I find these scales present, but in the smallest specimens (170 and 130 mm.) they seem not yet to be developed⁹.

IV. Common to all 3 species are the dermal ossifications of the lateral line. On the short anterior part of the trunk, which is protected by the endoskeletal parts described below, these ossicles are tube-shaped, on the rest of the body they gradually take the form of narrow longitudinal shields each provided with a more or less prominent short keel or spine, most prominent on the tail where the shields form a kind of serrature. On the caudal filament, on which the lateral line is continued, the ossifications again take the shape of tubes. In the two species where dermal asperities are found, the latter may be present in the thin dermal layer covering the ossicles of the lateral line¹⁰.

Endoskeleton.

The vertebral column does not show any important differences in the two species examined (*F. petimba* and *tabacaria*). In both species I have found the same number of vertebræ, 56 (4 + 52) abdominal and 31 caudal vertebræ¹¹.

The 4 anterior vertebræ (Pl. I, fig. 11, Pl. II, fig. 9) are modified in the same way as in *Aulostoma*, being extremely elongated and immovably united by sutures, forming one piece, which (in *petimba*) is between $\frac{1}{5}$ and $\frac{1}{6}$ of the whole length of the column. The spinous processes are united into one longitudinal crest, the transverse processes into a similar, but broader, almost horizontal plate, the members constituting which overlap each other towards the skull while those of the vertical plate are mostly joined with their margins.

As in *Aulostoma* the second and third vertebræ are by far the longest, their anterior and posterior portion being about equally elongated, whereas of the first vertebra only the posterior part, of the fourth only the anterior part is elongated and modified.

The first carries articular processes for connection with the skull, the fourth has on the posterior, unmodified part a small separate transverse process, corre-

sponding to the posterior one on the following vertebrae. From the anterior corner of the expanded transverse process of the second vertebra (at * in Pl. I, fig. 11) a strong ligament passes to the posttemporal. The following free abdominal vertebrae — like those of *Aulostoma* — are provided with two transverse processes on each side, but here the posterior process is always small compared with the anterior (Pl. II, fig. 9). The latter is especially large and distally flat and expanded on the 5–6 vertebrae immediately following the coalesced part. On the first caudal the posterior process suddenly disappears.

The inferior arch and spine form part of the anterior transverse process, being formed by a process on each side from the base of its lower face. The anterior 9–10 caudal vertebrae, which support the dorsal and anal fins, retain the transverse processes and are, except the first, provided besides with an upper set of similar, but shorter and more slender, pointed lateral processes, originating from the base of the neural arches. Behind these fins no lateral or transverse processes occur.

On all the free vertebrae articular processes are present, the anterior ones, as in *Aulostoma*, being large and high; on the caudals behind the fins similar inferior articular processes are developed. The vertebrae of the slender posterior part of the tail have their upper and lower spinous processes depressed, lying flat and overlapping caudally; at the end of the tail they rise again, and the last vertebra takes on the shape of a vertical plate, probably representing two hypural bones.

Ribs are wanting.

Connected with the vertebral column are some osseous structures, the anterior of which — the nuchal plates — are probably to be regarded as modified interneurals, while the others seem to be ossified tendons or ligaments.

The three nuchal bones are longitudinal plates (firmly) joined together and over-lapping each other towards the tail; they are through connective tissue fastened along the vertical lamella representing the modified spinous processes of the first four elongated vertebrae.

Their upper face is sculptured and more or less visible through the skin; the lower face is concave and carries on the foremost part of the first plate a short median keel, fitting into a much broader triangular excavation of the neural spine of the first vertebra; on the hind part of the second plate a median furrow begins and gradually deepens on the third into a narrow groove between two low lamellæ, which are continued into long and thin prolongations, reaching backwards along the spinous processes of the 9 or 10 anterior free vertebrae.

The three nuchal plates are evidently homologous to the plates in the corresponding position in *Aulostoma*; and as in the latter genus they are doubtless to be regarded as modified interneurals, the same interpretation of the nuchal plates in *Fistularia* seems justified. Small specific differences are to be met with in the nuchal plates: in *Fist. petimba* they are broader than in *F. tabacaria*; in the latter the ventral median keel of the first plate (the rudiment of the "stem" of an ordinary

interneural) is much smaller, and the sculpture of the upper face shows a somewhat different pattern.

Behind the unpaired nuchal plates paired, symmetrically arranged structures appear in the shape of a double series of long, thin, laterally compressed bones on each side, running along the tips of the spinous processes to the end of the tail, only interrupted by the dorsal fin (Pl. II, fig. 9 td); a similar, ventral, double series occurs along the inferior spines of the tail, beginning just behind the anal fin. Each member of both series extends over a number of (4, 5 or more) vertebræ; the uppermost rows are situated just below the skin (in alcoholic specimens they may be more or less visible through the skin); in *Fistularia petimba* they so to speak embrace the row of median scales. The two above-mentioned prolongations from the 3rd nuchal evidently belong to the same system. That these bones are ossified tendons or ligaments is hardly to be doubted; they apparently are structures similar in kind to the subdermal ossifications which are so richly developed in *Aulostoma*.

Ossifications of a similar nature are further the two large, flat bones, which, fastened to the epiotics of the skull, are situated along the back, one on each side of the nuchal plates. The upper face is sculptured on the anterior half and to a great extent visible through the skin; from the lower face, near the inner margin, of the posterior half originates a thin vertical lamella, enlarging the surface for muscular attachment. Like the corresponding bones in *Aulostoma* these structures are simply ossifications of tendons of the anterior part of the dorsal lateral muscles.

16 bisegmented interneurals support the dorsal fin. The foremost is short, about horizontal, and its lower end joins directly the dilated upper end of the spinous process of the first caudal vertebra; the following are interposed as usual, singly or in pairs or even three, between the spinous processes of the supporting vertebræ. With each lateral face of the first interneural an ossified tendon of the set in front of the fin is coalesced or firmly united; the like is the case with the hindmost interneural, a pair of tendons from the set behind the fin being joined with it.

The anal fin is supported by 15 interneurals, also bisegmented and with ossified tendons attached to the hindmost member. The first interneural is situated in front of the inferior spine of the first caudal, the following are interposed between the spines of 10 vertebræ.

The dorsal fin has 17—18 rays, the anterior 3, especially the foremost, extremely short; the anal fin has 16—17 rays, the anterior 2 very short¹².

The caudal fin has 10—11 + 2 + 10—11 rays, the 2 middle ones being extremely elongated, forming the peculiar filament. All the rays of the unpaired fins are laterally flattened, unjointed (but composed of two lateral halves), also the two composing the caudal filament. Only the caudal rays nearest to the caudal filament, 2 or 3 above and below this, are branched. The lateral line is continued along the filament almost to the tip, enclosed in a series of slender bony tubes; the presence of the latter may produce an appearance of joints¹³.

The head (Pl. I, fig. 5) is flattened, the long tubiform snout depressed and almost hexangular in transverse section. The postorbital part of the skull is flat above, with deeply excavated postfrontal region (fig. 6), the interorbital part more or less concave; the proximal half of the preorbital part is roof-shaped, the distal half flat, the whole forming a broad and rather thin and flat beak, with sharp edges and concave underside (fig. 7). The preorbital part is about $2\frac{1}{2}$ times as long as the rest in *F. tabacaria*, fully 3 times in *F. petimba*; the greater part belongs to the mesethmoid (somewhat less than $\frac{3}{4}$ ths); the whole terminal part (somewhat more than $\frac{1}{4}$) is made up by the vomer alone (while in *Aulostoma* the mesethmoid seen from above reaches along the middle line almost to the end of the snout).

On the upper aspect (fig. 6) the proximal part of the mesethmoid is seen forming the anterior borders of the nasal openings, while the other borders belong to the prefrontals (prf); above the nasal pits are found the frontals (fr), reaching far backwards, about to the posterior end of the skull, here embracing a great part of the narrow supraoccipital (so); the rest of the latter is enclosed between the epiotics (ep), which are coalesced behind the supraoccipital into one bone and form the median "occipital" crest. In the fossa on each side of the base of the latter is articulated the great ossified tendon (or muscular lateral plate); the somewhat swollen anterior, inner margins of the fossæ correspond to the knobs on the epiotics mentioned in *Aulostoma*. The end of the "occipital" crest is connected with the foremost nuchal shield. From above are further seen the postfrontals (pf), pterotics (sq) and the posttemporals (pt). The latter are in this genus firmly united with the skull, forming sutures with the pterotic, the frontal, epiotic and exoccipital. Besides are seen from above the exoccipitals (eo), broadly meeting from both sides over the foramen magnum and separated from the supraoccipital through the coalesced epiotics; finally, the knob-shaped, convex condyle is seen under the occipital foramen.

Parietals and opisthotics are absent.

From the triangular nasal groove a furrow, corresponding to that on the beak of *Aulostoma*, runs to the end of the snout, lodging the anterior part of the supraorbital lateral line; the median part of the mesethmoid and the vomer enclosed between the two furrows is elevated over the level of the lateral parts and sculptured, the pattern being somewhat different in the species examined; also the lateral parts of the mesethmoid are sculptured with fine radiating striæ. A row of slender, extremely thin tubes enclose the lateral line; no rudiment of a nasal bone, like that of *Aulostoma*, nor any antorbital bone is found here; the place taken up by the latter in *Aulostoma* is in this genus occupied by the front end of the prefrontal. The outer face of the prefrontal is deeply hollowed out (fig. 5, prf.); the upper border of the hollow is sharply serrated in *F. petimba* (and *depressa*), only crenulated in (adult) *F. tabacaria*.

On the lateral aspect of the brain-case as in *Aulostoma* a sharp crest (partly serrated in *F. petimba* and *depressa*) separates the upper from the lower surface, the two articular facets for the hyomandibular (fig. 7) are in the corresponding

position to those of *Aulostoma*, the prootic (pro) is provided with a sharply pointed ridge where the spine in *Aulostoma* is found, the pterotic (sq) is very large, combining below with the parasphenoid (pa) and the basioccipital (ob), the exoccipital carries a ventrally directed process just in front of the condyle for connection with the first vertebra — in short, if we take away the posttemporal, almost all the features and details resemble those of *Aulostoma*. Only at the orbit (Pl. I, fig. 8) we meet with some differences, especially in the extent of the alisphenoid (al), which here does not project laterally so far that it becomes visible as part of the postorbital process; on the other hand the alisphenoid is horizontally produced medially to meet its fellow from the opposite side, forming together with the prootic the bridge roofing over the "myodome". The anterior part of the "myodome" (the muscular fossa) is divided by a vertical lamella (l), rising from the excavated upper face of the parasphenoid; it appears like a process from the latter, but represents perhaps a basisphenoid (?). Below, (Pl. I, fig. 7) the basioccipital (ob) and the posterior part of the parasphenoid (pa) are flatly rounded, not keelshaped as in *Aulostoma*, and in front the parasphenoid reaches a good deal farther than in the latter, ending as a slender point, but as in A. without joining the vomer. The vomer (vo) has at the extreme anterior end a kind of knob from which starts ventrally a short median ridge or keel, carrying a few teeth, tapering behind; the hindmost part of the vomer is a slender point. The greater part of the under surface of the beak is here made up by the mesethmoid (mes).

Infraorbitals are wanting.

The 3 opercular bones (Pl. I, fig. 5) show in the main the same features as in *Aulostoma* the elongated posterior part of the suboperculum (s) is here divided into two long and slender branches, while in A. it is entire. The lamelliform interoperculum (io) surpasses in front the mandibular articulation.

The hyomandibular (hy) is still more sloping forwards than in *Aulostoma*; with the lower cartilaginous end it is connected with the horizontally placed styiform posterior end of the symplectic (sy). The greater part of the latter forms a vertical plate, the upper margin of which joins the skull, its posterior corner being firmly attached through ligament to the lower face of the prefrontal; in front the symplectic joins the metapterygoid (mt) in a long oblique suture, broadly overlapping the outer face of the metapterygoid; below, it unites with the preoperculum (pro) in a horizontal, straight suture, and, in front, in an oblique suture with the quadrate (qu).

The quadrate is very long, the outer face with an elevated, sculptured part, lying in continuation of the sculptured part of the preoperculum (pro), and in front carrying the articular head for the lower jaw; the upper, deeper situated part of the quadrate is smooth and joins the deep parts of the entopterygoid (ept) and metapterygoid (mt).

The palatine (pa) is small, with the relatively large maxillary process directed forwards; it does not meet its fellow from the opposite side; behind it is simply

pointed, not forked as in *Aulostoma*, and only immediately behind the maxillary process is found the connection with the vomer, below the somewhat broadened snout-end of the latter; its upper, inner margin is joined to the pointed front end of the entopterygoid. As in *Aulostoma* an ectopterygoid is wanting, being replaced by that part of the entopterygoid which unites with the oblique front margin of the quadrate. The upper margin of the entopterygoid is strongly thickened, its surface sculptured (fig. 5); it joins the lateral edge of the cranial beak, formed by the vomer and anterior part of the mesethmoid; along the remaining edge of the latter it is continued by the similarly thickened and projecting upper margin of the metapterygoid, which reaches to the prefrontal. In *F. petimba* (and *depressa*) this thickened part is strongly serrated, in *F. tabacaria* (adult) only crenulated.

On the inner face of the pterygoids no teeth are developed, but each palatine carries a row of teeth along its outer margin.

The obliquely ascending part of the preoperculum (fig. 5, pro) covers almost the whole lateral and the front face as well of the hyomandibular; the hyomandibular foramen is quite near to the articulation with the skull. The outer face of the preoperculum is beautifully ornamented with narrow ridges, crenulated or even more or less spiny.

The premaxilla (i) is small, pointed behind, and provided with a row of teeth; the maxilla (mx) is relatively large, broadening behind.

The articulation for the lower jaw is situated rather far behind the end of the snout, about at a level with the upper suture between the vomer and the mesethmoid. The mandible, therefore, which as in *Aulostoma* reaches farther forwards than the snout, is considerably elongated; it is composed like that of *Aulostoma*, with the small angular (an) in a similar place at the lower border, rather far from the posterior end. The upper margin of the dental, in front of its ascending part, is provided with teeth.

Branchial apparatus (Pl. II). As in *Aulostoma* the hyoid (fig. 5—6) is relatively short, and almost the whole gill-bearing part is situated behind the articulation of the hyoid to the skull. The hyoid appears at first sight to lack one of the typical elements, the stylohyal; but it cannot be doubted that this part really is present only in a reduced state and fused to the epihyal (eh). The latter is the largest piece, especially if seen from the outer side (fig. 5); the ceratohyal (ch) appears proportionately somewhat larger and the lower hypohyal (hy^I) somewhat smaller than is the case in *Aulostoma*. There are five branchiostegal rays, the lowermost very slender, fastened to the inner face of the ceratohyal, the others to the outer face, one to the same piece, the three to the epihyal; they increase in size upwards, the uppermost being especially stout and divided into two branches.

The glossohyal (fig. 1, gl) is extremely long, slender and laterally compressed; in length it surpasses the whole branchial apparatus; the urohyal also is long, angular and increasing in thickness behind, where it reaches the front ends of the coracoids, in *F. tabacaria* coossifying with the latter.

The first basibranchial, cartilaginous in *Aulostoma*, is here a bone, with broad and flat front end (Pl. II, fig. 1 col¹); it is the only basibranchial present.

The gill arches are completely smooth, without any trace of gill-rakers or teeth. The first arch is composed of 3 parts, a very short, clumsy hypobranchial, a long ceratobranchial and a slender epibranchial; the second arch consists of 4 parts, a pharyngobranchial (ph^{II}) provided with teeth being present in front of the slender epibranchial; the third arch has also 4 parts; its very slender epibranchial is separated from the ceratobranchial and articulates distally both with its own and the following pharyngobranchial; the first (ph^{III}) sends a process forwards along the whole length of the preceding pharyngobranchial; behind this process it is flat and beset with teeth. The fourth arch lacks the hypobranchial and the epibranchial, its tooth-bearing pharyngobranchial being supported by the preceding arch alone.

The fifth, the lower pharyngeal is richly provided with teeth.

As in *Aulostoma* the gills are continued on the pharynx wall, supported by cartilaginous prolongations from the ceratohyals (Pl. II, fig. 2).

The reduction of branchial skeletal parts in *Fistularia* seems about to be equal to that found in *Aulostoma*; only the epibranchials of the second and third arches appear less reduced, as the latter alone is separated from the ceratobranchial.

The following tabular view of the branchial apparatus in the two genera will immediately show the fundamental likeness¹⁴.

Aulostoma.

Gill arch	Basibranch.	Hypobr.	Ceratobr.	Epibr.	Pharyngobr.
I	(+)	+	+	+	
II	+	+	+	+	+
III		+	+	+	+
IV			+		+
V			+		

Fistularia.

Gill arch	Basibranch.	Hypobr.	Ceratobr.	Epibr.	Pharyngobr.
I	+	+	+	+	
II		+	+	+	+
III		+	+	+	+
IV			+		+
V			+		

The shoulder girdle (Pl. III, fig. 8,9) has been fully described by STARKS (55 p. 630), and only a few remarks need be added.

The clavicular arch consists of 3 bones, a supraclavicle being present.

The posttemporal (Pl. I, fig. 5 pt) is suturally united to the skull (vide supra); its outer margin is sculptured, with granules (*F. tabacaria*) or spines (*F. petimba*, *depressa*); about midway between the occipital suture and the posterior end the inner face shows a knob (Pl. I, fig. 7 k) or rugosity for muscular attachment and for a strong ligament, going to the front part of the first vertebra, corresponding to the bony fork described in *Aulostoma*; the ligament passing from the hind end of the posttemporal to the anterior corner of the transverse process of the second vertebra is also found in *Fistularia*. The supraclavicle is short; it has a shallow concavity at the upper end for articulation with the posttemporal, and the lower end covers part of the outside of the clavicle.

The part of the clavicle (fig. 9, cl) corresponding to the sculptured plate in *Aulostoma* is small (just observable through the skin, but hidden below the opercular membrane); under its upper posterior corner the clavicle carries the long postclavicle (pcl), which broadens behind into a plate, partly sculptured on its outer face and more or less visible through the skin. Distally the clavicle bifurcates into an outer (anterior) (o) and an inner (posterior) (i) branch; along the inside of the clavicle and that of its inner branch is attached the scapular arch.

The latter consists as usually of the scapula (sc) and the coracoid (co). The first encloses the wide scapular foramen; but the part encircling the anterior border of the foramen is only very thin cartilage (easily lost in drying, probably, therefore, overlooked by STARKS). The inferior margin of the coracoid expands into a large plate, broadening behind the pectoral fin, the outer face being to a great extent sculptured and visible through the skin; anteriorly it combines with both branches of the clavicle, ending in front of the outer (anterior) branch of the latter as a flat, pointed process, to which the urohyal is fastened. The part between the clavicular branches unites with its fellow from the opposite side, a particularly firm connection being established at the level of the inner (posterior) branch (fig. 8).

The four pterygials (ba) are well developed, similar to those in *Aulostoma*; the uppermost, rather small one is fastened to the scapula, the remaining three are larger, laterally compressed and somewhat hour-glass-shaped in outline¹⁵.

The pectoral fin has 15—16 soft unbranched rays, the uppermost rudimentary; the upper (4—5) rays are not jointed, as the rest are.

The pelvic bones, abdominal in position, are still farther apart from each other than in *Aulostoma*. Each is a flat bone with the exterior margin rounded in outline, the inferior straight. There are 6 ventral fin rays, the outer unbranched but jointed like the rest, which all are distally branched.

Visceral anatomy.

There are four complete gills and a large pseudobranchia, a slit between the fourth gill-arch and the lower pharyngeals.

The alimentary canal is for the greater part of its extent without mesentery; only about the last 4th part is provided with a mesentery; the whole alimentary canal is without curvatures, completely straight; compared with that of *Aulostoma* it is much longer, the anal opening lying much farther behind the ventrals, just in front of the anal fin as in most fishes. The oesophagus and stomach form together a long spindle-shaped part, by far the widest portion of the whole tract; the posterior pyloric part of the stomach is more muscular and narrow, sharply marked off from the intestine. Internally oesophagus and stomach are provided with longitudinal folds; the length of both together is two-thirds of that of the rest of the intestinal canal. The small intestine sends out from its front end one, conical, not very long *appendix pylorica*; the intestine commences about at a level behind the ventral fins, is widest anteriorly and tapers quite gradually backwards; the posterior fourth part is the rectum; the boundary between it and the small intestine is not very pronounced externally, no sudden change in width being found. As just mentioned the rectum and hindmost part of the adjacent intestine are suspended by a mesentery. In the pyloric part of the stomach of a large *F. petimba* from the Formosa Strait I found 8 small fishes, the longest ca. 50 mm., all belonging to the same species of the genus *Bregmaceros*, and more or less digested; of those most digested the otoliths were completely intact.*

The liver is small reaching only over half the length of the stomach, not lobed, pointed posteriorly, covering somewhat more of the ventral right side of the stomach than of the left. Quite near the posterior end the right margin has an incision for the gall-bladder, from which the biliary duct runs backwards following the intestinal artery and the portal vein, enclosed together with these in a peritoneal fold, like a kind of low mesentery along the stomach; it enters the intestine on its ventral side, immediately behind the base of the *appendix pylorica*.

The air-bladder is about twice the length of the liver, reaching from below the first of the coalesced vertebræ to the end of the last; here the main cavity of the bladder stops, but its posterior end sends out a pair of long, conical blind-sacs tapering to a point backwards and lying one on each outer side of the kidneys below the long and expanded transverse processes of the anterior free vertebræ; they are somewhat asymmetrical, the right reaching just behind the ventral fins, the left stopping just in front of them. About in the middle, a little behind it, the ventral wall of the main chamber contains a large, ovoid "red body"; at this spot the under-face of the air-bladder is tightly fastened to the stomach through a short "stalk", containing the principal vessels for the "*rete mirabile*", branches from the *arteria coeliaca* and the portal vein. The heart, the air-bladder, except its two prolongations, the whole liver and the greater part of the stomach, except its pyloric part, are enclosed in the "armoured" part of the trunk, protected on the sides and below by the large postclavicular and the coracoidal plates. The heart is situated between the distal branches of both clavicles and over the front ends of both coracoidal plates, the bulbus arteriosus lying over the hind end of the urohyal.

* Also KNER (28 b) p. 29 (260) has found a small fish in the stomach of a *Fistularia*.

The *aorta* crosses obliquely over the ventral face of the front end of the first vertebra, in the furrow seen on the first corpus (Pl. I, fig. 11**), to the left side where it is lying along the coalesced corpora, keeping up this asymmetrical position to the end of the body cavity, where it enters the subvertebral caudal canal.

The *arteria coeliaca* originates from the aorta a short way behind the entrance of the last branchial vein (or *arteria revehens*) ventrally where the arteries to the pectoral fins leave laterally; it passes to the right side of the oesophagus below the front end of the air-bladder and further along the right side of the stomach, giving off branches to the latter, the airbladder and the liver; at the gall-bladder it gives branches to the "red body" and follows the same course as the portal vein and biliary duct on to the front end of the pyloric appendage, where it still follows along the appendix with the biliary duct to the end of the latter and then separates from the portal vein, each of these vessels occupying in their further course backwards opposite faces of the intestine; in the mesentery of the hind part of the latter the *arteria coeliaca* leaves the intestinal wall and passing obliquely through the mesentery enters the dorsal body wall between the two gonads and anastomoses with the *aorta*.

The right cardinal vein is very large; imbedded in the right part of the kidney it enters from behind the coalesced part of the vertebral column, lying to the right side of the corpora, and receiving branchlets across the corpora from the opposite side, one for each vertebra. The left cardinal vein is wanting altogether. Along the left side of the coalesced vertebræ, imbedded with the aorta in a silvery sheath, a small vein runs forwards, anteriorly crossing over the right cardinal vein and going to the head. Small veinlets passing through the nerve-holes of the coalesced vertebræ join the right cardinal vein and the small "vertebral vein" on the left side. No branches from the aorta seem to enter the nerve-holes.

The kidneys are coalesced into one body reaching from the hind end of the body cavity to the last of the coalesced vertebræ. This body contains two symmetrically arranged urinary ducts, thus proving the originally paired condition of the kidneys. The ducts unite to a common, very short part opening as usual behind the (female) genital pore; there is no urinary bladder.

Dorsally over the front end of the air-bladder, just below the anterior end of the first vertebra, a small pyriform body is found on the left side, but nothing corresponding to it on the right side. I suppose it to be the remnant of the left pronephros, and a silvery thread, going backwards from it, I assume to be the rudiment of the pronephric duct (the condition of the old spirit material was such that a histological examination would scarcely give any reliable information).

Along the outer side of the aorta, dorsally to the air-bladder, runs the left vagus-nerve accompanied by the left sympathetic; the right vagus and the right sympathetic follow in a similar manner the right *vena cardinalis*; from the vagus and spinal nerves and probably also from the sympathetic branches are given off to the wall of the air-bladder.

Through the nerve-holes in the coalesced vertebræ only spinal nerves pass out.

A transverse commissure connects the two sympathetic trunks just in front of the rudimentary pronephros.

Genital organs. The ovaries appear to be unpaired, suspended by a mesoarium to the left side of the dorsal body wall. They are bandshaped and reach from the posterior end of the body cavity to a short distance behind the beginning of the intestine. Closer examination shows that two ovaries are present; posteriorly they unite into a short common oviduct with the usual opening behind the anus; above the rectum their double nature may be noticed, and as stated above the intestinal artery passes between them; but soon they externally appear quite coalesced; transverse sections reveal their double nature, the inner cavity being divided by a thin vertical partition. The numerous ovigerous lamellæ in each half leave part of the wall of the ovarian chambers free; in the middle of the fused ovarian band this free part is lateral, but behind and in front of the middle it may be more ventral. The testes externally resemble the ovaries, suspended by a mesorchium in the same position, band-shaped and of the like dimensions; transverse sections show that the band is made up of two closely joined gonads.

The peritoneum is silvery.

The axillary pore, behind the pectoral fin, mentioned by GÜNTHER appears to be the opening of the duct of a secreting gland. The latter is richly provided with blood vessels¹⁶.

Syngnathidæ.

In the second Volume (Part 2) of his great work on Fossil Fishes, published between 1833 and 1843 (p. 275), L. AGASSIZ states that he has not been able to give any special information about the skeleton of this interesting group for want of preparations fit for examination; neither could he fill up this blank through the literature: "car je ne trouve nulle part une description détaillée du squelette et des écailles des Lophobranches".

Regarding the skeleton very nearly the same might be said to day: a complete description, accompanied by the necessary illustrations is up to the present date not to be found anywhere; although DUMÉRIL in 1870 gave a monograph or at all events a detailed account of this group based on the material of the Musée d'Histoire naturelle at Paris and of the whole literature then available*. The fullest and most correct information is that to be found in the Scandinavian literature. As early as 1850 KRÖYER in his "Fishes of Denmark" has given several good and

* SEGOND (52) p. 619 says 1873: "Auguste Duméril a rassemblé dans sa quatrième sous-classe tous les documents que nous possérons sur les lophobranches. J'espérais trouver dans ce travail consciencieux, des observations nouvelles sur les parties centrales des pégases et des syngnathes, mais ces nouveaux documents manquent encore à l'ichthyologie A. Duméril se contente de dire que le squelette des lophobranches ne diffère en rien d'essentiel de celui des poissons osseux."

correct descriptions; later LILLJEBORG (1891) and SMITT (1895) have supplied more or less complete accounts of the skeleton; regarding the composition of the skull, these authors especially SMITT have interpreted several features more correctly than any previous or later author; but they have not avoided some grave errors.

I may add that these Scandinavian authors also give much good information about the anatomy of the soft parts, and it ought to be mentioned that in 1833 RETZIUS already described the main anatomical features of the most common species of northern pipe-fishes so completely, that in several points the investigations published as late as 1902 by HUOT do not contain much that is really new. The few remarks about the osteology in HUOT's paper contain several errors; and the same may be said of the papers published by MC. MURRICH, SCHÄFF, COPE, JORDAN & EVERMANN, SWINNERTON etc.

As to the systematic position of the Lophobranchs I shall here only mention that Cuvier in 1817 (*Règne animal* 1. Édit. II. p. 155) gave them rank as one of his 8 Orders or main divisions of the Class Pisces; he did so essentially on account of their gills. This elevated rank and isolated position has often been attacked; every one who has really examined their gills, has seen that these do not substantially differ from those of other Teleosteans; CUVIER himself has realized this fact, and so did RATHKE, RETZIUS, RYDER and several others. Nevertheless their isolated position is still maintained by many authors. Without entering further into any discussion of the systematic point I might only mention that in 1908 (23 b) I have expressed as my view, that the true Lophobranchii (or Syngnathidae), the Solenostomidae, the Fistularidae, Aulostomidae and the Centriscidae form one natural group; and I have briefly pointed out some characters in the cranial structure which seem to me to raise this view above doubt.

The true Pipefishes, the *Syngnathidae*, are a fairly homogenous family, naturally divided into two groups, one for which the well-known genera *Siphonostoma* and *Syngnathus*, the common pipefishes of European and N. American coasts, may serve as types, and one containing forms such as *Hippocampus*, the Sea-horse.

Proceeding to the osteology of this family, I think it most convenient to describe in some detail one type, and afterwards to point out some of the more essential features in which other forms deviate from this type. As type we may consider *Siphonostoma typhle*, a species which is to be found everywhere in the zostera-region of the Danish coasts, or at similar localities of the Baltic and the North Sea.

Siphonostoma typhle (L.).

Exoskeleton.

The dermal armour of *Siphonostoma* and other Syngnathids has often been described and its main features, I think, are so well known that a recapitulation here seems superfluous. Only regarding the nuchal plates and the composition of

the foremost "rings" of the trunk have I found it necessary to enter into details below in treating of the endoskeletal parts closely connected with them.

The arrangement of the dermal plates has been described by KRÖYER (29 p. 683), PETERS (41 p. 104), DUMÉRIL (12a p. 143, 12b p. 478), E. MOREAU (36 p. 28), SCHÄFF (50), LILLJEBORG (37 p. 437), SMITT (54 p. 675), HUOT (19 p. 202), * DUNCKER (13 p. 18, p. 62), a. o.; the shape and structure of the single plates, their relation to the layers of the skin etc. are especially mentioned by SCHÄFF, an account of their first development is given by KASANZEFF (24 p. 854).

The presence of "lateral-line organs" was first shown by DUNCKER (13 p. 22, Pl. 3); but as these organs — the existence of which I can confirm — are not enclosed in any canal, and some of them may appear on places, where the typical lateral line does not occur (e. g. on the operculum), it seems open to doubt if they really represent the true lateral line or some of the other dermal sensory organs found in teleosts.

Endoskeleton.

The vertebral column consists of 56 vertebræ; the anterior 19 I count as abdominal, as the front outline of the caudal armour, behind the anal opening, lies just beneath the middle of the 20th vertebra; this vertebra besides supports the anal fin and sometimes its transverse processes are joined to form the foremost inferior arch; but sometimes this is the case with the next vertebra. The three anterior abdominal vertebræ are immovably joined together (Pl. IV, fig. 4), their neural arches being firmly connected basally through sutures, with long dentations, while their corpora simply meet in the same way as those of all the remaining vertebræ. When macerated (even in hydrate of potassium) the three anterior vertebræ, therefore, always cohere, whereas the others drop off. The immobility is strengthened by the expanded clavicle, which is firmly united with the transverse processes of the two foremost vertebræ.

The first vertebra (Pl. IV, fig. 3, 4) is shorter than any of the following; in front it carries a pair of strong processes (a), articulated with the skull and behind continuing as wing-shaped transverse processes; the outer margin of the latter is embraced by folds of the anterior part of the clavicle. The spinous process is a low, elongated crest. The base of the neural arch has behind a deep triangular incision on each side, into which fits a long process from the next arch, corresponding to the process of the first vertebra; in this way the stiff connection mentioned above is brought about. The second vertebra carries on its middle a stout transverse process, somewhat bifid at the outer end, which is firmly bound by ligament to the clavicle. The neural arch and its spine are similar to those of the first vertebra.

The transverse process of the third vertebra is longer and more slender, the

* The small "intermedial" scutes which occur in most genera of Syngnathids, e. g. *Siphonostoma*, *Syngnathus*, *Nerophis*, have been overlooked as such by HUOT and mistaken for lateral-line organs.

neural arch only in front adapted for sutural connection with the preceding vertebra; the connection with the following being the same as that between the remaining abdominal vertebræ. These are in the main of one type, except the hindmost. They are long and slender, with long, flat and narrow, generally pointed transverse processes; the base of this process broadens gradually along the anterior half of the vertebra, more and more as we pass backwards, on the hindmost vertebræ almost reaching the front margin.

The spinous process is a low thin crest, in the middle over the level of the transverse process rising a little to form a vertical point. Articular processes are wanting, at most indicated as feeble undulations on the margins of the neural arches.

The hindmost abdominal vertebra (the 19th, Pl. IV, fig. 6, 7) supports the front part of the dorsal fin, but in different individuals a greater or lesser part; in structure, therefore, it corresponds to the 8 following caudal vertebræ, supporting the remaining greater part of the dorsal fin, but with the exception that it has no inferior arch. The triangular transverse process reaches basally along the whole anterior half of the vertebra, and backwards it extends along the lower margin of the corpus in the shape of a wing, rounded in outline (v). The spinous process as in the preceding vertebræ forms a thin longitudinal crest, but the upper margin of the latter carries some deep and narrow incisions (in the case figured two), strengthened along their margins with thickened ribs. Into each incision fits an interspinous bone. In some cases only the foremost interspinous bone is fastened to the posterior margin of the spinous process and for the rest to the following, the first caudal. The 8 (or 9) anterior caudals (Pl. IV, fig. 8, 9) show the same type as the last abdominal; only they are shorter, and the anterior extension of the transverse process is on the same level as the posterior wing; besides they possess inferior arches. The latter originates from the underside of the transverse process proper (fig. 9), near its hind margin; on the first caudal vertebra the distal ends of the arch may be separate and in position oblique towards the tail, while all the following form a short, vertical, inferior spine. Very often the first caudal vertebra has no inferior arch or only an indication of its basal part. The upper spinous processes each support 4 or 3 interspinous bones, the 8th, and sometimes also the second, 5. On the 8th caudal the posterior transverse wing is narrow and on the following it is wanting; evidently this structure is developed together with the muscles for the dorsal fin. As is well known the principal motor apparatus in the Syngnathids is the dorsal fin; to produce the powerful undulations of the latter the muscles to the fin rays are greatly developed, forming a voluminous layer inside the body muscles, separated from the latter by a pigmented membrane of connective tissue; the fin-muscles belonging to the outer part of this layer are basally attached to the transverse processes and their wing-like expansions. The remaining caudal vertebræ behind the dorsal fin are of one type, long and slender, with low dorsal crest, in the middle provided with a small vertical spine; the trans-

verse processes originate from the middle of the vertebra as short, flat triangles, pointing somewhat forwards; the posterior margin is thickened, the anterior quite thin. The inferior arch is situated under the middle, is short and so slender that the large vessels are to a great extent unprotected by skeleton. The vertebræ decrease in size evenly backwards; the last vertebra (Pl. IV, fig. 10) has no inferior arch, and immediately behind the transverse process it divides into two hypural bones, the upper of which is fused to the urostyle.

Of all the vertebræ, except the 3 anterior, the neural arches are basally pierced by more or fewer rounded openings.

Ribs are completely wanting. The distal ends of the transverse processes are by connective tissue fastened to the lateral plates of the dermal armour.

Interspinous bones. As modified interneurals may possibly be regarded the nuchal plates. The anterior smaller one covers the interspace between the occipital crest of the skull and the first spinous process; the posterior, larger and more elongated shield is situated over the spinous processes of the first and second vertebræ (Pl. IV, fig. 5). The anterior nuchal plate is provided with a median ventral keel, which — at all events in some individuals — may project rather far down in front of the spinous process of the first vertebra; the posterior also carries a median, but longitudinally cleft keel, embracing the lengthened spinous processes of the two anterior vertebrae. Thus these plates to a certain degree recall the structures found in *Aulostoma* where the interspinous origin of the nuchal plates is hardly to be doubted, a transition being found there through an uninterrupted series of structures gradually taking on the shape of ordinary interneurals. In *Fistularia* this transition is lost, but still some traces of their origin seem preserved, and besides the close relationship between the genera *Fistularia* and *Aulostoma* speak in favour of the interpretation accepted here. Now, in *Siphonostoma typhle* the presence of the ventral keel may indicate the last trace of the interspinous nature, but it may be of quite independent origin, and it is to be remembered that in some Syngnathids, e. g. *Hippocampus*, the anterior nuchal plate has no keel whatever, and that the relationship with the *Aulostomidae* is not very close. Furthermore the development of the embryo does not prove anything with regard to the nature of these shields. I have not been able to find them in a cartilaginous condition; they appear to originate as bone in connection with the spinous processes, from which they seem to be detached; but, on the other hand, they appear very early, before the median dermal plates are ossified.

The interspinous bones of the dorsal fin are bisegmented (Pl. IV, fig. 1, 8). The proximal (basal) segment is thin, the longitudinal muscular crest is wanting or slightly indicated, the cartilaginous axis richly developed. Close to the upper (cartilaginous) end it sends out a flat wing-like expansion to each side, or two, separated by an incision, sometimes almost closed to a foramen. Upon these expansions rest the medial margins of the upper lateral plates of the dermal armour, firmly attached by connective tissue (Pl. IV, fig. 12). Through the narrow apertures

left by the interspinous expansions and the dermal skeleton pass out the tendons of the fin-muscles to the rays. The distal segment is a small roundish cartilage, embraced by the cleft base of the fin-ray; it articulates with two neighbouring interneurals, and the whole series of these small cartilages is bound together by a ligament. The groups of interspinous bones attached to each vertebra are more or less fan-shaped; the median or the two median bones are generally straight, the anterior and posterior somewhat curved at their upper ends. The whole series produces a curious aspect, quite unique among teleosts.

It appears that in the larva the arrangement of these parts is more like that usually found in fishes, and is altered during growth. In larvae from the brood-pouch the spinous processes of these vertebrae are only represented by the median rib just over the transverse process, and the cartilaginous interneurals are almost parallel between two simple spines.

The interneurals of the anal fin are proximally fused into one piece (Pl. IV, fig. 11); distally there are two branches each provided with similar expansions as the dorsal interneurals; the expansions are joined to the two anterior plates of the inferior lateral row; these plates lie in continuation of the middle-lateral plates of the trunk. As in the dorsal fin the tendons for the anal fin muscles pass through the narrow openings left by the interneurals and dermal armour. The two confluent interneurals are connected through muscles with the lower face of the transverse processes from the foremost caudal vertebra; in specimens in which this vertebra has an inferior arch developed, the anal interneural is situated in front of the latter. The muscles constitute a narrow, fairly long and powerful bundle, which is easily separated into three, one for each fin-ray; to the inner side of this bundle are found the short and weak muscles originating from the interneurals. Outside the distal ends of the anal interneurals three small cartilages are found each embraced by its fin-ray; thus these interspinous bones are also bisegmented.

The fin-rays of the dorsal and anal fins are unjointed, and unbranched, like those of the pectoral fins; the rays of the caudal fin are all jointed, but unbranched; there are no short rays at the upper and lower margins of the caudal fin.

The number of rays is: D: 34—37; A: 3; C: 10.

Cranial skeleton. As in the other members of the group under examination the anterior part of the skull is highly elongated, Pl. V, figs. 1—4. The nuchal face as in *Aulostoma* and *Fistularia* slopes backwards so that the bones circumscribing the occipital foramen are visible from above. On the upper aspect (fig. 1) are seen: the supraoccipital (so), epiotics (ep), posttemporals (pt), pterotics (sq), frontals (fr), postfrontals (pf), prefrontals (prf), mesethmoid (mes) and vomer (vo). Along the middle of the last two bones a narrow, sharp crest is present. In front of the slightly expanded snout-end of the vomer is found a small cartilage, connected with the premaxilla and maxilla. The cartilage is a remnant of the contin-

uous ethmoidal cartilage found in the embryo and larva; during growth and ossification the cartilage is replaced by bones, only this small anterior median part and two basal lateral parts, each enclosed in the prefrontal (ectethmoid), being preserved.

The supraoccipital is in front wedged in between the frontals, behind it sends out a short, downwards directed nuchal process, connected through ligament with the anterior nuchal plate. The posterior margin of the epiotic projects like a crest, below which the strong tendon for part of the anterior lateral muscles is attached. Parietals and opisthotics are wanting.

The mesethmoid takes up more than half the length of the snout. The posttemporal (pt) is connected with the epiotic, pterotic and exoccipital; its pointed posterior end is bound to the front end of the clavicle by connective tissue.

On the lateral aspect the same bones are seen (Pl. V, fig. 4). On the posterior aspect (fig. 3) the exoccipitals meet each other above the foramen magnum as in *Aulostoma* and *Fistularia* and laterally each exoccipital projects into a process below the foramen, carrying an articular face for the process on the first vertebra. The condylar face is conically hollowed as usually; the margins of the hollow are stouter than the corresponding margins of the vertebræ.

On the lower aspect of the skull (Pl. V, fig. 2) the very large pterotics (sq) are particularly conspicuous, ventrally reaching the basioccipital (ob) and preventing the exoccipitals from meeting the prootics (pro). Between part of the latter and the basioccipital (ob) a cartilage is seen. The foramina for the nerves in the prootics are situated quite as in *Aulostoma* and *Fistularia*, those of the 5th nerve in the front face, towards the orbit, those of the seventh laterally (as typical in true Acanthopterygians); and the anterior articular surface for the hyomandibular also here belongs partly to the postfrontal, partly to the prootic, while the posterior belongs to the pterotic alone. A sharp ridge divides the part of the prootic visible from below from that looking towards the orbit; with this ridge a ligament from the hyomandibular is connected.

The parasphenoid (pa) is elongated, reaching farther in front than in *Aulostoma* and *Fistularia*, and connects in a long triangular suture with the vomer; it possesses a considerable orbital part, joining the frontal above and laterally bounding the fossa for the inferior musculi recti of the eye. A true "myodoma" is not developed, the prootics from both sides not meeting completely to form a bony roof over the origin of the eye-muscles.

The front end of the vomer is somewhat heart-shaped, edentulous; for a long way it is joined to the concave under face of the mesethmoid and its needle-shaped hind part reaches along the parasphenoid to the level of the prefrontals. The orbital wall of the brain-case is formed by the parasphenoid, prootic, postfrontal, alisphenoid (the latter, being small, is easily overlooked) and the frontal.

There is no canal for the lateral line in any of the cranial bones, nor in the preoperculum and preorbitals described below.

The mouth-parts are fairly large, except the intermaxilla (Pl. V, fig. 4, 5 i); the latter and particularly the maxilla (mx) is bound by strong ligaments to the snout-cartilage, the maxilla besides to the vomer and — as usual — to the maxillary process of the palatine. The mandible has three parts: the articular (ar) and dental (d) form together a large process for a branch of the tendon of the *M. adductor mandibulae* (another is attached to the maxilla); the angular (an) is small and as usual connected by a strong ligament — here a long one — with the interoperculum.

Teeth are completely wanting on all the bones of the mouth and pharynx, also on the branchial arches. Of the suspensory parts the hyomandibular (hy) is stout, fairly short and, contrary to the case in *Aulostoma* and *Fistularia*, very little sloping forwards. On the upper inner margin it has a wing-like expansion, joined by ligament to the prootic as mentioned above; the lower end is cartilaginous and connected with the proximal part of the horizontal symplectic (sy); the latter is joined to a process on the inner side of the stylohyal by a long ligament (l). The symplectic bifurcates into two branches; the lower fork is horizontal, continuing the horizontal stem and enclosing a cartilaginous axis; in front it joins the quadrate (qu); the upper fork is an oblique plate connected with the two antorbital (ao, ao') (particularly with the posterior, the preorbital proper), replacing so to speak the metapterygoid, which is completely wanting. The upper branch of the symplectic is bound to the skull by connective tissue.

The quadrate (qu) is much elongated, its outer face convex, the inner concave, behind it is pointed, broadening anteriorly; the front margin, contrary to the case in *Aulostoma* and *Fistularia*, slopes from behind forwards. The outer face is sculptured and carries a longitudinal ridge from the posterior end to the articular head for the mandible. The upper margin is for a long way not in contact with the pterygoid, a feature not to be found in the genera hitherto described. Only two pterygoids are developed; the ectopterygoid (ect), bent, with the front part joining the palatine (pa), the hind part connecting with the entopterygoid (ept) and the anterior margin of the quadrate; the latter also joins the anterior broad part of the entopterygoid, which tapers backwards to a point without reaching to the symplectic. The outside of the entopterygoid is covered by the anterior preorbital bone (ao'), except in front, their upper margins being joined.

The short palatine (pa) carries a prominent maxillary process. The preoperculum (pro) has a short ascending part covering part of the front face of the hyomandibular and extending to the cheek, embracing the origin of the cheek-muscle; the horizontal part is long, in front joining the posterior preorbital (ao) and — with a long oblique suture — the quadrate; the inner face carries a horizontal ridge connecting with the symplectic; (behind and) below the cartilaginous proximal end of the latter is the articular fossa for the stylohyal. The whole outer face is sculp-

tured, a longitudinal ridge, beginning from about the posterior angle, and continued by the above-described ridge on the quadrate, separates the cheek face proper from the inwards sloping under face.

The typical three opercular bones are present; but the suboperculum (s) is concealed by the operculum (o) (Pl. V, fig. 5), and the interoperculum (io) is generally only to be seen from below.

The operculum is large, vaulted, its upper anterior angle, outside the articulation with the hyomandibular, is drawn out into a muscle-process; the concave inner face shows a strong muscle-ridge, starting from the lower margin of the articular fossa. The suboperculum is extremely thin, sickle-shaped, hidden by the lower part of the operculum, only its hinder end is sometimes seen projecting outside the operculum into the opercular membrane; the latter besides encloses the two long and slender branchiostegal rays (r). Interoperculum (io) thin, fairly high, pointed at both ends, the front end joined by the ligament (li) to the angular, the hind end by the ligament (li') to the hyoid (to the process of the latter below which the branchiostegal rays are attached).

The infraorbitals are represented by the two large bones ao and ao' (Pl. V, figs. 4, 5), which however do not contain any lateral-line canal. The posterior (ao) is situated in the normal position for the antorbital (or preorbital); it is bound by strong connective tissue to the prefrontal, and in front of this spot it is emarginated for the nasal opening; inside the connection with the prefrontal the upper margin is firmly joined to the upper branch of the symplectic; the lower margin is suturally connected with the preoperculum, the front margin with the anterior preorbital (ao'). The latter is more elongated, its upper margin joined to the upper branch of the symplectic and to the entopterygoid, the lower margin to the outside of the quadrate; the front margin is free. The convex outer face of both antorbitals is sculptured; between their inner concave face and the outer face of the true suspensorial bones is the *Musc. adductor mandibulae*, the tendons of which appear below the margin of the foremost preorbital, branching to the mouth parts.

It is a curious fact that some of the previous authors did not recognise these bones as infraorbitals in spite of their position outside the muscles, covering these. That some authors have regarded the anterior infraorbital as the metapterygoid might be excused by the circumstance that its upper margin is suturally connected both to the entopterygoid and to the symplectic and thus to a certain degree plays the part of a metapterygoid; but in some other Syngnathids (e. g. *Nerophis*) it does not enter between the suspensorial bones, and besides its relation to the musculature ought to have prevented the mistake. That the posterior bone must be homologous to the preorbital, I think nobody will question; but in teleosts generally no bones are found in front of the preorbital; nevertheless they may occur in some fishes, as I have shown to be the case in *Amphisile*, where 1—4 small bones appear in this position. That no canal for the lateral line is present in the infra-

orbitals of *Siphonostoma*, and other Syngnathids is in accord with the fact that all the other bones of the skull as well as the dermal plates of the body are devoid of canals; and besides, if infraorbitals are found in other members of the group "Solenichthyes" (which is the case with *Amphisile*, *Centriscus*, *Aulostoma*) they also lack canals.

In *Siphonostoma*, and the Syngnathids generally, the connection between the cranial beak and the suspensory bones appears to be somewhat looser or weaker than in the preceding genera.

The hyoid (Pl. VI, figs. 1, 4, 5) is short, reaching only about to the front end of the first gill arch; it is composed of but 4 pieces, no division between an epihyal and a ceratohyal being visible. If we compare this form with *Aulostoma* and *Fistularia* it seems possible that the ceratohyal has vanished, or has been fused with the large lower hypohyal (hy^I); but I have not been able to find any trace of a suture, neither in the hypohyal nor in the epihyal, which might indicate two constituents. The lower hypohyal is very large as in the other members of the "Solenichthyes", and also here a considerable part of it covers the inside (fig. 4) of the epihyal (eh), whereas the latter overlaps on the outer side (fig. 5). The upper hypohyal (hy^{II}) is very small, roundish; the stylohyal (st) short and stout, with the articular head facing outwards, and carrying on the inner side, below the articular head, a strong process, which is connected by ligament with the symplectic. The epihyal on its outer side has a strong, triangular process, and below this are fixed the two long and slender branchiostegals (r), the upper of which is the stouter; both follow the opercular margins to the small gill-slit close to the nape (Pl. V, fig. 5 r).

The glossohyal (Pl. VI, figs. 1, 10 gl) is long and slender; the foremost longer part is cartilaginous; the proximal osseous part hardly projects over the anterior end of the hyoid; behind it is closed, without cartilage (sometimes a small separate nodule of cartilage is found between it and the first basibranchial). The urohyal is fairly long, reaching backwards past the level of the articulation of the hyoid; in front it is broad, head-shaped, the remaining part laterally compressed. Only two ossified basibranchials (copulae) are present; the first (co_I) follows immediately behind the glossohyal; its anterior end is without cartilage, the cartilaginous posterior end joins the cartilaginous front end of the second basibranchial (co_{II}); the posterior end of the latter reaches the hypobranchials (hy) of the second gill-arch. Sometimes an indication of a third basibranchial is found midway between the second and third arches in the shape of a weak lenticular nodule of cartilage.

As in *Aulostoma* and *Fistularia* the parts of the branchial arches belonging to the roof of the pharynx are reduced. The first gill-arch has only two parts, the ceratobranchial (c_I) and the epibranchial (e_I); the latter is rudimentary and widely separated from the first. The lower end of the ceratobranchial is completely

ossified, while in all the following it is cartilaginous. The epibranchial is sometimes incompletely ossified. The second gill-arch is composed of the typical 4 elements, the hypobranchial (hy_{II}) joins its fellow at the posterior end of the second basibranchial; its cartilaginous hind end passes without any articulation directly into the cartilaginous part of the ceratohyal (c_{II}); the latter is widely separated from the epihyal (e_{II}) which joins the considerably longer pharyngobranchial (ph_{II}). The third gill-arch is devoid of hypobranchial, its epibranchial separated from the ceratohyal but articulated to the pharyngobranchial; the latter (ph_{III}) is joined to the upper and inner side of the preceding pharyngobranchial. The fourth and fifth arches have only the ceratobranchial. Thus the branchial apparatus is still more reduced than in *Aulostoma* and *Fistularia*, not only the second and third epibranchials but also the first being separated from their ceratohyals; the fourth pharyngobranchial is lost, as well as the hypobranchials of the first and third arches; but two basibranchials are present; no trace of teeth. As the interspaces between the arches in the ventral median line are rather large, the whole gill-bearing apparatus appears elongated and reaches farther back than is usual in fishes; accordingly the operculum is also elongated. The five gill-clefts on each side are surrounded by gill-rakers, which are pointed and fairly long and contain an ossification (sometimes divided into two, the point being separately ossified); the gill-rakers are never directly joined to the skeleton, but enclosed in the skin, the posterior or inner row being farthest away from the skeleton; they do not go beyond the boundaries of the ceratobranchials.

The pectoral arch. This part seems to have been thoroughly examined by only two or three authors, PARKER (in his great work on the Shoulder-girdle (40) 1868), SMITT (54), and lately GOODRICH (15). None of these authors have made out the facts correctly; consequently their interpretation cannot be correct.

It is well known that the dermal armature in all *Syngnathidae* is composed of large bony scutes, arranged regularly in series and forming rings round the body. In *Siphonostoma typhle* each ring of the trunk anterior to the dorsal fin and the anal opening is composed of 7 plates (Pl. III fig. 2), 3 pairs — namely the superior (sl), median (ml) and inferior (il) lateral plates —, and one unpaired, the ventral plate. The interspaces between the large plates are filled out by small and thin ones forming one median series along the back, two along each lateral aspect (i) and one along each side of the belly. This arrangement is found immediately behind the pectoral fin. Anterior to the pectoral the arrangement is somewhat different. Here the clavicle (cl) forms part of the exoskeleton; the superior lateral plate is wanting, likewise the ventral plate; but in the closely related *Syngnathus* the ventral is present. In the dorsal median line is found an unpaired, rather thick and solid longitudinal plate (n), and anterior to this, behind the skull, a similar one, but smaller (n'). These two "nuchal" plates I regard as belonging to the endoskeleton, being in my opinion interspinous bones. Finally a plate is found, which seems to correspond to the true or median lateral plate of the following

rings; as it covers part of the muscles of the pectoral fin I propose to call it the "cover-plate" (c). The inferior lateral plate has the greater part on the ventral side, where it forms a large junction with its fellow from the other side; it may be termed the "jugular plate" (j).

In a slit between the clavicle and the "cover-plate" in front, and the lateral and inferior lateral of the first ring behind, the basals or pterygials of the pectoral fin are immovably fixed¹⁷.

Closer inspection shows that the clavicular arch only contains the posttemporal and the clavicle; the supraclavicle and the postclavicle are wanting. The posttemporal is already mentioned under the skull. The clavicle (Pl. III, figs. 1, 2, 6, 7 cl) has somewhat the form of a T; the anterior end of the horizontal branch is connected through ligament to the posttemporal; besides this branch is immovably fixed to the transverse processes of the 2 foremost vertebræ. The outer face of the anterior part of the horizontal branch is smooth and excavated, forming the interior wall of the tube leading to the gills; the hind part of the branch and the uncovered part of the stem are sculptured in the same way as the dermal plates. The lower end of the stem or vertical part is bifurcated, the outer branch (o) being connected with the lateral part of the jugular plate, the inner (i) with the horizontal part of the same. Through the passage thus produced a ventral portion of the lateral muscles goes to the urohyal.

The scapular skeleton is extremely weak; the cartilaginous part, preserved to a small extent in all bony fishes, here forms the greater part of the whole; in fact the ossifications appear so small in proportion to the cartilage, that the latter has been mistaken by the previous authors for the whole scapular skeleton.

The very small scapula (sc) has hitherto been quite overlooked; the coracoid (co) being much greater has not escaped attention but has been interpreted as an "interclavicle". PARKER wrongly supposed that it was composed of two pieces, and hence he described 2 "interclavicles"; SMITT observing better only corrected to one "interclavicle". GOODRICH figures only a "coraco-scapular cartilage"; the ossified coracoid is not represented in his figure, and the small scapular ossification is given as the first of his "5 radials" (i. e. pterygials).

The scapular foramen, present in other Teleosteans, here forms part of the large opening between the clavicle and the scapular arch; just in front of the scapular ossification pass the same nerves and blood-vessels which otherwise go through the foramen scapulare.

The 4 basals or pterygials (ba) are of peculiar shape. Their middle part is a narrow stalk, basally and distally they are laterally compressed and broad; so far their form might easily be derived from that found in *Fistularia* and *Aulostoma*. But in the Lophobranch the distal part is on both sides provided with 2 or 3 thin processes, which at their end are flattened out into more or less irregular plates. The latter lean against the dermal skeleton; those of the inner face are

immovably joined to the lateral and inferior lateral plate, those of the outer face to the dermal part of the clavicle and to the "cover-plate". In this way the structural arrangement before-mentioned is brought about; the whole part, on which the pectoral rays play, is solidly fastened between the lips of the slit in the armature. Through the narrow apertures left between the component skeletal parts the tendons pass from the pectoral muscles to the base of the fin-rays, thus arranged between and conducted by a system of "coulisses". In this way the whole scapular system is strengthened by the dermal armature, and the extremely thin and fragile, mostly cartilaginous, apparatus is rendered capable of forming the base for such powerful muscles as are really found here.

The peculiar structure of the pterygials and the mechanical part it plays, has hitherto escaped attention; only PARKER has observed the bony processes, which he compares with stag's-horns without understanding their functions.

The cleft base of the fin-rays embraces a small nodule of cartilage, which forms the joint with the cartilaginous mass resulting from the fusion of the distal ends of all the pterygials.

The (14) pectoral rays are as usual composed of two lateral halves, but unjointed and unbranched.

Osteology of other members of the Syngnathidæ.

In the other Syngnathids which I have examined the main features of the vertebral column are the same as in *Siphonostoma typhle*; i. a. the vertebræ supporting the dorsal fin are always provided with a secondary transverse process in the shape of a wing behind the primary one, whether they belong to the abdominal or the caudal portion. *Syngnathus acus* and *rostellatus* show hardly any peculiarities worth mentioning.

In *Nerophis* the three anterior vertebræ are still immovably joined together, but the third is more loosely attached to the second than in the genera *Siphonostoma*, *Syngnathus* and *Hippocampus*. In *Nerophis aequoreus* the greater part of the dorsal fin is situated on the abdominal vertebræ. In two specimens (♀) 12 resp. 11 vertebræ are modified to this end, 8 belonging to the abdominal, 4 or 3 to the caudal series; the groups of interspinous bones are the following:

A: 6, 4, 4, 3, 4, 3, 3, 3	4, 3, 3, 6 *
B: 4, 4, 4, 3, 4, 3, 4, 3	4, 4, 3.

All the abdominal vertebræ are long, with stout transverse processes, distally expanded and more directed downwards than in *Siphonostoma*, probably corresponding to the more compressed shape of the body; besides, these processes are somewhat nearer to the front end than in *S.* The first caudal has a well-developed inferior (haemal) arch; the last vertebræ carries a single vertical plate, probably

* The three hindmost of the last group are densely crowded together.

representing two fused hypurals and the urostyle, and embraced by 7 fin-rays; the latter are all really ventral to the end of the chorda. The dorsal interspinous bones are relatively longer, the spinous processes lower than in *Siphonostoma*; they possess similar but more regular expansions (cfr. Pl. IV, fig. 12). Anal fin and anal interneurals are wanting.

Nerophis ophidion has similar vertebrae to the preceding species; only the last caudal vertebra is without any plate, the caudal fin being absent. The dorsal fin is for the greater part situated on the tail. A specimen (♀) with 34 dorsal rays has its dorsal fin supported by 11 vertebrae, 3 abdominal and 8 caudal; the grouping of the interneurals is the following:

3, 3, 4 | 3, 3, 3, 2, 3, 3, 4, 3.

The caudal vertebrae, except the last, are provided with haemal arches; the last vertebra is rudimentary, without any processes save an indication of transverse processes. The number of caudal vertebrae in this specimen is 74!

In *Hippocampus* the vertebrae are shorter and stouter than in the preceding, elongated genera, but the general shape is the same. Also here the 3 anterior are immovable and first and second firmly joined to the clavicle. In the two species examined (*H. brevirostris* and *longirostris*) there are 11 abdominal vertebrae; the dorsal interspinous bones are connected with the two foremost caudal vertebrae (*H. brevirostris*, Pl. IV, fig. 2) or besides with the last abdominal (*longirostris*). The first caudal vertebra has a haemal arch but open below, sometimes joined to the next, which also may be open below. The haemal arches of the two anterior caudal vertebrae are directly in connection with the interspinous bones for the anal fin (Pl. IV, fig. 2). The secondary transverse process is very long, only separated by a narrow slit from the primary one on the vertebrae supporting the dorsal fin. The haemal arches are considerably stouter than in the elongated genera, and, as the vertebrae are shorter, the protection of the large subcaudal blood-vessels is much the same as in other fishes. The spinous processes are somewhat more strongly marked than in the other genera. The last vertebra rudimentary.

In *H. brevirostris* (♂) the number of vertebrae is found to be: 37 = 11 + 26.

The 15 (*H. brevirostris*) or 16 (*H. longirostris*) dorsal interspinous bones are bisegmented; the distal segment is a small cartilage; the proximal segment longer than in the preceding genera; the lateral expansions for connection with the 3 upper lateral plates of the armour are directed obliquely downwards. The row of interneurals is rather densely crowded, but two fan-shaped groups may easily be distinguished, one for each supporting vertebra (8 and 7 members). In each group the lateral expansions are directed towards the middle, pointing backwards on the anterior members and forwards on the posterior.

The anal fin in *H. brevirostris* has 3 bisegmented interspinous bones (not fused together); the terminal segment is a small cartilage, the proximal is long, reaching

to the hæmal arches of the two foremost caudal vertebræ; the fin-muscles originate only from the first. The anterior interneural is somewhat stouter than the others and with well-developed expansions for connection with the foremost pair of lower lateral plates, which bound the anal space; on the following interneurals the expansions are only indicated.

H. longirostris seems only to possess two anal interneurals.

The number of fin rays in the dorsal fin is 17—18, in the anal 4; their structure is as in the preceding genera¹⁸.

The other Syngnathids examined show essentially the same structure of the skull as *Siphonostoma*. *Syngnathus (acus and rostellatus)* only differs in minutiae in the outline or form of some of the bones. In *Nerophis (æquoreus and ophidion)* (Pl. V, figs. 10, 9) the most conspicuous differences are the following. The entopterygoid is longer and joins the upper branch of the symplectic. The posterior antorbital (ao) is considerably more elongated, in *N. æquoreus* reaching past the suture between the mesethmoid and vomer, while the anterior is much smaller and not in contact with the cranial beak (very often it is almost rudimentary, not reaching behind to the posterior preorbital); along the latter, therefore, the entopterygoid (ept) is uncovered for a long way; the front margin of ao' almost reaches the suture between the quadrate and the ectopterygoid. The bones of the skull, the suspensorial parts are stouter, the maxilla broader and stouter etc. than in *Siphonostoma*. In *Nerophis ophidion* the snout is short and stout, the mesethmoid and vomer therefore particularly powerful. In both species these two bones are about of equal length. The nuchal tendons, fastened to the epiotics, are ossified in *Ner. ophidion* (fig. 9 t), as in *Aulostoma*, *Fistularia* and *Solenostomus*, but unossified in *N. æquoreus*.

In *Hippocampus* (Pl. V, fig. 6) the differences seem more obvious; they are partly due to the large spines on the frontals, the smaller ones on the mesethmoid and supraoccipital, but besides, the braincase proper is relatively larger in proportion to the snout, the latter being not only shorter but also broader than in the preceding genera. The nuchal face is oblique in the opposite direction, from below upwards and backwards; the supraoccipital and its crest is much larger, forcing the epiotics (ep) down on the sides of the skull and giving attachment to the tendons (at *), which in the other genera are fastened to the epiotics. The posttemporal (pt) sends out from its lower margin a process (p) to the lateral wing of the exoccipital. The hyomandibular (fig. 7 hy) is much longer, and somewhat more sloping forwards, the ascending part of the preoperculum (pro), therefore, longer. As in *Siphonostoma* the entopterygoid does not reach the symplectic. The operculum is higher than long, the suboperculum extremely reduced, never visible from without (and very easily overlooked); the interoperculum short but high. There are three antorbitals (ao, ao', ao''). The same is found in the other genera of the Hippocampine group, e. g. *Solenognathus (hardwickii)*, *Gasterotokus* and *Phyllopteryx (foliatus)*. The posterior antorbital (ao) is small, especially in *Phyllopteryx* (Pl. V, fig. 8); in the latter the elongated middle antorbital (ao') is

provided with a hooked spine, pointing backwards. Also here the nuchal tendons appear to be fixed to the supraoccipital; the braincase is upon the whole similar to that of *Hippocampus*, but the snout is long and slender, and more than half its length is due to the mesethmoid.

In *Syngnathus* the branchial apparatus is like that of *Siphonostoma*, but in the other genera it differs considerably. In *Nerophis* (*aequoreus* and *ophidion*) the hyoid has only three pieces, the upper hypohyal, which in *Siphonostoma* is very small, being lost; there is only one branchiostegal, which bifurcates distally and is fixed to the inner side of the epihyal. The glossohyal is short but with long anterior cartilage, the urohyal long and stout. The gill-bearing part is still more elongated (Pl. VI, fig. 12); there are the same two basibranchials, but the first arch is provided with a hypobranchial, while all the following are devoid of hypobranchials; every trace of epibranchials is wanting, and the pharyngobranchials are reduced to one on each side, probably representing that of the second arch.* The gill-rakers are similar to those in *Siphonostoma*.

In *Hippocampus* (Pl. VI, fig. 11) (*brevirostris* and *longirostris*) the glossohyal (gl) is very short, the urohyal short and stout; the hyoid and the branchiostegals as in *Siphonostoma*. Basibranchials are totally absent. The first gill-arch possesses a hypobranchial and an epibranchial; the hypobranchial is longer than the ceratobranchial, and provided with flat lateral expansions; it is almost parallel to its fellow from the opposite side, or only feebly converging in front. The second arch is complete, having a pharyngobranchial, in the third only the hypobranchial is wanting. Thus, except the first arch, the gill-arches agree with those of *Siphonostoma*. The gill-rakers are somewhat longer than in the latter, but their ossified axis is confined to the basal part only.

The following tabular view of the genera examined will show the main features of the branchial apparatus:

Siphonostoma and *Syngnathus*.

Gill arch	(Copula) Basibr.	Hypobr.	Ceratob.	Epib.	Pharb.	Gill-rakers 1st row	Gill-rakers 2nd row
I	+		+	+		+	+
II	+	+	+	+	+	+	+
III	(+)		+	+	+	+	+
IV			+			+	+
V			+			+	

* Sometimes it may on the one side be divided in the middle by an articulation (representing 2d and 3d pharyngobranchial?); upon the whole it is often somewhat differently shaped on the two sides.

Nerophis.

Gill arch	(Copula) Basibr.	Hypobr.	Ceratob.	Epib.	Pharb.	Gill-rakers 1st row	Gill-rakers 2nd row
I	+	+	+			+	+
II	+		+		+	+	+
III			+		(+)	+	+
IV			+			+	+
V			+			+	

Hippocampus.

Gill arch	(Copula) Basibr.	Hypobr.	Ceratobr.	Epib.	Pharb.	Gill-rakers 1st row	Gill-rakers 2nd row
I		+	+	+		+	+
II		+	+	+	+	+	+
III			+	+	+	+	+
IV			+			+	
V			+			+	

Pectoral skeleton. *Nerophis* has no pectoral fins in the adult state; only the larvae possess well-developed pectorals, but without rays. In *Nerophis* the "pectoral ring" is composed mainly as in *Siphonostoma*, the only difference being that the second nuchal plate is joined to the clavicle, and the "cover-plate" is absent. As there is no slit in the armature for the missing pectoral fin the lateral plate of the following ring joins firmly on to the clavicle.

The clavicle is of the same type as in *Siphonostoma*, but every trace of the scapular arch has vanished together with the fin-muscles.

In *Hippocampus* (and its allies) the clavicular and scapular arches and the pterygials are in the main as in *Siphonostoma*²⁰. The pectoral ring does not materially differ from that of *Siphonostoma*. Comparing the figure (Pl. III, fig. 3) with the other one (fig. 2), the same constituents will easily be found. In *Hippocampus* there are 3 nuchal plates, the posterior is generally not to be found in the Syngnathine group. The anterior fig. 3 n' is of very peculiar shape, joining the skull and apparently forming the top of the bent head, often described as the "corona". This part is wanting in some members of the Hippocampine group (*Gasterotokus*, *Phyllopteryx*) but present in *Solenognathus*²¹. In *Phyllopteryx* the hindmost nuchal is provided with a long bony style, like the top of the supraoccipital, and several (paired) styles from the dermal armour supporting the curious dermals flaps characteristic of the genus.

Visceral anatomy.

All Syngnathidae possess 4 complete gills and a well-developed pseudobranchia, consisting of 3—4 lamellæ (4 in *Siphonostoma*, 3 in *Nerophis* and *Hippocampus*) of the same structure as those of the branchial arches. The upper gill lamellæ of each row take their origin from the pharyngeal wall, as in *Fistularia* and *Aulostoma*. On each side are 5 gill-slits, which do not reach farther dorsally than the ceratobranchial part of the arch; the anterior slit, between the hyoid and the first gill-arch, is much smaller than the following 4. The gill-rakers have already been mentioned, as also the fact that the structure of the gill-lamellæ does not materially differ from that of other teleostean fishes. For further information about the latter point I may refer to DUMÉRIL (12 a, p. 148 and b, p. 480), where the older literature is cited, and to RYDER (48, p. 193) and HUOT (19, p. 220).

The anatomy of the internal organs has been worked out and more or less completely described by several authors, among whom, besides those quoted by DUMÉRIL, I might mention RETZIUS, KRÖYER, LILLJEBORG and HUOT. Here I need only point out, for comparison with the other genera under consideration, that the intestinal canal is simple,* (straight or nearly so in the elongated forms, coiled in *Hippocampus*), apparently without distinct stomach, the boundary between the stomach and intestine being only marked off by the entrance of the bile-duct, without pyloric appendages and without mesentery (or only with rudiments of the latter, as in *Hippocampus*, cfr. MOREAU (36, p. 30)). The liver is not lobed, provided with a gall-bladder lying in an incision of its right side. The aorta follows the left side of the vertebral column. The air-bladder is present and provided at its anterior end with a "red gland". A urinary bladder is developed. The kidneys show peculiarities hardly found in any other Teleosteans. Such are the complete absence of Malpighian corpuscles (a feature only occurring also in the related genus *Solenostomus*), the situation of the whole kidney-substance, carrying urinary tubules and both urinary ducts, on one side of the body cavity, the right, following the strongly developed right cardinal vein (the left appears to be absent). Further ought to be noted the fact, that the pronephros or at any rate the large pronephric corpuscle and glomus and the coiled-up anterior part of the pronephric duct, structures so evident in other teleostean larvæ, here appear to be completely absent in the newly hatched larvæ (from the marsupium) and never to be developed later. Also the simple structure of the genital gland in the male, the testis being tubiform with central canal (cfr. JUNGERSEN 23 a, p. 119, German translation p. 203), is a feature which among many others shows that the Syngnathids have deviated strongly from a normal type and have been highly specialized²².

* A fact already known in 1673 to my countryman OLE BORCH (OLAUS BORRICHIIUS) for *Syngnathus* (3 p. 159).

Solenostomidae.

Solenostomus.

The genus *Solenostomus*, founded in 1803 by LACÉPÈDE (31, p. 102),* has been grouped with the *Syngnathidae* since the days of CUVIER (9a, p. 157), in modern times always as representing a distinct family. The species of the genus seem always to have been rare in collections, a fact which explains that their anatomical structure has never been thoroughly worked out. The only anatomical accounts known to me are those given by PALLAS (39, p. 35) and by GÜNTHER (16b, p. 151); both are very incomplete and contain some errors. Most authors have confined themselves to renewed descriptions of the oldest known species, or besides to the establishing on quite external characters of a few (3) new ones. The material which I have had the opportunity to examine only contains two species: *Sol. cyanopterus* Blk. and *Sol. paradoxus* (Pall.), and I greatly doubt the existence of more than these two species. Of both I have had at my disposal male and female specimens, all from Japan. For this most valuable material I am greatly indebted to Dr. SHIGEHO TANAKA and Mr. ALAN OWSTON.

The geographical distribution is very wide, and the two species seem to occur at the same localities; in fact both *S. paradoxus* and *cyanopterus* have been taken together at Boshu, Japan (JORDAN 1901), and specimens of both species are present in my collection from Japan from localities which are not far from each other; according to DUMÉRIL both are found at Mauritius (Isle de France).** The geographical range embraces the Indian Ocean and the western part of the Pacific, from Zanzibar to New Guinea and to the eastern coasts of Japan. Inside this wide area the localities where specimens actually have been found are rather few and scattered; no captures at the coasts of the continents or the great islands have hitherto been mentioned (or at all events distinctly stated). All the localities known to me from the literature and from Museum-specimens, which I have had the opportunity to see, are the following: Zanzibar (*S. cyanopterus*); Mauritius (*S. cyanopterus* (= *bleekeri*), *S. paradoxus*); Maldives (*S. paradoxus*); Amboyna (*S. paradoxus* (and "brachyurus")); Ceram, Wahai *** (*S. cyanopterus*); New Guinea (*S. cyanopterus*); "China" (*S. cyanopterus*);

* The name *Solenostomus* (1815 altered by RAFINESQUE to *Solenostoma*) was originally used by KLEIN 1744 for some true *Syngnathidae*, later, 1761, by SEBA for a species of the present genus, described in Thesaurus, Vol. 3, p. 106 and figured ibid. Pl. 34, fig. 4. This species is generally interpreted as identical with *Sol. paradoxus* (*Fistularia paradoxo*) of PALLAS, which also in my opinion is correct (cfr. for example the shape of the caudal peduncle).

** if *S. bleekeri* is = *cyanopterus*.

*** This locality, given by BLEEKER (2 p. 308) in the following words: "Habit. WAHAI, Ceram septentrionalis, in mari", has led to the erroneous conclusion that *Solen. cyanopterus* also occurred at HAWAII, in the Pacific! We meet the misunderstanding for the first time in KAUP (25 p. 2), who says: "Dr. Bleeker obtained his specimens in the sea of Hawaii and Ceram"; later we find it in JORDAN and SNYDER (22, p. 4) and in JORDAN and EVERMANN (21 b, p. 118); the latter say: "The only Hawaiian reference is that given by Bleeker. It is doubtful if the species really occurs in these islands"; and in the Synonymy they quote "Bleeker 1854, Natuurk. Tijdschr. Nederl. Indie, VI, p. 507, HAWAII and CERAM".

Boshu (Awa), Japan (*S. cyanopterus*, *S. paradoxus*); Jogashima, Japan (*S. cyanopterus*); Yenoura, Japan (*S. paradoxus*); Yodomi, Japan (*S. paradoxus* ("leptosoma")). All the Japanese localities are from the eastern coast of Hondo near the entrance to the Bay of Tokyo. Regarding their habits nothing definite is known; they most likely occur among sea-weeds, probably in shallow water; in fact two specimens of *S. cyanopterus* Jogashima kindly sent by Dr. TANAKA were taken "among sargassum". The time of breeding is unknown; I may only mention that a female *S. paradoxus* in my possession taken at Yenoura, Suruga Gulf, 7/12 1903, carried eggs with embryos and hatched embryos in the pouch.

As all current descriptions contain some more or less grave errors I have found it advisable to conclude my account of the anatomical structure with a revised definition of the genus and of the two species examined.

The following anatomical description has mainly been based on specimens of *Sol. cyanopterus*; the few points in which *Sol. paradoxus* differs are so small and insignificant that they can most conveniently be included in the definition of this species as given below.

Before describing the structures found by dissection I wish to point out a few features visible from without which seem not to have been observed hitherto or at least not to have been noted in the descriptions or figures known to me.

Such are the peculiar small cutaneous prolongations or "villi" scattered over a great part or most of the skin, also on that of the fins. In some specimens they are all quite small and difficult to see, in others some of them are at certain places rather prominent and easily seen, showing a tendency to symmetrical arrangement. The smallest ones are simple, low elevations, or like bluntly conical warts; the more developed are not only larger but may be more or less branched. In male specimens of *S. cyanopterus* they are specially large and frequently branched behind the anus, at the posterior margins and on the ventral sides of the "hump" carrying the anal and second dorsal fins; in some specimens in the British Museum very visible papillæ form a ring round (on) the eyeball, and these papillæ seem always to be present, but often difficult to see. They occur in both sexes and in both species examined,* but seem to be very variable as to their number and development (seasonal? perhaps more strongly developed at breeding time?)²³. At the mandibular symphysis *S. cyanopterus* has a well developed barbel; in spite of its size it has hitherto been overlooked, most likely because it is concealed between the mandibular rami. In *S. paradoxus* it seems less developed.

In addition to the well-known sexual difference shown by the ventral fins, DUMÉRIL gives the name correctly (12 b, p. 498): "Les 3 indiv. décrits par M. Bleeker . . . ont été pris dans la mer, à l'île Wahai et au nord de l'île Ceram". Wahai is (according to Andree's and Stieler's maps) a town on the north coast of Ceram.

* In 2 specimens of *S. paradoxus* in the Brit. Museum (a from Amboyna, Dr. Bleeker's collection, b from the Maldives, coll. S. Gardiner) I found them strongly developed; less visible on most of the specimens of *S. cyanopterus*, but always distinguishable, mostly so on spec. g (from China, coll. by Sir E. Belcher).

another is to be found in the nasal organ. The triangular fossa just anterior to the eye, where the nasal openings ought to be, shows in the male its hind part beset with thin cutaneous lamellæ radiating from beneath a flap hanging down from the upper margin of the fossa (Pl. VII, fig. 6). The lamellæ are thin, low at their upper end, enlarged below into projecting flaps; they are richly provided with blood-vessels; in each a small vessel follows the margin and breaks up into a network in the interior. In the female the skin of the fossa is smooth and even. Any real nasal openings I have not been able to detect.

In the male of *Sol. cyanopterus* the height of the snout at the middle of its length is greater than in the female, and the whole profile of the anterior part of the head is different (cfr. fig. 6, Pl. VII). The proportions of the height of the snout to its length (from the front margin of the eye to the end) are in the male about as 1 to 3, in the female ca. 1 to 4. In *Sol. paradoxus* there seems not to be any marked sexual difference in the form of the snout; but the material of this species at my disposal is too scanty and besides not well enough preserved for settling this point with certainty.

No lateral line canals are to be found, neither on the head nor on the body.

The following measurements have been made on 5 specimens of *S. cyanopterus* and 2 of *S. paradoxus*. Of *S. cyanopterus* specimens A and C are from Zanzibar, kindly lent me from the R. Museum at Berlin, the others, *S. paradoxus* included, are from Japan (*S. cyanopterus* B and D from Jogashima, E from Boshu, Sagami Sea; *S. paradoxus* B from Yenoura, Suruga Gulf).

Mm.	<i>Solenostomus cyanopterus</i>					<i>S. paradoxus</i>	
	♂ A	♂ B	♀ C	♀ D	♀ E	♂ A	♀ B
From snout to end of caudal fin	96	105	109	92	125	61	94
" " end of tail	65	71	81	65	95	46	68
" " nape	29	30	33	27	38	19	26
" " front margin of eye	22	21	26	20	29	15	19
Height of snout at its middle	8	8	7	5,5	7—8	2	3(2,8)
From foremost caudal fin-ray to end of caudal fin	36	41	32	30	32	17	28
Length of ventral fin	20	20	22	18	31	10	17
Height of first dorsal fin	17	17	17	15	20	11—12	15
Greatest height of thorax, between D ₁ and V	13,5	13	16,5	14	22	9	10
Height of narrowest part of body	6	6	6	6 (5,8)	7	3	4
" between D ₂ and A	10	12	13	10	16	6—7	7
Length of tail, from anus	8	14	15	14	17	10	15
" of vertebral column	40	42	45	40	55	27	40—41
From gill-slit to anal opening	21	27	30	24	38	16—17	26

Exoskeleton.

The dermal skeleton (Pl. VII, fig. 6) is composed of large ossifications arranged in transverse and longitudinal series, leaving large interspaces of naked skin. The shape and arrangement as well as the number of these ossifications are almost the

same in both species. Only on the high part of the body, anterior to the first dorsal and the ventrals, do unpaired ossifications occur, a row of 5 scutes forming an uninterrupted keel along the median dorsal line, while another, but interrupted, series, composed of 4 (exceptionally 5 or 3) median scutes, is found along the ventral margin. The members of the dorsal row are more or less cruciform, their longitudinal stems suturally united together, their transverse branches — except that of the first — united to the uppermost members of each of the paired transverse series. The scutes composing the latter are star-like, their branches mostly joined together, thus forming a kind of meshwork; the ventral members meet their fellows from the other side or are firmly united to the median unpaired ventral scutes. In this way the whole forepart, anterior to the fins, is apparently made immovable, forming a kind of "thorax". Of the transverse rows on each side of the "thorax", 3 behind the pectoral are most regular; in front of the pectoral the clavicle (cl) enters between the dermal ossicles, and the arrangement appears less regular. The hindmost of the 3 regular series consists of 6 members, the ventral of which is joined to the posterior median scute (No. IV); the upper 4 are not connected with the next row in front. This row contains 4 scutes, the ventral of which is joined to the median scutes II and III. All 4 members are connected with the 4 forming the next transverse row; the ventral scute of this row meets its fellow from the opposite side and moreover joins the unpaired scute No. II; the second upper one is connected with a branch of the clavicle. The next transverse row just in front of the pectoral also contains 4 dermal scutes; the ventral joins its fellow from the opposite side; between the uppermost and the second upper enters the clavicle, combining through a separate process with each. No more complete transverse series are to be found, the shoulder girdle forming the greater part of the skeleton at the anterior border of the body; only ventral dermal scutes are present corresponding to the ventral members of the transverse rows. The foremost pair always meet in the ventral median line, while behind them is interposed, between the next pair, the foremost unpaired scute I. Comparing several individuals some minor irregularities may be found in this region, while the more complete transverse series always seem to be identical as to arrangement and number.

Behind the thorax, on the slender part of the body and on the tail, an arrangement of the dermal scutes in vertical transverse rows is more or less pronounced, but in accordance with the greater mobility of this part the connections between the component members are partly dissolved, and no unpaired median scutes are found nor any junction between the scutes of the opposite sides at the margins of the body. Apart from the higher, hump-like, part carrying the second dorsal and the anal each transverse row is composed of 2 or 3 members, rows of 3 alternating — but not quite regularly — with rows of 2. In some of the 3-membered rows the members may be more firmly connected, in others only loosely or not at all, and the rows do not always correspond on both sides; that is to say, the same row which on the right side consists of 3 members may on the left only possess

two, and vice versa. At the end of the tail the rows are often incomplete, lacking upper or lower members. On the "hump" 3 large, anchor-shaped, marginal scutes are developed, reaching from the base of the second dorsal and the anal to the nearest members of the ordinary rows, being joined to these or interposed between them; thus, on this part of the tail, transverse rows of 5 or 4 members are found, and probably a certain amount of stiffness is acquired in this way. Sometimes only the dorsal set is firmly connected with the neighbouring upper scute, while the ventral set is interposed between the corresponding lower ones, sometimes the reverse is the case, and in some specimens both sets are firmly connected. In one (female) specimen of *S. paradoxus* 4 anal marginal scutes occur instead of 3.

Setting aside the marginal scutes of the "hump" the other scutes might as well be described as longitudinally arranged in 3 lateral rows*, an upper, a median, composed of fewer but larger members, and a lower. The number of scutes in the upper and lower longitudinal rows generally differ slightly, the one having one or two more than the other, and generally the number is not quite the same on both sides; the latter is also the case with the median row (comp. the table below, where the numbers are given). The shape of the scutes is more or less that of a star, with 4 or 3 branches. All the dermal scutes are provided with keels, most prominent in *S. paradoxus*, here producing a spiny aspect especially on the slender part of the body and on the tail.

The total number of transverse rows behind the pectorals, which naturally is the same as that of plates in the upper and lower longitudinal rows of body and tail, is for *S. cyanopterus* 28–30, for *S. paradoxus* 29–33 (for details comp. the table below).

Number of dermal scutes.

	Narrow part of trunk + tail				Total number of transverse rows, including the 4 on "thorax"	
	Median lateral row		upper lower lateral rows			
	left side	right side	left side	right side	left side	right side
<i>S. cyanopterus</i>						
A ♂	13	13	26 26	26 26	30	30
B ♂	13	14	26 24	26 25	30 (28)	30 (29)
C ♀	12	13	25 24	25 24	29 (28)	29 (28)
D ♀	13	11	25 25	25 25	29	29
E ♀	15	15	24 24	25 24	28	29 (28)
<i>S. paradoxus</i>						
A ♂	13	13	28 25	26 28	32 (29)	30 (32)
B ♀	20	21	28 28	29 28	32	33 (32)

* GÜNTHER (16 b, p. 151) only counts 2 rows; probably a misprint or a lapsus calami, since previously (42, p. 137) he gave the number correctly as 3.

Endoskeleton.

The vertebral column (Pl. VII, fig. 3) is composed of 33 vertebræ, 19 abdominal and 14 caudal. Ribs are wanting. The 3 anterior vertebræ are suturally united, the remaining only connected by means of the corpora, no articular processes being developed.

The 5 anterior vertebræ are larger and stouter than the rest, especially the 2nd and 3rd are large; from the 6th the vertebræ decrease in size backwards, only the last being again somewhat enlarged and together with the last but one expanded into a large vertical plate supporting the rays of the caudal fin.

Strong anterior articular processes on the 1st vertebra overlap corresponding processes on the exoccipitals, allowing the skull to be moved vertically. The tendons for the muscles which raise the head are ossified (as in *Fistularia*, *Aulostoma*, *Nerophis ophidion*), forming on each side a large flat bone, in front fastened to the epiotic, behind dissolving into numerous fine threads (Pl. III, fig. 10 td). Posteriorly the 1st vertebra is immovably joined to the 2nd by means of strong denticulations, and in the same way the second joins the third. Spinous processes are developed on all the vertebræ. Transverse processes are wanting on the anterior 4 and only indicated on the 5th; from the 6th on all the remaining abdominal vertebræ show a well-developed transverse process, increasing in size backwards and becoming more and more directed downwards; on the first caudal it joins its fellow from the opposite side forming a strong laterally compressed inferior spine. No "secondary" transverse processes occur on any of the vertebræ.

The superior and inferior spinous processes on the 9th or in another specimen the 10th caudal (the 28th or 29th vertebræ) are almost vertical, those on the following inclined or bent forwards; this position is apparently due to the extreme development of the parts supporting the caudal fin. On most of the vertebræ a process occurs from the base of the neural arch behind the spinous process and a similar one ventrally in the corresponding position (i. e.: on the abdominal vertebræ behind the transverse process, on the caudal behind the inferior arch). On the penultimate caudal vertebra these processes are fused with their fellows from the opposite side, distally expanding into a large, laterally compressed plate. Probably the still larger plate surrounding the last vertebra is made up of corresponding elements fused with the true upper and lower spines and the hypurals. To elucidate the exact composition of this ray-supporting apparatus an examination of sufficiently young specimens would be necessary. That the extraordinarily large size of the caudal plate is caused by the great development of the fin is very evident and needs no further explanation.

If we compare the vertebral column with that of the Syngnathidæ the chief points of resemblance seem to be the intimate connection of the 3 anterior vertebræ and the absence of articulations between the neural arches of all the other vertebræ; in general shape there are no obvious resemblances, neither with the Syngnathidæ nor with *Fistularia*, *Aulostoma* or *Centriscidae*.

As the muscles for the second dorsal (and the anal) do not show any particular development and as correspondingly no muscular processes on the vertebræ supporting these fins are present either, we are justified in supposing that these fins are not used for locomotion in the way characteristic for the Syngnathidæ²¹.

The interspinous bones of the first dorsal fin are unisegmented, 5 in number. The first is broad and stout, its lower end bifurcated, in one specimen skirting over the tip of the spinous process on the 6th vertebra; the anterior branch forms a broad plate, the front margin of which seems firmly connected at its lower extremity with the underside of the 5th median dermal scute; the posterior branch is narrow but fairly strong; together with it the following 3 interspinous bones are enclosed in the space between the spinous processes of the 6th and 7th vertebræ, closely packed together; the fifth interneural is a short broad plate, firmly embraced by the bifurcated tip of the 8th vertebral spine. Thus the supporting apparatus for the large rays of the first dorsal is in this way considerably strengthened.

The interspinous bones of the second dorsal and the anal are bisegmented, the distal segment being only represented by a cartilaginous nodule, very much like that of the Syngnathidæ.

The second dorsal fin is supported by 17 interspinous bones. Distally the 1st is laterally compressed, flattened out into a plate supporting the anterior corner of the dorsal "hump"; in a similar way the posterior corner of the hump is strengthened by an expansion formed by the fusion of the distal parts of the 2 or 3 hindmost interneurals. The 3 anterior are enclosed in the space between the spinous processes of the 1st and 2nd caudal vertebræ, the following 3 or 4 between the 2nd and 3rd, next 3 or 4 between the 3rd and 4th, then 4 or 5 between the 4th and 5th, and finally 2 or 3 behind the latter. There are no connections with the marginal scutes of the dermal skeleton, consequently the bony expansions at the distal end of these interneurals characteristic for the Syngnathidæ are not developed here.

Those of the anal fin are likewise 17 or 16, the anterior 2 distally fused together, and the same is the case with the posterior 3 or 2. The first is situated in front of the inferior spine of the first caudal; the following interspace encloses 3, the next 3 each have 4, and the last very short one lies behind the inferior spine of the 5th caudal.

The 5 fin-rays of the first dorsal are strong and long, pointed, without any longitudinal or transverse division; they are to be regarded as spinous rays.

The number of rays in the 2nd dorsal and the anal (in the specimens examined by me) is 18—20 in *Sol. cyanopterus*, 21—22 in *S. paradoxus* (comp. the tab. p. 322 [56]); that of the caudal fin always 16. The fin-rays of the 2nd dorsal and of the anal are feeble, unbranched but ending in a bundle of extremely fine threads; the distal part of most of them is transversely jointed, only some of the anterior are without joints. The caudal rays are comparatively strong, the median

and longest less strong; all are simple, unbranched, evenly tapering and pointed; viewed under a microscope their distal part appears longitudinally divided, but the two halves are tightly adpressed; no joints (or only a few and indistinct traces) are to be seen²⁵.

The cranial skeleton. In general appearance the head resembles that of a Syngnathid. In proportion to the brain-case the snout part is extremely prolonged and strongly compressed laterally. As in Syngnathids the quadrato-mandibular articulation is situated almost below the front end of the vomer, thus the position of the mandible when the mouth is closed is almost vertical (opposite to the case in *Fistularia*, *Aulostoma* and *Centriscus*, but agreeing with *Amphisile*, *Siphonostoma* etc.). On the upper side of the skull 3 crests are observed, one median, shorter, on the supraoccipital, and 2 lateral, longer, beginning at the hind margin of the epiotics, running forwards on the frontals, rising in height over the orbits and from here converging towards the mesethmoid, where they merge into one sharp edge just above the anterior ends of the nasal fossæ. The crests are (or may be) finely denticulated (especially in *S. paradoxus*).

The supraoccipital joins the frontals; parietals (and opisthotics) are absent.

The epiotic is large; just below the posterior end of the crest mentioned above an ossified tendon for the strong nuchal muscles is fastened (cfr. p. 315 [49]), and below this bone the epiotic is connected with the upper fork of the posttemporal (pt). The exoccipital carries a lateral process for connection with the articular process of the first vertebra; both exoccipitals meet above the occipital foramen. The articular face of the basioccipital is concave, oblique in position, sloping from behind forwards and downwards. On the lower face of the skull the basioccipital is laterally expanded (above the parasphenoid) and in front separated from the prootic by a narrow cartilage (as in *Syngnathus*). The pterotic (sq) is large, reaching the basioccipital below and thus intervening between the exoccipital and the prootic. Posteriorly the pterotic carries a crest, connected with the lower fork of the posttemporal; in front it forms together with the prootic the posterior articular face for the hyomandibular, while the anterior articular face belongs to the prootic and postfrontal.

The greater part of the cranial "beak" belongs to the mesethmoid. This bone embraces most of the nasal fossa, forming the greater part of its roof and floor and its whole median wall, while the rest of the fossa is bounded by the frontal and prefrontal. Just in front of the nasal fossa the mesethmoid carries a strong lateral spine, which may be more or less branched, and seems most strongly developed in *S. paradoxus*.

The vomer (vo) is short in proportion to the mesethmoid, laterally compressed towards its front end. As in *Syngnathus* a small rounded rostral cartilage is present. The posterior end of the vomer underlies only the foremost part of the mesethmoid, reaching behind about to the level of the oblique suture between the

quadrate and the symplectic, ending far in front of the parasphenoid. The anterior end of the parasphenoid is found at a level with the middle of the nasal fossa. Thus a large part of the lower face of the mesethmoid intervenes between the vomer and parasphenoid forming alone the roof of the mouth-tube as in *Fistularia* and *Aulostoma*; this part of the mesethmoid is excavated below, with projecting margins, to which the suspensory bones (entopterygoid and mainly the symplectic (sy)) are fastened. The parasphenoid forms an obtuse angle below the posterior margin of the orbit and reaches along the prootics and basioccipital almost to the articular condyle of the latter. At the posterior orbital wall the parasphenoid sends out an ascending process to meet the front part of the prootic and the alisphenoid. Between this process and its fellow from the opposite side the upper face is somewhat hollowed for the attachment of the inferior musculi recti of the eye. As far as I could make out no bridging over of this muscular fossa by the prootics or alisphenoids is found, and consequently no "myodoma" is developed. The alisphenoid is fairly large, forming part of the orbital wall between the frontal, postfrontal, prootic and ascending process of the parasphenoid.

The intermaxilla (i) has a distinct but small ascending part connected with the rostral cartilage; the maxilla (mx) is relatively large, as usual connected with the vomer and rostral cartilage and with the maxillary process of the palatine. The lower jaw (Pl. VI, fig. 6) seems only to be composed of the articular (ar) and the (edentulous) dental (d); a separate angular I have not been able to make out.

The hyomandibular (Pl. VII, fig. 3 hy) is short, comparatively slender; its outer face joining the preoperculum is sculptured, its inner face anteriorly drawn out into a slight ala; its lower end is cartilaginous and joins the hind end of the horizontal symplectic (sy). The latter forms a long and high plate, the upper margin of which joins the mesethmoid, the lower margin is thickened and contains a cartilaginous axis; the bifurcation characteristic for the Syngnathids is absent here. Anteriorly it joins the quadrate in a long oblique suture, and its upper anterior point overlaps suturally the posterior end of the entopterygoid (ept). As in Syngnathids the metapterygoid is wanting. The entopterygoid is a narrow lamella, joining the ectopterygoid (ect) anteriorly in a short suture. The latter is sabre-shaped, joining the anterior thickened margin of the quadrate in a long suture, and in a short suture connecting with the palatine (pa); this bone is short and stout, giving off as usual a short, diverging maxillary process. The quadrate (qu) is long and high, its anterior margin almost vertical (thus in position intermediate between that in *Fistularia* and *Aulostoma* on the one side and Syngnathids on the other); the upper margin in front touches the entopterygoid, but apart from this a narrow membranous strip intervenes between these bones as a feeble indication of the large interspace found in *Syngnathus*; the outer face is very slightly convex with a longitudinal (denticulated) crest running towards the articular head for the mandible and continuing a similar crest along the preoperculum.

The ascending part of the preoperculum (pro) is short, slightly oblique, its

anterior margin embracing the origin of the cheek-muscle; the long horizontal part joins the quadrate in an oblique suture, a little past the middle of the snout; with the lower part of the symplectic it connects through a rounded crest running on the inner face along the upper margin. A reticulated sculpture adorns the outer face of the preoperculum as well as that of the quadrate, entopterygoid and symplectic; the more prominent crests are finely denticulated²⁶.

Three opercular bones are present as usual²⁷. The operculum (Pl. VII, fig. 6 o) is large, somewhat fan-shaped, the surface reticulated and carrying 3 crests radiating from the upper muscular process, the uppermost one following the upper margin. The suboperculum (s) is a long and extremely narrow bone, almost bristle-like, posteriorly tapering; keeping at some distance from the operculum it curves round the anterior, lower and posterior margins of the latter. It has hitherto apparently been mistaken for one of the branchiostegals. The interoperculum is disconnected from the suboperculum and situated on the inner face of the preoperculum, forming a very thin lamella, as usual connected by ligament with the mandible.

Nasals and infraorbitals are completely wanting, and no lateral-line canals are to be found in the preoperculum or in any other bones of the skull.

The hyoid (Pl. VI, fig. 2, 3) is very unlike that of the true Lophobranchiates, being here complete, composed of all the typical parts: 2 hypohyals (hy^I, hy^{II}), small on the outer aspect (fig. 2), a long ceratohyal (ch), a short epihyal (eh), and a very short stylohyal (st); the latter carries on its outer face a long horizontal process pointing forwards and lodged into a fossa on the inner side of the preoperculum. On the inner face of the hyoid (fig. 3) both hypohyals — especially the lower — are produced into long processes covering the anterior part of the ceratohyal.

The urohyal (Pl. VII, fig. 3 u) is long and slender, posteriorly cleft into 2 long branches, the left again bifurcating. Only one branchiostegal (r) is present, fixed along the outer face of the epihyal and ceratohyal. The single stem is soon bent at an open angle and then divides into two slender branches, the lower of which is much longer than the upper and following the equally slender suboperculum curves round the operculum about to the upper end of the gill-slit²⁸.

The branchial skeleton (Pl. VI, fig. 9) is reduced and rudimentary, even more than is the case in the *Syngnathidae*. All unpaired elements — glossohyal and basibranchials (copulae) are wanting, and there are no traces of gill-rakers. On the other hand, teeth are present on the lower and upper pharyngeals. The first gill-arch consists of two slender bones about of equal length, connected through an undivided cartilage; they represent the hypobranchial and ceratobranchial. The second arch consists of three or four parts: a rather long hypobranchial, connected by undivided cartilage with the ceratobranchial, and a very small, rudimentary epibranchial, carrying a single tooth; this part may be absent; in the specimen figured it is developed only on the right side; the fourth part, the pharyngobranchial, is widely separated from the rest, united to the pharyngeal belonging to the third arch. Of the third arch the hypobranchial is wanting, as in the *Syngna-*

thidæ; the remaining three (or two) parts being the ceratobranchial, a rudimentary epibranchial (the latter sometimes absent) with two teeth, and, widely separated from the rest, the pharyngobranchial. The fourth and fifth arches only consist of the ceratobranchial, that of the fifth — the "lower pharyngeal" — expands into a narrow plate carrying a number of pointed teeth.

The two „upper pharyngeals“ (Pl. VI, fig. 7, 8) are joined end to end, and on the ventral face each expands into a tooth-bearing lamella with its margin dorsally enrolled; they are — as already stated — widely separated from the other parts of the branchial skeleton, but the rows of gills are continued almost to their posterior end, on the pharyngeal membrane. A comparison with the *Syngnathidæ* and with *Fistularia* and *Aulostoma* tends to show that these two pharyngobranchials really belong to the second and third arches, as stated above.

In tabular form the main features of the branchial skeleton would be:

Gill-arch	Basibranchials	Hypobr.	Ceratobr.	Epibr.	Pharyngo-br.	Gill rakers
I		+	+			
II		+	+	[+]	+	
III			+	[+]	+	
IV			+			
V			+			

Compared with the other genera, *Hippocampus* (Pl. VI, fig. 11) would be the one, which in construction of the gill-apparatus is the nearest to *Solenostomus*.

The shoulder-girdle (Pl. VII, figs. 3, 4, 5). The clavicular arch is composed of 3 parts: the posttemporal (pt; supraclavicular I), the supraclavicular (II) (scl) and the clavicular (cl); as in Syngnathids the postclavicular is wanting. The post-temporal does not form part of the skull, as is the case in Syngnathids; seen from the outer side (Pl. VII, figs. 3, 5) it appears bifurcated, the upper branch suturally united to the epiotic (ep), the lower one to the pterotic (sq); from the inner face a process combines with the exoccipital. With its hind end articulates the upper end of the slender and fairly long supraclavicle (scl), which in turn is articulated on the outer face of the upper end of the clavicle. The clavicle (cl) resembles to a certain degree that of the Syngnathids; the two processes p and p' combining with the dermal plates, the first behind, the latter in front of the pectoral fin, are easily recognisable as homologous to the parts in *Siphonostoma* or *Hippocampus* lettered in the same way in figs. 2, 3 and 7, Pl. III; but a great difference is apparent in the fact, that in *Solenostomus* no connection between the clavicle and the anterior vertebrae has been established; the great anterior expansion of the clavula used for this connection in Syngnathids is therefore absent here, the corresponding part only being used for connection with the supraclavicle. In this point some resemblance to *Fistularia* is apparent; and the lower part of the clavicle

resembles that of *Fistularia* still more, as it divides into an outer (anterior) larger (o), and an inner (posterior) narrower branch (i). To the latter is joined the greater part of the scapular arch, only the lower anterior end of the coracoid being connected with the outer branch; thus a large opening is surrounded by the clavicle and the coracoid. In *Aulostoma* the corresponding opening is reduced to a mere hole through the enlargement of the anterior part of the coracoid; in the Syngnathids, on the other hand, the same space is open ventrally (only closed with the dermal skeleton) because the coracoid here has not developed any anterior process.

The scapular arch (Pl. VII, figs. 4, 5), while in general shape recalling that of Syngnathids, is in some respects intermediate between this and that of Aulostomids, especially of *Fistularia*. The unossified, cartilaginous part of the arch is proportionally much smaller than in Syngnathids, not very much greater than in *Fistularia*. As in the Syngnathids the scapula (sc) is very small, at first sight appearing like a pterygial, but the scapular foramen is restricted to the scapular region; this foramen is narrow, vertically elliptic, bounded by the scapula and part of the clavicle. The latter condition might be derived from that found in *Fistularia*, if we suppose the thin cartilaginous anterior part of the scapula in the latter to have been suppressed in *Solenostomus*.

The coracoid (co) is the largest bone of the arch; its slender anterior branch is tipped with cartilage, firmly connected with the outer branch of the clavicle; its lower posterior angle is drawn out into a process (co') apparently corresponding to that lettered in the same way in the other genera. The 4 pterygials (basals) (ba) are rather large, resembling those in Syngnathids, being laterally compressed, in their middle constricted into a narrow stalk; distally their cartilaginous ends are confluent, forming one continuous semicircle, the upper part of which belongs to the scapula. The outer face of this semicircular cartilage is even, but the inner (medial) face (fig. 4) is provided with a number of elevations or columns between which the tendons from the medial muscles to the fin rays are guided. Ligaments passing from one to another of these columns, and the skin connecting with their distal ends, convert the fossæ between them into regular holes for the tendons. Thus, only the inner faces of the pterygials show structures (cartilaginous) comparable to the peculiar osseous excrescences occurring on both faces of the pterygials in Syngnathids. Of the 4 pterygials the lowermost is by far the largest, as also is the case in all the other genera²⁹.

The base of each of the feebly ossified fin-rays embraces a separate small nodular cartilage, which by means of a saddle-shaped face plays on the convex margin of the combined pterygial (and scapular) cartilage; quite as in Syngnathids. Most of the fin-rays — some of the superior and inferior only being excepted — are jointed; all are unbranched, the distal ends forming a bundle of extremely fine threads.

The ventrals are almost vertical in position, with that face outwards which

in most fishes is turned towards the belly. Accordingly, the pubic bones (Pl. VII, fig. 3 p) are not lying flat but stand upright. Those margins, which are usually as inner margins in contact, are here not only free of each other but diverge, pointing upwards and outwards; whereas those margins, which are usually the outer margins and diverge, here converge and (nearly) meet ventrally. Each pubic bone forms a large erect plate somewhat inclined from the mid-ventral line towards the lateral body wall; it is thick behind where the ventral rays are attached, extremely thin at the upper and anterior margins. The interior is to a great extent cartilage, and the lower anterior part is almost unossified. The outer surface carries a strong crest (cr) dividing between the muscles to the lowermost, spinous, ray and those to the other rays; above and parallel to this crest a smaller and less prominent one is found in addition. The upper margin of each pubic is firmly joined to the lateral body-wall (especially through dense connective tissue to the inside of the second dermal scute from below in the posterior transverse thoracic row); the lower margin of the anterior part joins the median ventral scute, here meeting its fellow from the opposite side. The posterior ventral corner (*) of the thick hind part is tightly fastened to the inside of the lowermost scute of the last row of the thorax. In this way the skeletal support of the ventral fin-muscles is strengthened³⁰.

Of the 7 rays in the ventral fin the outer (lower) is an undivided spine; the remaining 6 are biramous, the two main branches parting nearest to the base in the innermost (uppermost) rays. Each of the two main branches is again longitudinally split, but the two halves are tightly pressed together. Indistinct traces of a transverse articulation are visible. In the female some of the peculiar thread-like appendices for retention and nutrition (?) of the eggs and young are ossified; these ossifications appear as rather long, slender branches from the divided rays, except the uppermost one; they are generally twisted in a corkscrew-like manner and end in a small rounded knob; (counting from below the 2nd ray carries 2, the 3rd 3, the 4th 5, the 5th 4, the 6th only 1 of these osseous branchlets in an old and large specimen of *S. cyanopterus* in my possession)

Number of fin-rays in the specimens examined.

	P	V	D ₁	D ₂	A	C
<i>Sol. cyanopterus.</i>						
A ♂	26	7	5	18	18	16
B ♂	27	7	5	20	20	16
C ♀	27	7	5	18	20	16
D ♀	26	7	5	19	19	16
E ♀	24	7	5	19	19	16
<i>Sol. paradoxus.</i>						
A ♂	26	7	5	22?	23?	16
B ♀	24	7	5	22	23	16

In the literature we find the following:

	P	V	D ₁	D ₂	A	C
<i>Solen. cyanopterus.</i>						
Bleeker 1851	22	11	5	19	19	12
Günther 1866	26*					
	18	7	5	18	16—17	14
Duméril 1870	26**			18**	18**	20**
	25	7	5	16	16	20
Günther 1870	26	7	5	18	16—18	
Jordan and Snyder 1901	27	7	5	20	19	15
<i>Solen. paradoxus.</i>						
Seba 1758		7	4	3		13
Pallas 1770	c. 25	7	5	c. 18	c. 12	14
Bleeker 1854	25	7	5	20	20	15
Duméril 1870	♂ 27	8				
	♀ 25	7	5	18	18	16
Günther 1870	25	7	5	20		
Jordan and Snyder 1901	24	7	5	21	22	16***
Tanaka 1908	c. 23	7	5	19	16	15****

Remaining anatomical features and visceral anatomy.

In the female the inferior (outer) margins of the two ventrals are united at the base for quite a short distance but otherwise free of each other; the upper (inner) margins are fused with the abdominal skin, the fusion reaching to the front border of the anus; in this way is formed the often-mentioned brood-sac. The lining of this sac carries a great number of filaments arranged in longitudinal rows; most of the filaments take their origin from all the fin-rays except the lowermost (outer) spinous ray, but quite a number form one row along the middle line of the abdomen; the longest and most developed are those of the anterior half of the sac, but along the fin-rays they are found almost to the hind margin of the sac, gradually decreasing in length, the hindmost being very small.

Part, if not all, of the filaments on the rays contain a slender, undulated or twisted bony axis, an outgrowth from the bone of the ray, as mentioned above under the osteology of the ventrals. This axis only occupies the basal part of the

* The number 26 is given in the description, 18 in the formula.

** These numbers are given for „*Sol. bleekeri* A. Dum.“ which I consider as identical with *cyanopterus* Blk.

*** The number of caudal rays taken from the figure.

**** TANAKA's species “*Sol. leptosoma*” I regard as a male *S. paradoxus*. The number of caudal rays is that given in T.'s figure. Also BLEEKER'S *Sol. brachyurus* is in my opinion = *paradoxus*; no number of fin-rays is stated. KAUP 1856 has the following numbers for “*Solen. paradoxus*” P: 27, V: 7, D₁: 5, D₂: 18—19, A: 18—19, C: 15, but his “*paradoxus*” comprises both *cyanopterus* and *paradoxus*. His material of 5 specimens is still in the Museum of Paris and contains 2 *paradoxus* (1 from Isle de France, 1 from the Indian Ocean) and 3 *cyanopterus* (2 from New Guinea, 1 from Isle de France; the latter = “*S. bleekeri*” Dum.).

filament, scarcely reaching to the middle of its length (Pl. III, fig. 11 ax). When the filament is laid under the microscope the bony axis appears transparent and refringent, but its bony nature is easily shown through staining, e. g. with alizarine or haematoxyline; I suppose it is the structure about which GÜNTHER says (16 b, p. 151): "A slightly undulated canal runs along the interior of the filament". In the filaments from the middle line of the abdominal skin I have found no bony axis. All the filaments are richly beset with shorter or longer branchlets or twigs. Each branchlet is expanded at its end into a regular concave disc, looking like a sucker; this I take to be the special organ of retention for the eggs and young. I am not able to elucidate the special manner in which the retention is brought about, whether each egg is always held by one sucker, and the young also, or if in the latter case two or more discs are at work. My only specimen with a few eggs and newly hatched young still contained in the sac (a *S. paradoxus*) is not well enough preserved to show things definitely; it seems to have been somewhat dried and shrivelled before being preserved in alcohol, but the presence of traces of discs fastened to the eggs, one on each, and also to the embryos, I have ascertained with certainty. Whether the filaments are also organs of nutrition I am not in a position to decide; they are provided with blood-vessels, from the stem entering every branchlet; thus the nutritive function seems to me to be at least possible, a secretion to the interior of the sac being probable. Certainly many questions of great interest regarding the biology and development of these curious fishes are to be solved, and it is to be hoped that some day one of the zoologists having the opportunity of observing the living animals in their natural surroundings will take up the task.

Possibly the whole interior lining of the brood-sac belongs to the ventrals; the real condition might perhaps be, that both ventrals as in the Gobies are coalesced along their upper or inner margins and the coalesced part again fused with the abdominal skin; if this interpretation should prove to be the correct one, the power of sending out filaments would be possessed only by the fin; this question — perhaps of no great importance — could most probably be solved by an examination of the histology of appropriate material or of developmental stages.

On the "thorax" only the dorsal part of the muscles is fully developed, most of the lateral body-wall below the vertebral column being devoid of muscles; the same is the case on the posterior, slender portion of the body with part of the ventral body-wall. The myomeres are here well developed along the whole part provided with dermal ossifications and further along a narrow strip close to the ventral middle line of the belly, from the ventrals to about the anus; the intervening lateral space of the body-wall, covering the side of the intestine, is — like the "linea alba" — devoid of muscles. No division into myomeres is seen in the strong dorsal muscles reaching from the skull to the level of the 3rd transverse row of scutes; and this part of the musculature is provided with a flat strong ossification (Pl. III, fig. 10 td), corresponding to that found in *Fistularia*, *Aulostoma*,

and *Nerophis ophidion*; narrow in front, where it firmly joins the epiotic, it widens gradually backwards, finally dissolving into a number of threads. Between the skull and the first transverse row of scutes it may be seen through the skin, the remaining part being more or less concealed by the overlying upper members of the 3 anterior transverse rows of scutes.

The branchial cavities of the left and right sides communicate through a large, oval opening (Pl. VII, fig. 3 o) under the branchial skeleton, a condition only found in a few other fishes (e. g. *Zeugopterus* and some other flounders). There are 4 complete gills (i. e. composed each of 2 rows of branchial lamellæ) (Pl. III, fig. 11 I—IV) and a well-developed pseudobranch (fig. 11 ps); the 5 gill slits on each side are small, oblique, somewhat like button-holes in shape (as in Syngnathids), and as stated above not provided with gill-rakers. The branchial laminæ are rather short and clumsy, intermediate in shape between the type found in Syngnathids and that of fishes generally; their number in each row from 6 to 12, the anterior row of the first gill having 9, the posterior of the last gill only 6. The pseudobranch consists of a single row of 8 leaves arranged along the inner, posterior border of the hyomandibular and preoperculum, in front of the first slit. As in Syngnathids the gills are not restricted to the gill-arches but for a great part take their origin above and below these from the soft walls of the pharynx; the rows are almost vertical in spite of the oblique position of the gill-arches.³¹

As in Syngnathids the alimentary canal (Pl. III, fig. 11) is simple, straight, without any externally visible demarcation between stomach and intestine, and without mesentery. The muscular oesophagus (oe) widens evenly into a thin-walled, somewhat spindle-shaped dilatation, distended with food; it suddenly narrows where the intestine passes from the "thorax" into the slender part of the body, just above the root of the ventrals and below the most expanded part of the air-bladder. Immediately in front of this narrowing the dilatation ventrally fills out the space between the two halves of the pelvis and the posterior end of the liver, forming here a kind of cuneiform sacculation, no doubt only an accidental adaptation to the given space, due to the state of stuffing with food in the specimen dissected. On the ventral side of the anterior half of the spindle-shaped dilatation, in the median line, the bile-duct enters (at bd in the figure), as in Syngnathids the only indication of the beginning of the intestine (duodenum); thus the greater part of what at first sight seems to be a "stomachal" dilatation is really formed by the small intestine. The remaining part of the latter fills most of the body cavity in the slender, posterior part of the body; at the spot * in the figure a circular constriction marks off the beginning of the rectum (r)*. The fold and the small sacculation apparent at ** in the figure is — as far as I can see — only an accidental formation due to an accumulation of the contents.

* The rectum and adjacent parts unfortunately were somewhat damaged during my dissection of the only specimen which I could sacrifice; hence I am not quite sure about a few features, e. g. the possible existence of an urinary bladder.

The liver (l) is laterally compressed with sharp ventral edge. The left part is seen below the alimentary canal, while the right side of the latter is covered by the right part. From an incision in the posterior edge of the right part proceeds the bile-duct, turning upwards and forwards to the intestine. The gall-bladder is situated as in Syngnathids between the right side of the alimentary canal and the right part of the liver; the bile-ducts from the liver, the portal vein and hepatic artery as well as the hepatic vein seem to be arranged quite as in the Syngnathids.

The alimentary canal in the dissected specimen contained rather large crustaceans (Palæmonids; one fairly well preserved specimen was about 12 mm. in length).³²

The existence of an air-bladder has hitherto been denied (cf. GÜNTHER 16 b p. 151; BOULENGER 4 c p. 633). Nevertheless, if sufficiently transparent specimens are held against the light an oval, clear body is always to be seen over the intestine just below the first dorsal, and always in the same way filling a downward bend of the intestine, thus suggesting the presence of an air-bladder. Through dissection the suspicion is confirmed and the fact easily settled. The air-bladder (bl) is irregularly pyriform, anteriorly narrowing into a point reaching about to the hind end of the oesophagus, posteriorly also tapering but more abruptly, and ending behind the level of the ventrals.

The kidneys (Pl. III, fig. 11 k) reach from below the second vertebra to the end of the body cavity. From the level of the 12th vertebra they are united into one body containing in its middle, between the two ducts, the right cardinal vein, which seems the only one developed and is anteriorly embedded in the right kidney. The anterior part of each kidney represents the "head kidney", as it contains a large "pronephric glomerulus" (or "glomus"), from which the wide, straight duct passes backwards through the whole organ; at some distance behind the "glomus" urinary tubules appear and are present in the whole remaining part of the kidney. As usual in teleosts the "head-kidney" has no tubules, consisting only of lymphatic tissue surrounding the "glomus" and the beginning of the duct; the latter part is not convoluted, as otherwise in bony fishes, but straight like its continuation through the secreting nephros. The secreting tubules of the latter are short, combining to wide collecting tubules regularly grouped around the duct into which they debouch. No malpighian corpuscles (or glomeruli) are to be seen. Thus the kidney of *Solenostomus* only in the latter respect resembles that of Syngnathids; in almost every other respect it is not only different but very peculiar; especially so in preserving the whole pronephric duct and the pronephric glomerulus, a feature very rarely met with in bony fishes (from my own experience I only know of *Zoarces viviparus* possessing that structure in the adult state). In Syngnathids a "head-kidney" is not only absent in the adult, but a "pronephros" ("glomus") seems not at all to be formed in the embryo according to HUOT, whose

statements I am able to confirm for embryos in that stage of development at which they leave the marsupium.

The anterior part of the testis (te), situated under the posterior part of the air-bladder, is somewhat irregularly coiled, the remaining part being straight and gradually tapering into a narrow thread lying close to its fellow from the other side below the kidney; above the rectum the testis (or vas deferens, no boundary between the two being observable) widens a little again. If the two male ducts are united at all it can only be at the junction with the urethra, like the case in Syngnathids. (As stated p. 325 [59] this part unfortunately has been somewhat damaged.) The male organ is of the same peculiar type as that of Syngnathids, i. e. it forms a simple hollow sac or tube.

I regret that the scarcity of my material did not allow me also to dissect a female specimen. I have only had the opportunity to look at a partly dissected specimen in the British Museum (probably the one which had been used by GÜNTHER for his anatomical statements) and to write down the following note: "The ovaries are situated in the anterior part of the body cavity, each with a long narrow oviduct; the two oviducts seem to unite into an enlarged portion above the rectum"³³.

Family *Solenostomidae*.

Two dorsal fins, the anterior spinous. Ventrals present, very large. Tail short, caudal fin very large. Skin with star-like dermal ossifications in transverse and longitudinal rows. No visible lateral line. Gill-openings wide, opercular membranes free of isthmus. Nasals, infraorbitals and metapterygoid wanting. Hyoid complete; branchial skeleton reduced. Supracleavicle present, postcleavicle absent; scapular foramen closed. Vertebræ without articular processes, upper and lower spines long and well developed. The 3 anterior vertebræ immovable, suturally united. Ribs absent. Pseudobranchia present, well developed. Gills 4, gill-rakers absent, branchial slits 5. Air-bladder present, without duct. Intestinal canal simple, straight, without stomachal sac or pyloric appendages.

Genus *Solenostomus* Lacép.

General form laterally compressed. Snout tubular, very long and strongly compressed. Mouth an oblique slit, bounded above by the premaxilla, toothless. Chin with a barbel, more or less concealed. Olfactory organ an open pit, smooth in the female, provided with radiating lamellæ in the male. 3 opercular bones present, subopercular extremely thin, bristle-like; interopercular lamellar, concealed. One bifid branchiostegal. Septum between the branchial cavities perforated by a large opening. Anterior part of body high, forming a thorax, posterior part slender; tail very short, its anterior part high, dorsally and ventrally forming a kind of

hump, carrying the second dorsal and the anal; the posterior part carrying the caudal fin lower. The soft skin, covering the dermal ossifications, with scattered small (more or less developed, in some places branched) cutaneous papillæ.

Anterior dorsal with 5 spines, short but high, at posterior border of thorax, opposite to ventrals; the latter very large, with one spine and 6 bifurcated soft rays; free in male, united to abdomen in the female, forming a brood-sac. Second dorsal and anal opposite, long and rather low, composed of numerous soft, unbranched rays, like those of the pectorals. Caudal fin extremely large, with strong, unbranched rays, the middle ones longer and somewhat more slender than the rest.

Glossohyal and basibranchials absent, epibranchials absent or quite rudimentary; pharyngobranchials apparently one — but composed of two — on each side, provided with teeth like the lower pharyngeals.

D. 5, V. 7, C. 16.

Solenostomus cyanopterus Bleeker 1859.

Syn: *S. paradoxum* Blk. 1852, 1853.
S. paradoxus Kaup 1856, pro parte.
S. cyanopterus Duméril 1870.
S. Bleekeri " "

Snout rather stout, its height in the middle of its length being in the male about $\frac{1}{3}$ of its length (from anterior margin of the eye to the end of the snout), in the female about $\frac{1}{4}$. Caudal peduncle stout, the membrane of the caudal fin beginning very near or almost close to the second dorsal and anal (closest in the male). Profile of second dorsal and anal evenly arched. Colour brown, minutely dotted with black and whitish, or pink with small purplish-brown spots. Eye red. First dorsal fin with two large, ovate, black ocelli between the first 3 rays.

P. 24—27, D. 5/18—20, A. 16—20, C. 16, V. 7.

Solenostomus paradoxus (Pallas).

Syn: *Solenostomus varius rostro serrato* etc. Seba 1758.
Fistularia paradoxa Pallas 1770.
Solenostomus paradoxus Lacép. 1803.
Solenostomus " pro parte Kaup 1856.
Solenostomus paradoxus Duméril 1870.
Solenostoma brachyurum Bleeker 1855.
Solenostoma leptosoma Tanaka 1908.

Snout elongated, its height (apparently in both sexes) in the middle being about $\frac{1}{7}$ of its length (from anterior margin of eye). Caudal peduncle slender, the membrane of the caudal fin beginning at a distance from the second dorsal and anal of more than half the length of these fins (about $\frac{2}{3}$ in the female, $\frac{5}{6}$ in the

male). The rays in the middle and behind the middle of the anal and second dorsal somewhat elongated, thus giving the profile of these fins a higher and more acutely arched shape than in the preceding species.

Colour light brownish, irregularly mottled with orange spots; membrane of first dorsal with two dark ocelli between the first 3 rays.

P. 24—26, D. 5/18—22, A. 18—23, C. 16, V. 7.

Conclusion.

With the preceding part of the present contribution I have finished my account of the principal structural features, especially the osteology, of the fishes which in my first contribution I considered to be a group of related forms and (23 b p. 42 [4]) provisionally had designated as "Hemibranchii (\div Gastrosteidæ and Aulorhynchidæ) + "Lophobranchii" (Solenostomidæ and Syngnathidæ)", at the same time pointing out a number of characteristics in the composition of the cranial skeleton, which seemed to me an expression of natural affinity. Since the publication of my first paper I have had the great satisfaction of learning that the author of the latest attempts at a systematic arrangement of the Class Pisces, C. T. REGAN, has adopted my view (45 b and c). Furthermore he has given the group as circumscribed by me a systematic name, namely *Solenichthyes*, to replace the, of course, quite provisional designation quoted above. Originally, however, REGAN only included *Amphisile* and *Centriscus* under the name *Solenichthyes* (cfr. 23 b Note 1, p. 42); but later (45) he has extended its domain to embrace all the forms pointed out by me as related. Although I do not like the name on purely etymological grounds*, I adopt it and am going to use it in the following systematic arrangement, in which I shall try to condense the principal characteristics set forth and treated at length in the descriptive parts of my work.

Suborder *Solenichthyes*.

Snout tubiform, mouth terminal, the ethmovomerine part of skull and mandibular suspensory parts anterior to hyomandibular being greatly elongated; palatine short and connected with front end of vomer; metapterygoid, if present, removed from contact with the hyomandibular. Parietals and opisthotics absent; pterotics joining cranial base below, preventing exoccipitals from meeting prototics. Opercular apparatus consisting of the 3 usual bones. Lateral line bones of head reduced in number or absent; infraorbitals, if present, only represented by preorbitals, never containing any lateral line canal. Anterior 3—6 vertebræ immovable. Ribs absent. Gills 4, pseudobranchia present; branchial slits 5.

* Because the fishes themselves are not tubiform, only their snouts being so.

Intestinal canal simple, without stomachal sac. Air-bladder present, ductless. Ventrals (if present) abdominal in position, 5—7 rays. Fin-rays of pectoral, (second) dorsal and anal fins distally unbranched.

- A. Post-clavicle and metapterygoid present; anterior 4—6 vertebræ elongated, more or less modified; vertebræ with articular processes. (4—5 branchiostegal rays.) Lateral line canals present (at least on head: *Centriscus*): **Aulostomata** ("Bouches-en-flûte").

1st Family: *Centriscidae*.

Mouth toothless. Body laterally compressed, stiff; tail short, movable. All the components of mandibular suspensorium present; palatine, ento- and metapterygoid connected with the elongated ethmo-vomerine part of skull. Nasal and preorbital well developed, the first containing a lateral line canal. Hyoid of normal composition; 4 branchiostegal rays; branchial skeleton complete, upper and lower pharyngeals carrying teeth. Posttemporal suturally united to skull; supraclavicle present; scapular foramen enclosed in scapula; pectoral pterygials stout, leaving no interspaces. Anterior 5—6 vertebræ elongated, their transverse processes, except those of the first and last, firmly connected with large dermal plates. Two dorsal fins, anterior spinous, the spines, except 1—3 of the foremost, fused with their interneurals; posterior dorsal opposite to anal. Outer ray of ventral spinous. Two nasal openings. Appendices pyloricæ absent.

Genera: *Centriscus*, *Amphisile*.

2nd Family: *Aulostomidae*.

Mouth toothed; body elongated, tail short. Occipital condyle convex. Ectopterygoid wanting, other suspensory bones present; palatine, ento- and metapterygoid (in *Fistularia* also symplectic) connected with ethmo-vomerine part of skull. Nasal quite rudimentary or absent; preorbital rudimentary or absent. Hyoid composed as usual of 5 pieces; 4 or 5 branchiostegals; branchial skeleton reduced, only one basibranchial being ossified, 4th epibranchial absent, the remaining 3 more or less separated from their cerato-branchials; 1st pharyngobranchial absent, 2nd—4th and lower pharyngeals provided with teeth. Posttemporal present, supraclavicle present or absent; scapular foramen enclosed in scapula; pterygials elongated, leaving interspaces between. Anterior 4 vertebræ much elongated and suturally united, their transverse and spinous processes forming continuous lamellæ. Transverse processes of free abdominal vertebræ divided into an anterior and a posterior part. First dorsal fin, if present, spinous, second dorsal opposite to anal. Ventral fin with 6 rays, the outer unbranched, but jointed. Lateral line canals developed. Two nasal openings. One or two appendices pyloricæ.

Genera: *Aulostoma*, *Fistularia*.

- B. Postclavicle and metapterygoid absent; anterior 3 vertebræ suturally united, not specially elongated; vertebræ without articular processes. (1—3 branchiostegal rays.) Lateral line canals absent. *Lophobranchii.*

3rd Family: *Solenostomidae.*

Mouth toothless; body laterally compressed, tail short. Nasal and infraorbitals (preorbitals) absent. Palatine, ecto- and entopterygoid and symplectic connected with ethmo-vomerine part of skull. Hyoid of normal composition; 1 branchiostegal ray; branchial skeleton reduced, glossohyal and basibranchials wanting, epibranchials absent or quite rudimentary, only 2nd and 3rd pharyngobranchials present, remote from ceratobranchials, provided with teeth like the lower pharyngeals. Posttemporal attached to skull, supraclavicle present; scapular foramen closed below, being surrounded by scapula and clavicle; pterygials elongated with open spaces between, not fixed between dermal plates. Upper and lower spinous processes long and slender. Skin with large stellate ossifications, leaving large spaces unprotected. Gill-opening wide, opercular membrane free of isthmus. Two dorsal fins, anterior spinous; posterior opposite to anal; tail-fin very large. Ventrals very large, with 7 rays, the outer spinous. Nasal organ an open pit. Appendices pyloricae none.

Genus: *Solenostomus.*

4th Family: *Syngnathidae.*

Mouth toothless; body elongated, angular or laterally compressed, tail long. Nasal absent; 2 or 3 infraorbitals (preorbitals) present. Palatine, entopterygoid (sometimes also ectopterygoid) and symplectic connected with snout part of skull. Hyoid only composed of 3—4 pieces; 1—3 branchiostegal rays; branchial skeleton reduced, basibranchials being absent or reduced to 2, hypobranchials 1—2, epibranchials 3, remote from ceratobranchials or completely absent, 2nd and 3rd or only 2nd pharyngobranchial present, toothless as also lower pharyngeals. Posttemporal suturally united to skull; supraclavicle absent; upper part of clavicle expanded and connected firmly with transverse processes of the two foremost vertebræ. Scapular foramen continued below into interspace between clavicle and coracoid; pterygials with open interspaces, their distal parts fixed between dermal scutes. In some members coraco-scapular and pterygial skeleton absent as also pectoral fins. Transverse processes on vertebræ well developed, connected with dermal plates; spinous processes low crests, except on the vertebræ carrying the dorsal fin, the spinous processes of which are elevated and divided, each supporting a group of interneurals; a secondary transverse process on the same vertebræ, behind the primary one, for attachment of muscles moving the dorsal fin. Skin with complete armour of dermal plates. Gill-lamellæ few on each branchial arch, short and clumsy, with large transverse leaflets. Gill-opening dorsal, very small, the margins of opercular membrane being largely fused to isthmus and body. One dorsal fin, anal small, below dorsal, or absent; caudal fin small, in some members

rudimentary or quite absent; in latter case tail more or less prehensile. Ventrals absent. Two nasal openings. No pyloric appendices.

- a. Subfamily: *Syngnathini*. Preorbital bones 2; nuchal plates generally 2 (one prenuchal and one nuchal); rarely 3 nuchals (one prenuchal and 2 nuchals).

Genera: *Siphonostoma*, *Syngnathus*, *Ichthycampus*, *Nannocampus*†, *Urocampus*, *Doryichthys*, *Leptoichthys*†, *Coelonotus*†, *Stigmatophora**, *Nerophis*, *Protocampus*†**.

- b. Subfamily: *Hippocampini*. Preorbital bones 3; nuchals 3 or 2; in latter case prenuchal wanting.

Genera: *Hippocampus*, *Solenognathus*, *Phyllopteryx*, *Gastrotokenus*, *Acentronura*†.

+. 3 nuchals, a prenuchal or "corona" being present.

Hippocampus, *Solenognathus*.

++. 2 nuchals, a prenuchal absent.

Gastrotokenus, *Phyllopteryx*.

The genera marked with † I have not seen.

That all the members of the group *Solenichthyes* are aberrant and much specialised is evident, and that they must all be derived from one common stock of less specialised forms is hardly to be doubted. But where their parentage is to be sought, or to which of the other groups of existing Teleosts they are most nearly related, is to me still an open question. As fossils, carrying quite the same stamp as in modern time, they date far back in the tertiary formations; the existing genera *Amphisile*, *Aulostoma* and *Solenostomus* as well as true Syngnathids ("Syngnathus bolcensis" Zign.) are found in Eocene (Mt. Bolca and Mt. Postale), *Fistularia**** at least in Oligocene formations (Glarus schists); unfortunately the extinct Eocene genera *Urosphen*, *Solenorhynchus* and *Calamostoma* (Mt. Bolca and Mt. Postale), which are undoubtedly *Solenichthyes*, the first belonging to the *Aulostomidae*, the

* 3 nuchals are present, a small prenuchal, a large first nuchal and a smaller second nuchal. Of the two preorbitals the posterior (true preorbital) is very short, the anterior extremely long.

** I have omitted the genus *Osphylolax* (with a single species: *pellucidus*) described by COPE (Proc. Ac. Sc. Philadelphia, 1875, p. 450, Pl. 25; the description repeated in JORDAN and EVERMANN 21 a p. 775). I am quite sure that it is due to a mistake. Judging from the figures and description it must simply be a *Nerophis aequoreus*, the dorsal fin of which has been damaged and deprived of its larger anterior part. This would explain not only the shortness of the dorsal fin, containing 16 rays in stead of 40—44, but also the peculiar dorsal tube in front of the fin, which is said to be "closed above by a series of small radiate ossicles in the median line, between which the cavity may be entered by small bodies." These small ossicles evidently are the upper ends of interspinous bones with their peculiar osseous expansions, which have been laid bare by the abrasion of the front part of the dorsal fin. The "free superior edges (of lateral scutes), which form a series of longitudinal lateral grooves" in the "lumbar region" I imagine are also due to accident (and drying?).

*** "*Fistularia tenuirostris*" Ag. from Mt. Bolca cannot in my opinion be a true *Fistularia*; but it belongs at all events to the *Solenichthyes*, as also the genus *Pseudosyngnathus* (*Syngnathus opisthopterus* Ag.), which is no Syngnathid.

two latter to the *Solenostomidae** do not throw any light upon the question of derivation from other forms, but they may prove to be of use in filling up some of the gaps between the now existing genera. Leaving aside the latter point for the present and only considering the existing forms reviewed above I think it will be agreed, that the Syngnathids are the most aberrant and most strongly specialised Solenichthyes. Compared with the other forms the Syngnathids have acquired a more complete dermal armour and an elongated tail; at the same time they have lost the first dorsal and the ventrals, and reduced or lost the anal; the second dorsal, taking up the function of locomotion, has generally been lengthened and often encroaches upon a greater or lesser part of the trunk; the metapterygoid is lost, the shoulder girdle has lost the postclavicle (and supraclavicle), the clavicle, expanding above, has been connected firmly to the anterior vertebræ, while the pectoral skeleton is weakened like the branchial skeleton. Less transformed are the *Solenostomidae* which have kept the first (spinous) dorsal fin and the ventrals (with a spine); the metapterygoid is lost, the shoulder girdle has lost its postclavicle but is otherwise complete, while the pectoral skeleton is weakened, tending greatly towards the structure found in Syngnathids, as also does the branchial skeleton and the vertebræ in losing the articular processes. Upon the whole the majority of characteristics combine the Solenostomids with the Syngnathids, with which they have been placed since CUVIER established his *Lophobranchii*; the correctness of his view in this respect may now I think be regarded as settled. But on the other hand the *Solenostomidae* show likenesses with different members of the group *Aulostomata*; some of these likenesses may perhaps seem to be of less importance — a matter, however, by no means easy to judge with any degree of certainty. Thus, the extreme shortness of the tail in proportion to the trunk and head, the lateral compression of body and head, the mandibular barbel remind one of *Aulostoma* (while the position of the mouth slit is more like that of Syngnathids and Centriscids). Further, there are some external likenesses with *Centriscus* in the (dorsal) fins — as already alluded to by REGAN (45 a and c) — **, in the stiffness of the trunk, and, I might add, in the dermal ossifications: from a four-sided shape with cruciform crests, which the large lateral plates show in the adult *Centriscus* and all the scales in the young ones, the stellate dermal scutes in *Solenostomus* — and besides also the plate-forms found in *Syngnathidae* (cfr. *Hippocampus* and those of young *Syngnathus*) — could easily be derived.

In the group *Aulostomata* the family *Aulostomidae* approaches the group *Lophobranchii* (*Solenostomidae* and *Syngnathidae*) in the commencing reduction of the branchial skeleton and in the fact that the upper parts of the rows of branchial

* In a forthcoming paper I hope to show that *Calamostoma (breviculum* Ag.) must belong to the *Solenostomidae*. That the genus *Solenostomus* itself is represented in the Mt. Bolca formation, as also *Amphisile*, I know from photographs, kindly sent to me from the Museo Civico in Verona.

** BOULENGER (4 c, p. 633) has also expressed the opinion that "the unique genus *Solen* may be regarded as in many respects intermediate between the Centriscidæ and the Syngnathidæ."

lamellæ leave the gill-arches and take their origin from the pharyngeal wall; further in the shape of the pectoral pterygials, and in the weakening of the anterior border of the scapular foramen; if the weak or cartilaginous anterior part of the scapula atrophied, we should have the condition found in *Solenostomus*, from which a step farther leads to that of *Syngnathidae*. The large ossified nuchal tendons, so characteristic of the *Aulostomidae*, also occur in *Solenostomidae* and at least in one of the *Syngnathidae*, namely *Nerophis ophidion*. The genus *Fistularia*, besides, has the symplectic connected with the ethmoid region of the skull as in the *Lophobranchii*, and with the *Syngnathidae* it shares the loss of the first dorsal fin, which in *Aulostoma* is so to speak going to disappear. In both *Aulostoma* and *Fistularia* the outer ray of the ventral fin has given up its spinous character, perhaps a step towards degradation of the fin; the separation of the pelvic bones in the median line and the weak structure of these bones might possibly point in the same direction.

In spite of the many features of far going specialisation the family *Centriscidae* must be considered to contain upon the whole the least aberrant members of the suborder *Solenichthyes*; to this conclusion point the facts, that all the components of the mandibular suspensory parts are present, that nasals are well developed, that the branchial skeleton is complete, the shape of the pectoral pterygials, the structure of the ventral fins etc.

Notes.

Aulostoma.

¹ p. 270 [4]. The scales are regarded by most authors as simply ctenoid. A figure is found in KNER (28 b, p. 259 [28]); the scale represented shows seven teeth, united basally into one part, which appears separated by a distinct boundary line from the main scale-plate; that this representation is incorrect can easily be verified.

² p. 271 [5]. The very conspicuous system of "inscriptiones tendineæ" is — as far as I know — only mentioned in recent times, by A. S. WOODWARD (59, p. 375), in his definition of the genus *Aulostoma*: "Intermuscular bones very numerous and long". But already AGASSIZ who, curiously enough, does not appear to have known their existence in the living forms, states for the fossil *A. bolcense* (1, T. 4, p. 282): "De nombreuses arêtes musculaires effilées paraissent avoir soutenu les muscles tout le long de la colonne vertébrale", and fig. 3 of his Pl. 35 shows these structures very distinctly.

³ p. 274 [8]. BRIDGE (5, p. 576) has correctly described the interspinous bones for the unpaired fins in *Aulostoma chinense*; but he does not mention the anterior ray-less elements of the anterior part of the trunk, in front of the spinous section of the dorsal fin.

4 274 [8]. KNER (28 b, p. 257 [26]) declares that the dorsal spines in *Aulostoma (chinense)* are not true spines, without, however, demonstrating why: "Sie tragen ebenso wenig die Merkmale eines Stachels an sich, wie jene der *Notacanthinen*, von denen später die Rede sein wird". Die Strahlen der übrigen Flossen sind gegliedert und am Ende so breit und compress, wie bei den Lophobranchiern. Die Gliederung ist ziemlich spärlich, äusserst zart und sogar oft leicht zu übersehen, der Übergang vom un- zum gegliederten Strahle erfolgt hier fast unmerklich. Nur die Strahlen der Bauchflossen und die letzten der zweiten Dorsale und der Anale sind zugleich gabelig getheilt".

5 p. 279 [13]. Very little is to be found in the literature about the osteology of *Aulostoma*; generally the few remarks apply to the family (or "superfamily") including both *Aulostoma* and *Fistularia*, and as the latter apparently has been examined oftener, the remarks seem mostly or wholly based on *Fistularia*, nothing particularly concerning *Aulostoma* being stated. This is the case e. g. with the statement found in several authors about the four anterior vertebrae being elongated (COPE, GILL (1884), JORDAN & EVERMANN, REGAN etc.) or elongated and fused together (GÜNTHER, SM. WOODWARD, BOULENGER), and the absence of ribs. A few remarks concerning the cranial skeleton are given by CUVIER (9 b, T. 2, p. 625). After having pointed out some cranial features characteristic for his family "Bouches en flûte" (i. e.: *Fistularia*, *Aulostoma*, *Centriscus* and *Amphisile*), especially regarding the composition of the elongated snout ("Les frontaux en forment la base; l'ethmoïde, excessivement alongé, en fait la plus grande partie; et le vomer, placé au bout du précédent, forme la pointe."), he continues: "Dans la *fistularia tabacaria*, le museau est en demi-cone grêle et un peu creux à sa face inférieure. Les apophyses anté et post-orbitaire continuent la courbe régulière et à peu près circulaire du bord orbital du frontal, de sorte que plus des deux tiers des orbites sont entourés par les frontaux." It is quite evident from this description, that *Aulostoma* is meant instead of *Fistularia*, and every doubt is removed, when we read the description of "*l'aulostome chinois*", quoted below p. 339 [73] note 14. Through some mistake the names have simply been exchanged.

The most important contributions are given by STARKS (55); after having pointed out the characteristics for the "superfamily" e. g. that "parietals are absent, pterotic interposed between and entirely separating prootic from exoccipital; condyle of basioccipital a round knob" etc. (p. 624), he states for *Aulostoma*: "post-temporal not united to cranium; palatines united to each other and to cranium; each transverse process behind fourth vertebra is formed equally by a process from each adjoining vertebra (or each end of each vertebra carries a half of each transverse process)"; and p. 629 he gives the following description of the skull: "The epiotics are large, low, conical bones on each side of the supraoccipital. Each articulates to the frontal anteriorly, to the exoccipital posteriorly, and to the pterotic at its outer edge. The pterotic forms the posterior lateral angle of the cranium. It is anterior to the exoccipitals, which form, with the basioccipital, a posterior projection. The exoccipitals project downwards on each side far below the condyle of the basioccipital. They meet broadly above the foramen magnum." A full and in all essentials very correct description is given of the shoulder girdle, illustrated with a figure. The only point in this description I wish to correct is the statement on p. 630: "The hypocoracoid (my coracoid) is attached along its entire anterior edge to the clavicle without leaving the usual opening between." The opening is really found, but very small indeed; cf. my fig. 5, Pl. III.

The branchial arches are figured by RATHKE (44, Tab. I, Fig. 4, *Aulostoma (Fistularia chinense)*). The figure is correct in every essential; his description, given below, as well as the explanation of the figure and the tabular summary on p. 19 show, that R.'s interpretation of the component parts is also the right one. He writes on p. 17: "Anmerkung. Eine sehr merkwürdige Abweichung von der Regel, nach welcher bei den Gräthenfischen die Kiemen-

* I have not been able to find anything about the *Notacanthini* in the continuation of KNER's work in the 43th and 44th vols. of the Wiener Sitzungsberichte.

bogen gebildet sind, bietet die *Fistularia (Aulostoma) chinensis* dar. Bei ihr hangen nur die zu dem vordersten Bogen gehörigen Segmente, deren es 3 giebt, unter einander innig zusammen: von den 4 Segmenten aber, die einem jeden der 2 folgenden Bogen angehören, ist bei Exemplaren dieses Fisches, die eine Länge von fast $1\frac{1}{2}$ Fuss haben, das dritte und äusserst kleine von dem zweiten und beträchtlich grossen ungefähr um 3 bis 4 Linien nach oben hin entfernt; und um eben so weit stehen auch die beiden Segmente von einander ab, die dem vierten oder hintersten Kiemenbogen zugehören, und wovon das oberste dem vierten Segmente der beiden davor liegenden Kiemenbogen entspricht. Die Lücke zwischen den angegebenen Gliedern wird allein durch die Haut des Schlundes ausgefüllt." The elongated glossohyal is noticed on p. 4. On the other side the statement about the opercular apparatus being only composed of 2 pieces (l. c. p. 76) is wrong. RATHKE's figure is copied by BRÜHL (6 a, Tab. IV, fig. 11) and his statements referred to l. c. p. 119; and also repeated by DUVERNOY in Cuvier's Leçons, T. VII, p. 257, p. 268. This information seems to have been quite overlooked later. The next author who mentions the branchial skeleton is COPE (8, p. 457) who (incorrectly) states: "Superior branchihyals (= epibranchials) cartilage, three superior pharyngeals (= pharyngobranchials)."

⁶ p. 280 [14]. But little information regarding the visceral anatomy of the *Aulostomidae* or *Fistularidae* is found in the literature.

Already DUVERNOY (in CUVIER's Leçons etc. 2. Edit., 4th vol., 2, p. 143) pointed out that in CUVIER's family "Les bouches-en-flâte" the intestinal canal did not possess any stomachal blind-sac; he adds: "Le canal alimentaire semble tout d'une venue; à peine peut-on y reconnaître une première partie distincte qui serait l'estomac." But DUVERNOY seems only to have examined *Centriscus scolopax*, not *Fistularia* nor *Aulostoma* (nor *Amphisile*).

Of internal structures in *Aulostoma* GÜNTHER (16 a, p. 537) gives the following account: "The stomach is spacious, elongate, with thin membranes, which become thicker towards the pylorus; it passes without curvature or dilatation into the intestine, which is extremely short, quite straight, without curve or circumvolution, and rather wider at its commencement than posteriorly; two pyloric appendages of moderate size on each side of the pyloric portion of the stomach. Air bladder large."

In the stomach G. found remains of small fish. (LACÉPÈDE 31, T. 10, p. 101 mentions fish-eggs and worms.) Curiously enough neither GÜNTHER nor later authors mention the position of the anal opening close behind the ventrals and far from the anal fin.

The number of gills, the presence of a pseudobranchia and the slit behind the 4th gill-arch are rightly mentioned by previous authors (LACÉPÈDE, GÜNTHER, JORDAN etc.).

Fistularia.

⁷ p. 281 [15]. Minute dermal asperities in Fistularians are mentioned for the first time by KLUNZINGER (27, p. 515). In a very young specimen, 13 Ctm. long, from the Red Sea, which he considered as representing a new species (*Fistularia villosa* Klzgr.) he found the "Rumpf dicht mit kurzen weichen Dörnchen oder Härchen überzogen." Later HILGENDORF (17, p. 231) observed the same asperities in two small specimens, one (108 mm.) from Japan, another from New Britain, and concluded that they as well as KLUNZINGER's *F. villosa* simply were young stages of *F. serrata* Cuv., "die im erwachsenen Zustande nackt ist." Apparently without knowing Hilgendorfs observations LÜTKEN (33, p. 584 [176]) also declared that *F. villosa* Klzg. must be the young *F. serrata*, to which he referred a specimen of 130 mm. length in the Museum

* I very much regret in my first contribution (1908) to have completely overlooked that CUVIER's Leçons, l. c. p. 143, and especially p. 365, contain a complete description of the alimentary canal of *Centriscus scolopax*; *inter alia* it points out the entrance of the bile-duct, and concludes: "Ici, comme dans les cyprins, l'œsophage et l'estomac réunis, sont rudimentaires." On p. 492 the liver is described, p. 564 the gall-bladder mentioned, and p. 612, absence of the pancreas.

of Copenhagen, coated with spinelets; and further, LÜTKEN stated that he found a similar coating well developed on the tail and posterior part of the body of a *F. tabacaria* of 280 mm. length and not completely disappeared from the tail of another, still larger specimen of 415 mm. length; hence he concluded that the species *F. serrata* and *tabacaria* both went through a "villosa-stage", which in the latter apparently was of greater duration. That LÜTKEN (like Hilgendorf) considered "*F. serrata*" as always naked in the adult state is easily explained through the fact, that his material of Fistularians from the Indo-Pacific really contained only the *F. depressa* Gthr. Quite naturally therefore he referred his young "villose" specimen of 130 mm. length to a naked "*F. serrata*"; now I refer the same specimen to the species *F. petimba* not only on account of its rough skin but also because the head shows the characteristics of this species. The splitting up of the old *F. serrata* into two species, the one naked, the other rough, is due to GÜNTHER (16 c, p. 68); only the first he designated with a new species-name, *depressa*, while he left the old name *serrata* for the latter, the rough one, for which JORDAN (& GILBERT) later perhaps more correctly introduced as new name *petimba*, originally used by LACÉPÈDE for specimens captured by COMMERSON in the Indo-Pacific.

⁸ p. 282 [16]. These structures were observed by GÜNTHER (16 a, p. 531), and earlier by AGASSIZ (1, T. 4, p. 278; comp. p. 338 [72]).

⁹ p. 282 [16]. The median scales in *F. petimba* were also observed by GÜNTHER ("*F. serrata*" 16 a, p. 535), and compared by him to the dorsal spines of *Aulostoma*: "They are evidently rudiments of the spinous portion at least of the dorsal fin, which, in *Aulostoma*, is more developed, the spines being free." It seems difficult to understand how the author would be able to reconcile this hypothesis with the fact that *F. petimba* has scales or "spines" of quite the same structure along the belly and on the upper and lower side of the tail. Their presence on "the abdomen" G. himself has mentioned.

¹⁰ p. 282 [16]. The ossicles of the lateral line have been noticed by several previous authors (GÜNTHER a. o.).

¹¹ p. 282 [16]. The number of vertebræ is differently given by different authors; thus e. g. CUVIER (9 b, T. 1, p. 231) has 56 abdominal, 33 caudal vertebræ, GÜNTHER (16 a, p. 529) 4 + 49/33 in *F. tabacaria*; (p. 533) 47/34 (Rüpp.), 47/29 (Rosenthal)* in *F. serrata*; JORDAN and EVERMANN (21 a, p. 756): 4 + 44 to 49 + 28 to 33. Probably the number varies individually within narrow limits, with no value for the distinction of the species.

¹² p. 284 [18]. Remarks about the vertebral column, or more or less incomplete descriptions, are found in various authors. The modification of the anterior part has early been observed, but as far as I am aware CUVIER was the first to settle its composition of four vertebræ in the almost complete and correct description of the column, given in the second edition of his *Leçons etc.* (1835, 9 b, T. 1, p. 227). LACÉPÈDE (31, T. 10, p. 95) and ROSENTHAL (47, p. 31) regard the ankylosed part as one single vertebra, while MECKEL (35, p. 232) has at all events indicated a compound structure in the following words: "Bei *Fistularia* besteht gleichfalls der erste, sehr längliche Wirbel aus mehrern, durch Fugen verbundenen Stücken", and CUVIER & VALENCIENNES (10, p. 359) speak of coalescence of vertebræ in this way: "Plusieurs [poissons] ont aussi les corps d'une partie de leur vertèbres soudés ensemble; on en voit des exemples dans les cyprins, les silures et les fistulaires, et de plus marqués encore dans un grand nombre de chondroptérygiens." AGASSIZ (1, T. 4, p. 276) uses rather indistinct terms: "La colonne vertébrale offre cela de très-particulier, que toute sa partie antérieure ne présente

* GÜNTHER has not observed that ROSENTHAL counts the 4 anterior vertebræ as one; the number thus ought to be quoted as 50/29.

qu'une masse continue sans articulation. Les vertèbres ne commencent à être distinctes que près des ventrales."

Figures of the whole skeleton are given by ROSENTHAL (47, Tab. 9, Fig. 8) ("*Fist. serrata*", if *F. petimba* or *depressa* I am not able to decide) and AGASSIZ (1, Atlas, Vol. 4, Tab. 35, Fig. 1) (*F. tabacaria*, wrongly on the plate designated as *Aulostoma chinense*); in both figures the system of ossified tendons along the vertebrae is omitted. Separate figures of the ankylosed anterior part are given by BRÜHL (6 a, Tab. 9, Fig. 38, 40; 6 b, Tab. 10, Fig. 10, 11; in both works *F. tabacaria*) and OWEN (38, p. 41, Fig. 35, *F. tabacaria*; copied by GOODRICH 15, p. 412). A very detailed and elaborated description of the anterior coalesced vertebrae is found in KLEIN (26 a, p. 327—28); nevertheless K. declares that he was not able to find "real sutures" between the component vertebrae, and therefore he feels not quite sure about their number, but supposes it to be four. BRÜHL furthermore has figured other parts of the vertebral column (esp. in 6 b, Tab. 10, Figs. 9—15, 17—23), but some of his figures are not quite correct (e. g. 13, 19 and others). He seems to be the only author, who figures anything of the ossified tendons, of which one only is represented in 6 b, Tab. 10, Fig. 23; the text says: "r—r': an die spina angelegerter, sehr langer, knöchener Flossenstrahl." I suppose that GÜNTHER is speaking of these structures when he states (16 a, p. 533): "... the interneurals long, horizontally situated, so that they form together one continuous bony strip." Evidently G. has not observed the paired symmetrical arrangement of the structures in question. Also AGASSIZ possibly has these bones in view (and not only the nuchal plates?) when he writes (1, T. 4, p. 278): "Enfin, il y a de semblables pièces allongées, sur la ligne médiane du dos, qui semblent rappeler la tendance qui règne généralement chez les Aulostomes, à avoir une dorsale épineuse."** The "pièces semblables" are evidently the spindle-shaped bones imbedded in the skin of *Fist. tabacaria*, forming the strip along each ventral side peculiar just for this species and mentioned on p. 281 [15] of this work; this will be seen from the words immediately preceding the above quotation: "En avant des ventrales, et depuis leur insertion jusqu'au bout de la queue, on remarque en outre une série de lames cornées, acérées, et qui paraissent avoir quelque analogie avec les écussons abdominaux des Belones."

The 3 nuchal plates seem first to have been specially noticed by GÜNTHER (16 a, p. 532), who describes: "A narrow strip [of shields] along the median line of the back behind the skull; they are, in fact, confluent neural spines, belonging to the anterior portion of the vertebral column." This interpretation I think must now be given up. Later they are described by KLEIN (26 a, p. 326) as one narrow plate, behind drawn out into a long point "welches gespalten sich auf die Dornfortsätze der 3 vorderen abgesonderten Wirbel legt."

The large lateral bones, which are fastened to the epiotics, are well described by AGASSIZ (1, p. 278) and still better by GÜNTHER (16 a, p. 532). In comparing them with the similar structures in *Mugil* which GÜNTHER (cfr. l. c. p. 412) regards as "processes of the paroccipital", he apparently does not consider them simply as ossified tendons. The same comparison with *Mugil* is found in DARESTE (11, p. 1089): "Les occipitaux externes présentent de très-grand prolongements osseux, qui s'extendent dans la région dorsale et sont l'exagération d'une disposition qui se rencontre chez les Mugiloïdes."

¹³ p. 284 [98]. While already LACÉPÈDE supposed the caudal filament to be a ray (31, T. 10, p. 93: "Cet appendice ressemble entièrement par sa contexture aux rayons articulés des

* In the work 6 b BRÜHL believes he is dealing with *Aulostoma chinense*; the mistake I think is due to the wrong labelling of a skeleton in the Paris Museum, probably the same which served AGASSIZ for his figure, mentioned above, and wrongly designated as *Aulostoma chinense* on his plate; but while AGASSIZ in his text has corrected the mistake BRÜHL has not been aware of it.

** They are at all events figured on the fossil *F. Koenigii* (1, T. 4, Pl. 35, Fig. 5), and Ag. remarks in the description of this species: "Au dessus de la colonne vertébrale on remarque quelques osselets qui paraissent correspondre au pièces impaires du milieu du dos, que j'ai mentionnées en décrivant la charpente solide du *F. tabacaria*."

nageoires, et présente des articulations entièrement analogues à celles de ces derniers") MECKEL curiously enough (35, p. 200) believed it to be a continuation of the vertebrae ("Bei *Fistularia* findet sich die merkwürdige Anordnung, dass sich die immer kleiner werdenden Wirbel über die Schwanzflosse hinaus in einen langen, sehr dünnen Faden verwandeln, welcher nur in seinem Anfange in unvollkommene Wirbel abgetheilt erscheint"). KNER (28 b, p. 259 [28]) has partly seen the continuation of the lateral line on the caudal filament: "Letzterer (der Seitencanal) setzt sich durch die Mitte der Caudale zwischen zwei fadig verlängerten Strahlen weit hinaus fort."

The structure of the fin-rays generally is already mentioned by AGASSIZ (1, p. 278) in so far as he says that they are "peu divisés et à peine articulés." KNER (28 b, p. 257 [26]) on the other side says that in all the fins the rays are simple, unjointed and unbranched, and of a similar compressed shape as those in the Lophobranchiata." He has evidently not examined the ventrals carefully enough.

14 p. 288 [22]. The cranial skeleton of *Fistularia* has early and often been examined, but a thorough, sufficiently illustrated, description has hitherto never been published, and very many of the statements made by previous authors are incorrect. The figures of ROSENTHAL (47, pl. 9, figs. 8—12) are rather small and imperfect, and the explanation (l. c. p. 30) is too incomplete and defective to be of any use now.

In the last (6th) volume of his "System der vergl. Anatomie" (1833) MECKEL has given some scattered notes regarding the visceral (suspensory and branchial) skeleton. P. 107—108 he describes and recognizes the 3 opercular bones and points out the presence of the pre-operculum (cfr. also p. 113, 114); p. 122 he remarks that the hyoid ("vordere Zungenbeinäste") is small, flat and low (p. 123), only composed of two pieces, the first (i. e. the stylohyal) and second (i. e. epihyal) being absent, and the fourth (i. e. the two hypohyals combined) single and very small, and that the whole is almost entirely made up of the third (i. e. the ceratohyal), which is elongated and curved (p. 126); it carries 5 branchiostegal rays or rather "4, because the upper is split into two branches, which form the first and second ray." P. 135 it is stated that the basibranchials (die "tiefe unpaare mittlere Schicht des Zungenbeins") are wanting, while a urohyal ("das oberflächliche mittlere Zungenbein") is present (repeated on p. 142); p. 148 is noticed that the glossohyal ("der vor der Vereinigung der vorderen Seitenäste liegende Knochen oder Knorpel") is very long; p. 152 that the branchial arches are small and slender, and p. 154 that they are of a very simple structure: "Von einer Theilung des langen, geraden Kiemenstückes in zwei Hälften findet sich keine Spur. Nur in den vorderen Bögen findet sich ferner ein oberes, sehr kleines, nach vorn gewandtes, gleichfalls gerades Stück, das keine Kiemen trägt und daher eben so gut oberer Schlundkopfknochen seyn kann." Finally p. 161 and p. 162 is correctly stated that gill-rakers are completely absent.

AGASSIZ (1, p. 277) describes quite correctly those features, which may be seen without separating a mounted skeleton, and which might be of use in comparing with fossils. Worth mentioning is that he describes the 3 opercular bones rightly. He has seen the long glossohyal and counts 5 branchiostegals, but besides he adds two more at the symphysis of the hyoid; this mistake is due to the preparation, in which a strip of dried up skin is preserved; the latter also accounts for the following mistake: "La membrane qui forme le tube buccal, entre l'appareil hyoïde, les mâchoires et les pièces operculaires, est soutenue par de nombreuses fibres osseuses très-grèles." In CUVIER's Leçons etc. (9 b, T. 2, p. 626) is found the following: "Dans l'*aulostome chinois*', le museau est large, mince et plat comme une épée à deux tranchants. Le mastoïdien (i. e. the posttemporal) donne en arrière une apophyse qui dépasse beaucoup le condyle. Dans ces deux poissons [*Fist.* and *Aul.*], le basilaire, au lieu d'une facette articulaire creuse, conique, comme nous en avons vu jusqu'à présent, donne

* i. e. *Fist. tabacaria*, cfr. above p. 335 [69] note 5. Perhaps the same wrong labelling, which caused the designation of *F. tabacaria* as *Aulostoma chinense* on pl. 35 in AGASSIZ's work as well as BRÜHL's mistake, is also the cause of the exchanging of the same names in CUVIER's Leçons.

au contraire une facette convexe, et qui forme un véritable condyle semblable à celui des reptiles."

In KÖSTLIN's, from a modern view, somewhat curious work (30) observations about cranial structures in the most different fishes are scattered in a rather bewildering way; among these also some remarks on *Fistularia*. On p. 317 he says: "Auch bei *Fistularia* und *Syngnathus* scheinen sich die beiderseitigen Scheitelbeine hinter der schmalen Hinterhauptsschuppe ein wenig zu berühren." What are here named parietals are evidently the epiphyses; thus for *Fistularia* the observation is correct, but not for *Syngnathus*. The structure of the ethmoidal region in *F.* seems quite obscure to K., as he p. 343 ascribes nasals to *Fistularia*, but coalesced with the ethmoid "as in *Trigla* and *Heterobranchus*", and further on p. 361 about the antorbital bone: "Eine besondere Grösse erreicht die Platte bei einigen Fischen, deren Nasenbeine oder deren Siebbeine ungewöhnlich entwickelt sind. So streckt sie sich bei *Fistularia* an jedem Rande des Siebbeins sehr lang nach vorn aus; bei *Syngnathus* und *Lepidoleprus* zieht sie sich, wie die angrenzenden Nasenbeine, sehr lang nach vorn aus." Does K. mean the lateral parts of the mesethmoid? On p. 362 an arch of infraorbitals is ascribed to *Fistularia*. On p. 378 the suspensory apparatus for the mandible is mentioned in terms rather difficult to understand, but to which the key is found on p. 375, where K. compares his terminology with that of CUVIER: "Endlich ist von den Acanthopterygiern noch *Fistularia* zu nennen, wo die einzeln Stücke der Quadratbeingruppe sich so gegen einander verschieben, dass das untere Stück (i. e. the quadratum) viel mehr nach vorn liegt, als das obere (i. e. the hyomandibular); der gewöhnliche Zusammenhang der Stücke wird aber darum nicht aufgehoben. Sowohl das untere (ɔ: quadratum) als das vordere Stück (i. e. the metapterygoid) sind hier in die Länge gezogen; dieses bildet den unteren Rand der Augenhöhle und articulirt mit dem vordern Stirnbein; das untere Stück (ɔ: quadratum) gränzt theils an das Flügelbein (i. e. entopterygoid) theils an das Siebbein (which latter statement is wrong!), und die Gelenkfläche ist mit ihm ganz nach vorn gerückt; das obere Stück (ɔ: the hyomandibular) ist sehr klein und verkümmert." As will be seen on closer examination, K. regards the symplectic and the metapterygoid as one piece, not to mention the smaller defects. He adds: "Unter den übrigen Fischen kommt fast dieselbe Anordnung bei *Syngnathus* vor", which to a certain degree may be true!

BRÜHL (6 a, Tab. 9, Fig. 38) has figured the skull, but his figure does not give details of any importance. The lettering shows only some of the most conspicuous parts, such as AGASSIZ had already mentioned. Of the suspensorial parts and adnexa, for example, he evidently has only recognized the preoperculum (Pop) and quadrate (u. Gb., i. e. "unteres Gelenkbein"), while the whole palato-pterygial part is marked: o. St and Gb? (i. e. "oberes Stück" and „Gelenkbein“?); that is to say B. was not able to make out its composition). BRÜHL's text contains but very few observations, dispersed in a similar way to those of KÖSTLIN. P. 88, speaking of the different ways in which "Schnabelbildungen" may arise in fishes, he states that one way (the fourth) may be "Durch einen sehr gestreckten Riechbeinkörper mit Hülfe ähnlicher Haupt- und vorderer Stirnbeine(?) bei *Fistularia*, *Aulostoma*. Dass Zwischen- und Oberkiefer hier keinen Anteil an der verlängerten Kopfbildung haben, zeigt die eben cit. Figur (Tab. 9, Fig. 38), wo die genannten Knochen (ibid.: Z. K. und O. K.) kleine absteigende Knochenstiele darstellen." On p. 96 he mentions Polypterus, Synbranchus, Tetraodon and *Fistularia* as examples of fishes, where the pterygo-palatine arch has given up its articulation with the skull and acquired a connection by means of suture. P. 111 he observes that "Der Zungenknochen (i. e. the glossohyal) ist sehr lang bei *Aulostoma chinense* (after RATHKE), *Fistul. tabacaria* and *Syngnathus*." On p. 123, Note 4, he states against RATHKE (who (44, p. 77) ascribes only one opercular bone to *Fistularia* and several other genera) that his figures show for *Fistul.* as for several other genera that the opercular apparatus is "mehr weniger normal gebaut d. i. aus 4, 3 und wenigstens 2 Stücken bestehend." The lettering of his Fig. 38 on Pl. 9 shows that he only recognized 2 in *Fistularia*, and that he regarded the interoperculum as the suboperculum, while the real suboperculum is omitted.

By far the most complete and correct account of the skull is that of GÜNTHER (16 a, p. 532). After having described the general form and the frontals he says: "The greater part of the upper surface of the snout is formed by the ethmoid, whilst the vomer occupies the anterior fourth or fifth. The praefrontal is situated in front of the orbit, elongate and triangular. There is a deep and long groove on the side of the snout for the muscles of the jaws; its bottom is entirely ossified, and formed by the tympanic (the quadrate), preoperculum, entopterygoid, pre- and mesotympanic (= metapterygoid and symplectic), these bones being exceedingly long. The entopterygoid (= entopterygoid) and pretympanic (= metapterygoid) are situated immediately below the ethmoid, and provided with a crenulated ridge which is externally visible. The bones which in other fishes constitute the bottom of the tympanic cavity below the orbit, are carried forwards before the orbit in *Fistularia*; the epitympanic (= hyomandibular) appears to be absent." And later is added: "Turbinal bone (= nasal) very small; infraorbitals none."

On page 530–31 the 3 opercular bones are correctly described, as well as the branchiostegals, but in "*F. serrata*" G. (p. 534) incorrectly gives the numbers as 6. The absence of gill-rakers is noted as well as the "series of three elongate patches of (villiform) teeth on each side of the roof of the pharynx" and the long series of teeth on the lower pharyngeals; features which already LACÉPÈDE (31, p. 92) had pointed out (but L. regarded the operculum as composed of only one piece). "The glossohyal", GÜNTHER finally adds, "is exceedingly long, half as long as the tube."

Thus, with the exception of the statements, that the hyomandibular ("epitympanic") is absent and a nasal ("turbinal") present, GÜNTHER's above-quoted description proves to be quite correct; but except few remarks on the frontals he does not give any information whatever about the bones composing the brain-case. Ten years later DARESTE (11, p. 1089) gave the following account, which seems inferior to that of Günther, and contains some errors emphasized by me below: "Le type des Fistulaires est caractérisé tout d'abord par l'allongement de la région de la tête qui précède la cavité crânienne: les frontaux principaux, très-allongés et soudés entre eux, sont précédés par un ethmoïde excessivement long, lequel est lui-même précédé par un vomer également assez long. Cet allongement des os antérieurs du crâne s'accompagne d'un allongement considérable de l'aile temporaire; donc les trois os principaux, temporal (=hyomandibular), tympanique (= metapterygoid) et jugal (=quadrate), sont soudés au sphénoïde dans toute leur étendue. Au contraire, les mâchoires et l'aile palatine sont fort petites. L'aile palatine s'unit au vomer non-seulement par le palatin, mais aussi par le ptérygoïdien interne. Les frontaux antérieurs sont très-écartés des palatins. La boîte crânienne, très petite, ne porte pas de véritable crête. Les frontaux principaux s'unissent aux mastoïdiens (=pterotics) et aux frontaux postérieurs. Les occipitaux externes (=epiotics) présentent de très-grands prolongements osseux, qui s'étendent dans la région dorsale et sont l'exagération d'une disposition qui se rencontre chez les Mugiloïdes."

Thus DARESTE has not observed anything about the most remarkable points in the composition of the brain-case either: the relation of the pterotics, and of the epiotics to their neighbours and the absence of parietals etc.

The first author to analyse in details the skull of *Fistularia* is KLEIN.

KLEIN (26 b and c) has given most elaborate and painstaking descriptions of the single bones composing the skull (not of the suspensorial nor the branchial skeletal parts), descriptions which hardly anybody will be able to understand without having the necessary preparations in his hands; and even so it is hard work to follow the author. I can therefore well understand that SWINNERTON (56 a, p. 575) has given up the "attempt to explain the why and the wherefore of Klein's tangle in describing the auditory region." Nevertheless, the descriptions are generally very correct, but the interpretations are often more or less deficient. Through careful study of KL's work it will be evident, that — overlooking the dividing suture — he regards the prootic and the postfrontal as one piece, which together with the pterotic he designates "ala temporalis"; as "ala orbitalis" he considers the alisphenoid, which he quite correctly describes with all minutiae. The posttemporal is regarded as "squama

"temporalis", or pterotic, in spite of the fact, that he has rightly observed that the "hinder part" of his "ala temporalis" contains the exterior semicircular auditory canal, as the pterotic does in other fishes, and that his "squama temporalis" here does not take any share in the formation of the wall of the brain cavity, as the pterotic normally does. The coalesced epiotics together with the supraoccipital are described as "occipitale superius"; but he has, however, observed (b, p. 144) that: "Die in den Gehörkapseln sich entwickelnden occipital. extern., epiotica, sind mit der untern Fläche des occipital. superius verwachsen", which fact he later repeats (c, p. 186 and especially p. 207). In a parenthesis on p. 142 he states: "parietal. lassen sich nicht als abgesonderte Platten darstellen", and later, on p. 246 he declares, that he has not been able to find parietals in several fishes, among others *Gasterosteus* (where parietals are present!) and *Fistularia*; "sie sind entweder als völlig mit den frontalia verwachsen, oder überhaupt fehlend zu betrachten." He rightly describes the parasphenoidal fossa for the eye-muscles and points out that there is no proper eye-muscle canal; further the prefrontals (b, p. 188) (only his remark about the attachment of the "Infraorbitalbogen" is wrong, in as much infraorbitals are totally wanting!). In the snout region (b, p. 221–22) he commits a mistake in regarding the whole dorsally visible part as one bone, the mesethmoid, his "septum narium"; his "vomer" is only the ventrally projecting, keel-shaped part of the real vomer (the part carrying teeth). Finally (b, p. 251) he mentions *Fistularia* among other fishes which lack nasalia. It is worth pointing out that KLEIN is the only earlier author — as far as I have seen — who has examined the inner aspect of the brain-case; the descriptions of the inner structures, which — it may be said by the way — are by no means easy to make out, are dispersed throughout his work; a good deal is to be found in (c) on page 206–07. Upon the whole KL.'s account is very scattered; the principal descriptions of the posterior part of the skull will be found in (a, p. 325) b, pp. 141–144; of the anterior part 188–89; p. 221–222; several details are found in c, p. 140, 186, 206 etc.

JORDAN and EVERMANN state (21 a, p. 755) that the long tubiform snout in *Fistularia* is "formed by the symplectic, proethmoid (=? prefrontal), metapterygoid, mesopterygoid (= entopterygoid), quadrate, palatines, vomer, and mesethmoid." "Post-temporal coossified with the cranium. Branchiostegals 5 to 7." "Gill-rakers obsolete. Basibranchial elements wanting." And on p. 756 they add a tabular formula of the branchial skeleton after Mr. RUTTER, which is correct, save on two points: 1) a first basibranchial is present, and 2) the 3 pharyngobranchials are to be referred to the second, third and fourth arch, not to the first, second and third. Already in 1871 COPE (8, p. 457), calling attention to the structure of the branchial skeleton in the fishes, for which he founded his group *Hemibranchii*, ascribed to *Fistularia* "three osseous anterior superior branchihyals (= epibranchials) and three superior pharyngeals, directed forwards."

SIEBENROCK (53, Pl. 5, Fig. 17) figures the brain-case of "*F. serrata*", seen from above; the figure is good in most respects but defective on one essential point: the sutures between the supraoccipital and the epiotics are omitted, because S. regards the supraoccipital + the two epiotics as one bone, which he calls "Supraoccipitale" (so). Describing on p. 131 the connections of the posttemporal ("Suprascapulare", s. sc.) he says: "Die sonst übliche Verbindungsweise mit dem Paroccipitale (= epiotic) kann hier nicht stattfinden, weil dieser Knochen gänzlich fehlt. Eine weitere Merkwürdigkeit bilden die Parietalia, die zu einer unpaaren Platte vereinigt sind und vom Supraoccipitale bei *F. tabacaria* Linné nahezu, bei *F. serrata* Bloch aber gänzlich bedeckt werden. Daher reichen die Frontalia (fr.) so weit nach rückwärts, dass sie nach Wegnahme der Suprascapularia (= posttemporals) theilweise den Hinterrand des Schädels begrenzen helfen." What S. here regards as the coalesced parietals is simply the supraoccipital (shown in my figure 6 on Pl. I as so), and there is no difference between the species; in my specimens of "*F. serrata*" (i. e. *petimba*), the narrow supraoccipital is quite as visible as in *F. tabacaria*.

SWINNERTON (56 a, p. 575 f. f.) compares the skulls of *Gasterosteus*, *Syngnathus* and *Fistularia*, which he believes all to be more or less related to each other and therefore has put together in one group, his *Thoracosteini*. In quoting S. below, I emphasize the mistakes

regarding *Fistularia*. On p. 575 S. W. writes: "... all are alike in the absence of an opisthotic* and basisphenoid, the even upper surface, the sculpturing of the roofing bones, the simplicity of the post-temporal, the essential shape of the ethmoid and the great size of the supra-occipital, which separates the parietals widely, and appears to separate the hinder portion of the frontals. In *Gasterosteus* the exoccipital extends forwards between the pterotics and basioccipital to the pro-otic. In the others the pterotic extends ventrally to the basioccipital, and also part of the way into the large membranous space between this and the pro-otic, thus separating the exoccipital widely and the basioccipital partially, from the pro-otic In the sphenoidal region of *Fistularia* the pro-otic completely encloses the foramen for the exit of part of the fifth nerve, and forms the hinder boundary of the other exit. The large alisphenoid forms the front boundary of the rest. No eye-muscle canal is present, consequently the parasphenoid lies flat against the floor of the cranium. Laterally it sends out processes up to the sphenotic (= postfrontal; in *Fist.* the process is united to the prootic and does not at all reach the postfrontal)." P. 576: "In the anterior portion of the cranium, *Fistularia* and *Syngnathus* present the same features as those given above for *Gasterosteus*, but it is greatly elongated, and almost completely ossified. In the first this region is proportionally much wider, because the narrow pre-ethmoid is supplemented laterally by the nasals." "In the viscerai skeleton all are alike in the tendency towards weakening of the branchial apparatus", in the great forward slant of the hyomandibular**, in the great elongation of the symplectic, in the great reduction or complete suppression of the metapterygoid cartilage***, in the absence of an ectopterygoid****, and in the possession of the acrartete condition."† "In *Fistularia* the reduction of the branchial skeleton has advanced much further than in *Syngnathus*, for all the basibranchials and the fourth epibranchial are absent. The pharyngobranchials of the second to fourth arches are present, but, unlike those of *Gasterosteus*, the first two are fused; the third is free, and all are rod-like, and lie one behind the other." P. 577: "In the hyoid arch the basihyal (= glossohyal) though present during development, is absent in the adult *Syngnathus* ‡‡, but attains a great length in *Fistularia*." "Of the bones immediately concerned in the gill-cover and branchiostegal membrane, the operculum alone survives in *Syngnathus* ‡‡‡, but are all present, together with five branchiostegal rays, in the *Fistularia*." P. 578: "In *Fistularia* the inner lamina of the suborbital bone alone remains, the quadrate is much larger posteriorly, and the pterygoid bone bears a close resemblance to that of *Gasterosteus*. Between the hinder process of the last named bone and the suborbital is the undoubted metapterygoid, which thus occupies a similar position to, but is much smaller than, a in *Syngnathus*." ‡‡‡‡ What SWINNERTON here calls the suborbital must be the symplectic in *Fistularia*; of sub-

* In *Gasterosteus* an opisthotic is present!

** In *Gasterosteus* I cannot admit any "weakening" of this apparatus.

*** In *Gasterosteus*, *Spinachia*, etc. the hyomandibular is not more sloping forwards than in very many other fishes (nor in *Syngnathus*).

**** In *Gasterosteus*, *Spinachia*, *Eucalia*, *Apeltes* etc. an ossified metapterygoid is present (overlooked by SWINNERTON in his monograph!); in *Syngnathus* only (as in the other Lophobranchiates) it is absent.

***** The ectopterygoid is present in *Syngnathus* (and Lophobranchiates generally).

† The acrartete condition is defined by SWINNERTON as the condition, in which the attachment of the palatine cartilage or its derivatives is confined solely to the preethmoid cornua. Now, in *Fist.* the palatine is attached to the vomer alone.

‡‡ It is present in all adult Syngnathids.

‡‡‡ In *Syngnathus* and all the Lophobranchiates all 3 opercular bones are present, and 1 or 2 branchiostegals.

‡‡‡‡ a in *Syngnathus* is the anterior infraorbital bone; comp. the reproduction of SWINNERTON's figure 50, p. 356 [90] with my fig. 4 on Pl. V, and what is said on p. 356 [90] of this paper.

orbitals this genus has no trace whatever. From the above quotations it will appear that GÜNTHER, publishing in 1861, had by far a more correct apprehension than SWINNERTON in 1902, of the cranial structures in *Fistularia*.

In his admirable paper on the shoulder-girdle in the Hemibranchiates STARKS (55, p. 624) correctly points out the absence of opisthotics and parietals and the position of the pterotic, the form of the occipital condyle, the presence of the long ossified lateral nuchal tendons as cranial features common to both *Fistularia* and *Aulostoma*. But in adding: "basisphenoid bridging anterior edges of prooties above rectus muscles of eye making basis cranii appear double, but no myodome in continuation", he makes a mistake: there is no basiphenoid in the described position, the bridge is formed by the prootic itself, in *Fistularia* together with the alisphenoid — as already known to KLEIN. As osteological characters distinguishing *F.* from *Aulostoma* S. mentions, that the palatines are free from the cranium, the posttemporal united suturally to the latter, and that the transverse processes are normal. The latter point is less correct, in so far that the double transverse processes are also found in *Fistularia*, the posterior one is only very small compared with the corresponding process in *Aulostoma*.

¹⁵ p. 289 [23]. While LACÉPÈDE (31, p. 92) only observed, that the anterior part of the body in *Fistularia* was enclosed in a kind of armour, consisting of 6 long bony plates, hidden below the skin, AGASSIZ (1, p. 278) had a more complete notion of these elements and referred the large ventral plates to the coracoid ("humérus"), the lateral to the postclavicle ("os styloïde"); besides he remarks that the pterygials ("os carpiens") are well developed.

ROSENTHAL (47, pl. 9, Text p. 31) designates the shoulder-girdle as "Gürtel" (without entering into its composition), the postclavicle as "Seitenschuppen", the coracoidal plates as "Vordere Bauchschuppen, die vom Winkel des Gürtels entstehen", the ossified nuchal tendons as "Lange Rückenschuppen, die vom Hinterhaupt abgehn."

BRÜHL (6 a, Pl. 12, Fig. 36) gives a rather poor and incorrect figure on which sc (i. e. "scapula") is the posttemporal; the suprascapular is omitted; the lateral (dermal) part of the clavicle is lettered V. A. 1 (i. e. "Vorderarm, erstes Stück" = scapula in the present paper); the real scapula and three pterygials are lettered H. W. (i. e. "Handwurzel"), and the coracoid V. A. 2 (i. e. "Vorderarm, zweites Stück"); the postclavicle and the coracoidal plates are marked "? 1" and "? 2", probably indicating that they may be regarded as separate parts belonging to the two "Vorderarm-Stücke". In the text nothing is found about these questions; upon the whole are only found two statements, the one wrong (p. 174), viz. that *Fist.* has only one "Schulterblatttheil" (the posttemporal), the other (p. 176) that it has two "Ober- und Vorderarmknochen."

GÜNTHER (16 a, p. 532) apparently regards the posttemporal as part of the skull: "The process on which the humeral arch is suspended is very long, reaching as far backwards as the operculum; suprascapula and scapula (= supraclavicle) short, simple; the humerus (i. e. the clavicle) emits a process backwards for the coracoid (i. e. the postclavicle), another downwards for the radius and ulna (i. e. scapula and coracoid), and finally a third for its symphysis. There are three bones participating in the symphyseal junction of the humeral arch: the urohyal, which is very elongate, the humeral and the pubic bones. Radius and ulna reduced to a single subcircular bone; there are four narrow, longish carpal bones (i. e. pterygials)." (I suppose that part of the scapula is looked upon as one of these "carpal bones", the small uppermost pterygial having been overlooked; otherwise the statement, that there is only one subcircular bone representing the scapula and coracoid, is unintelligible). Farther down he describes the postclavicle ("coracoid") as composed of two bones; and the ventral shields or "pubic bones". Curiously enough G. has not seen that the ventrals are provided with typical "pubic bones"; and in the diagnosis of the family *Fistularidae* (p. 529) he expressly states, that the ventrals "are separate from the pubic bones, which remain attached to the humeral arch."

A very lengthy and circumstantial description of the shoulder-girdle (and the urohyal) is

given by KLEIN (26 a, p. 326—27); but, curiously enough, he does not give any morphological interpretation of the constituents described in so many words; only the ventral coracoidal plates he designates, like GÜNTHER, as "Beckenknochen."

COPE (8, p. 457) regarded the coracoidal plates as interclavicles, and this interpretation later has been generally accepted, until STARKS (p. 625) declared that these bones were not separated from the coracoids. Thus we find these elements called interclavicles in the description of JORDAN and EVERMANN (21 a, p. 756, 757), which otherwise in the main follows GÜNTHER but uses other names; they only speak of 3 pectoral ossicles (i. e. pterygials).

In SIEBENROCK's paper (53, p. 131) only the posttemporal and its connection with the cranial bones are described; S. correctly places *Fist.* among the fishes, which possess all three elements in the clavicular arch: posttemporal, supraclavicle and clavicle.

STARKS (55, p. 625, 630) describes in detail the ventral coracoidal plate and the shoulder-girdle, giving a very good figure. The few points, in which I have anything to add, will be found on pag. 289 [23] of my paper; they are in the main the structure of the scapula and the connection between the coracoid plates from the opposite sides in the ventral median line, which latter point seems not to have been observed by STARKS.

Recently SWINNERTON (56 b, p. 379) has raised the question about a probable separate existence of the ventral coracoidal plates as interclavicles in the group of fishes, comprising *Fistularia*. As his own contribution to the question only regards *Gasterosteus*, which in my opinion does not at all belong to this group, I shall later come back to it in treating of this genus. Only I may just state here, that the considerations set forth by STARKS have in my opinion lost nothing in validity through SWINNERTON'S observation.

¹⁶ p. 292 [26]. That there are four gills, a well developed pseudobranchia and a slit behind the fourth gill-arch has been seen by previous authors, but some, MECKEL f. i. (p. 18) deny the presence of a pseudo-branch; already LACÉPÈDE mentions the presence of the pseudobranchia here as well in *Aulostoma* ("le rudiment d'une cinquième branchie"); L. also says that COMMERSON has found the stomach, in the specimens dissected by him, very long, and filled with small fishes.

KNER (28 b, p. 29 [260]), after having made the following statements: "die Rechenzähne sind äusserst kurz und spitz (they are really wanting); Schlundzähne konnte ich nicht wahrnehmen", adds: "Der Darm macht keine Windungen (im lang gestreckten Magen fand sich ein Fischchen vor), die dünnwandige Schwimmblase reicht nur bis zu den grossen queren Fortsätzen der Bauchwirbel." (*Fistularia immaculata* = *F. serrata* autt.).

GÜNTHER (16 a, p. 535) gives the following information about the visceral anatomy of *Fistularia* ("*serrata*"): "The greater portion of the case formed by the bony shields behind the head is filled by the air-bladder, the membrane of which is thin, coating the interior surface of the upper and lateral shields, and firmly attached posteriorly to the muscular mass which commences behind those shields. A portion of the stomach and liver also are enclosed in that anterior portion of the abdominal cavity. The stomach is elongate, subcylindrical, and passes gradually into the intestine, which is short and straight to the vent. I observe only one short pyloric appendage, enveloped by a portion of the pancreas, which is situated along the whole posterior side of the stomach and encircles its pyloric portion. The spleen is elongate, ovate. The abdominal cavity is extremely narrow from the point where the muscular mass of the vertebral column commences. The kidneys are thick and very long, extending along the whole abdominal cavity upwards to the air-bladder."

The kidneys have been described by HYRTL (20 b, p. 70) in "*Fist. serrata*." He also states that a urinary bladder is absent. But some pages before in the same work, p. 38, he says: "Eine sehr unansehnliche Andeutung einer Harnblase als spindelförmige Erweiterung des einfach gewordenen Harnleiters habe ich an ... *Fistularia serrata* ... wahrgenommen." I have not been able to see the least trace of a bladder.

The genital organs have been correctly described by HYRTL (20 a, p. 406) in *F. serrata*.

The olfactory organ of *Fistularia* has been described by BURNE (7, p. 633). In the accompanying figure LAC ("lacrymal scute") is the prefrontal, N (supposed to be the nasal) part of the ethmoid.

Syngnathidæ.

¹⁷ p. 303 [37]. DUNCKER's description (13, p. 21–22) of the two anterior body rings is different from that given by me. As upper parts of D.'s foremost ring, his "Schulterring", are regarded the superior lateral scutes (sl in my fig. 2 on Pl. III) which I refer to the second ring, that behind the pectoral, to which they undoubtedly belong. As lateral parts of the "shoulder-ring" D. further counts two "plates" on each side, one in front of the pectoral fin, the "Skapularschild", one behind, the "Axillarschild"; the first is the dermal part of the clavicle + the "coverplate" (Pl. III, fig. 2 c), the "Axillarschild" is my median lateral plate (Pl. III, fig. 2 ml) of the second ring (the first ring of typical composition). Finally, as inferior parts of the "Schulterring" are regarded two plates on each side, my "jugular plate" (Pl. III, fig. 2 j), which he termes "Infrascapulare", and my inferior lateral plate of the second ring (fig. 2 il). Thus the difference really consists in the facts: 1) that D. regards my first and second rings as only one, the "Schulterring"; 2) that he has apparently not observed that the clavicular dermal part and the "cover-plate" are two separate structures.

¹⁸ p. 306 [40]. Regarding the structure of the vertebral column, which is examined without great difficulty, several features have earlier been noticed, and more or less correct information will be found scattered through the literature. While the peculiar arrangement of the interspinous bones for the dorsal fin has been very early noticed and later has been mentioned by several authors, as also the immovable connection between the shoulder-girdle and the two anterior vertebræ, the fact that the three anterior vertebræ besides are immobile, because their neural arches are suturally united, seems never to have been observed before.

SCHNEIDER in Petri Artedi *Synonymia Piscium etc.* 1789 (49) p. 338–39 and Tab. II, figs. 20–21 has given some primitive and rough, not quite correct, representations of transverse sections of *Syngnathus typhle* (or *acus*) and (fig. 22) a small part of the skeleton at the region of the dorsal fin, seen from the side. The latter figure is extremely incorrect but — as far as I know — hitherto the only existing, representing the peculiar groups of the parts supporting the fin-rays; they are here called: "Processus spinosi in radios 4–6 diffusi". Thus the fact that interspinous bones are combined with the spinous processes has escaped attention.

MECKEL (35) p. 202 remarks that the vertebræ in *Syngnathus* are elongated, p. 203 that articular processes are wanting or at least "höchst unmerklich"; p. 204 that the spinous processes are split: "Ihre Schenkel bestehen aus fünf bis sechs zarten, dünnen Stäbchen, die fast senkrecht in die Höhe steigen und sich an den meisten zu einem einfachen, mittlern, langen, aber niedrigen Blatte vereinigen, das aber unter der Rückenflosse theils bedeutend höher wird, theils sich von vorn nach hinten in drei, vier bis fünf in dieser Richtung aus einander weichende Strahlen spaltet, welche die Flossenstrahlen tragen." Thus, M. has overlooked the presence of interspinous bones ("Nebendornen" Meckel). On p. 244 he adds that ribs are wanting, a fact also mentioned by CUVIER and VALENCIENNES (10, p. 296).

KRÖYER (29, p. 685) describes the vertebral column in *Siphonostoma typhle* in the following way: "The vertebral column consists of 55 vertebræ, proportionately large and strongly built, especially the foremost, lying over the abdominal cavity; these are moreover for the greater part provided with strongly developed transverse processes. On the other hand the abdominal vertebræ almost completely want spinous processes; the latter, however, are found on the nine or ten anterior caudal vertebræ, to which the dorsal fin is attached, and are very conspicuous and of peculiar shape, each of them being split into three or four, with the points free, projecting, rays; thus this part of the column being formed like a finely

serrated saw. Ribs could not be observed." Regarding *Syngnathus acus* KR. says (p. 701): "The vertebral column consists of 66 vertebræ*, the 22 of which are situated over the abdominal cavity, the remaining 44 may be regarded as caudals. Thus the vertebræ in number agree with the (transverse) rows of scutes; they are proportionately large and strong. In all the abdominal vertebræ the transverse processes are strongly developed in length, while the spinous processes may be said almost to be absent, the neural canal generally appearing in the shape of a simple roof with sharp crest. On the two last abdominal vertebræ, however, and on the eight anterior caudals, i. e. on the vertebræ carrying the dorsal fin, are found, quite as in the preceding species (*S. typhle*), strongly developed spinous processes of peculiar shape, each formed by four divergent rays (only exceptionally five or three). The interspinous bones, attached to these rays, are of an extreme slenderness. The transverse processes of the vertebræ decrease in length with the beginning of the dorsal fin, and disappear, almost completely vanishing, at its end. The transverse processes of the first vertebræ in the pipe-fishes are of peculiar form: large, flat, blade- or wing-shaped, behind strongly elongated (quite to the transverse processes of the next vertebra), and pointed like a dagger. The inferior spinous processes begin to appear on the first caudal, but they are always very small, and the canal, which they form for the blood-vessels, is very incomplete, because they only take up a small part of the length of the vertebræ, thus large interspaces being left between them. On the other hand the lower surface of the caudals is hollowed out into a rather deep furrow." In a similar way KR. describes the column at length in *Nerophis aquoreus*. Here he finds 82 vertebræ, about 30 belonging to the abdominals; he points out the difference from the preceding in the shape of the transverse processes. Regarding the vertebræ, supporting the dorsal fin, he says; "In the vertebræ, lying under the dorsal fin (24th to 35th, both included, or the eight last abdominal and a pair of the anterior caudal vertebræ) the spinous processes divide each into three to four large spines, supporting the same number of strong interspinous bones." About the last caudal vertebræ, carrying the rudimentary caudal fin, is said that it appears to have no plate-shaped enlargement at its end.

KNER (28 a, p. 57—58) in his description of the muscles of the dorsal fin and the action of the latter as a locomotory apparatus, mentions that in *Syngnathus* "die langen Flossenträger am Skelete in fächerartig auslaufende Bündel gestellt sind, und zwar sitzen bei *Sygn. rubescens* acht solche Bündel, deren jedes aus 3—5 Flossenträgern besteht, auf eben so vielen Wirbeln auf Bei *Hippocampus* sind dagegen die langen Flossenträger fast parallel, nur die vorderen und hinteren etwas divergirend und die Flosse sitzt (wenigstens bei *Hipp. guttulatus*) bloss auf drei Wirbeln auf, deren obere Schenkelbögen statt einfache Dornfortsätze zu bilden, sich sogleich in drei kurze strahlig auslaufende Knochenfasern zertheilen, auf welche die Flossenträger sodann aufsitzen." KNER's statements are repeated by DUMÉRIL (12 a, p. 140, b, p. 475) without any further additions of his own; only p. 142, p. 476 he mentions as a character of these fishes, the absence of ribs. COPE (8 p. 457) remarks: "Anterior vertebræ modified, the diapophyses much expanded." MOREAU (36, p. 29): "Les vertèbres correspondent aux anneaux du corps et sont par conséquent en nombre égal; elles sont relativement développées, grosses et longues avec très-grandes apophyses. Les apophyses épineuses sont généralement larges, elles présentent au niveau de la dorsale une disposition singulière, elles se divisent en tiges plus ou moins nombreuses qui sont en rapport avec autant d'interépineux." p. 30 the latter point is repeated with the addition, that "ces tiges sont tantôt presque droites, parallèles (*Hippocampes*), tantôt divergentes comme les branches d'un éventail (*Syngnathes*). Les interépineux ont leur extrémité supérieure très-développée."

RYDER (48, p. 197 and Pl. XVII) observed in the "larvæ" of *Hippocampus* the distal segment of the interspinous bones as a separate cartilage, articulated to the still cartilaginous proximal part. "In adult specimens, the interspinous basalia which are at this young stage

* In CUVIER'S Leçons etc. I, p. 232 the same number is given for *Sygn. acus*; for *Hippocampus* 15 + 46 = 61.

nearly in contact with the notochord by their proximal ends, are pushed farther out and become apposed upon and interposed between the spinous dorsal radii springing directly from three vertebrae."

Mc. MURRICH describes and figures (34, p. 648—49, and Pl. XLII, fig. 2) the developing interspinous bones in the larval *Syngnathus peckianus* as cartilaginous rays, resting directly on the membrane surrounding the spinal cord *; in later stages (l. c. fig. 6) they are said to be united distally by a longitudinal bar, resting on which are cartilaginous nodules (i. e. the distal interspinous segment of the adult), each supporting a fin-ray. The urostylic cartilages for the, at first heterocercal, tail-fin are large and may be compared to the interspinous rays of the dorsal fin. The anal fin (the interspinous rays of which are not mentioned or figured) is, wrongly, stated to atrophy in the adult.

LILLJEBORG (32, p. 449) gives the number of vertebrae in *Siphonostoma typhle* as 52—55, of which the anterior 17—18 are abdominal. "The two first are modified and longer than the remaining, strongly coalesced, the border between their neural arches having disappeared, and serving as attachment for the shoulder-girdle. To this end the transverse processes of the first vertebra are very much expanded, giving strong and immovable attachment to the upper ends of the clavicles. Also the transverse processes of the second are somewhat expanded, and their ends are attached to the clavicles, where the latter are bent. Otherwise the vertebrae in general have transverse processes, to the end of which the plate-rings are fastened. These processes are longest on the abdominal vertebrae and generally truncated. The spinous processes are low, laterally compressed and plate-shaped, only little or not at all separated, and show a series of several rods connected by thin lamellæ. The anterior caudal vertebrae, which support the dorsal fin, have the spinous processes somewhat more elevated, and with 3—4 free points, to which the interspinous bones of this fin are attached. Ribs are wanting."

SMITT (54), who has so admirably interpreted the suspensory parts of the head-skeleton which are by no means so easy to make out as the vertebrae, only says regarding the latter (p. 666), that they are but slightly ossified, elongated, "the processes straight and of uniform breadth or slightly broader at the top; but in the vertebrae above which the dorsal fin is attached, the upper spinous processes are divided sagitally (in the longitudinal direction of the body) into three or four divergent branches. Distinct haemal arches appear only at the beginning of the caudal region, where a few may be found." Thus it does not seem clear, if SMITT has observed the interspinous bones or not.

BRIDGE (5, p. 578) describes at length the (34) interspinous bones in *Siphonostoma typhle* and mentions briefly those of *Hippocampus guttulatus*. He points out their bisegmental structure, the distal segment being represented by a cartilaginous nodule, and says that in *Siphonostoma* they exhibit "a slight tendency to become arranged in groups of four each. In each group the segments converge slightly towards their proximal ends, where they are firmly attached to the summit of the neural arch of a subjacent vertebra. Distally the segments diverge slightly and their dorsal extremities expanding somewhat come into apposition, and form with one another a continuous peripheral margin." Into the bony structures, which build up the latter, he does not enter, nor has he any remarks regarding the structure of the supporting vertebrae.

JORDAN and EVERMANN (21 a, p. 759) in their diagnosis of the order Lophobranchii adopt the remarks of COPE, quoted above; the same are repeated in later works, by JORDAN and SNYDER (22, p. 3) and JORDAN and EVERMANN (21 b, p. 117).

HUOT (19, p. 252) remarks: "Dans la région du corps où se trouve la nageoire dorsale, les apophyses épineuses se prolongent par des cartilages interépineux qui, eux-mêmes, se prolongent par les rayons cartilagineux(?) des nageoires", which mode of stating the facts is

* These cartilaginous rods are according to Mc. M.'s figure 2, as well as my own observations in *Siphonostoma typhle* and *Syngn. rostellatus*, parallel to each other, as are the interspinous bones in most adult bony fishes.

somewhat misleading; further he mentions that the vertebral column in Lophobranchs, where the tail-fin is absent, is pointed behind, while in forms with a caudal fin the last vertebra is provided with "deux lames cartilagineuses situées dans le plan médian de symétrie, l'une dorsalement, et l'autre ventralement" (both are really ventral in position).

REGAN (45 c, p. 5) remarks that, in contrast to the Centriscidae and Amphisiliidae (his Solenichthyidae), the "anterior vertebræ are not elongate."

¹⁹ p. 308 [42]. The skeleton of the head has been examined by several authors. Curiously enough some facts have been correctly stated by older observers which later authors have failed to interpret properly, apparently because they did not know the previous literature or at all events did not consult it carefully enough, every support from illustrations being missing.

Already LACÉPÈDE (31, T. III, p. 44, p. 60) correctly gave the number of branchiostegal rays as two in *Siphonostoma typhle* (and the *Syngnathi*) and in *Hippocampus*.

MECKEL (35, p. 343), speaking of the suspensorial apparatus in Teleosts, which (with exception of the pterygo-palatine part) he calls "Gelenktheil des Schlafbeins" and regards as representing the quadrate of Reptiles and Birds in spite of his own statement, that it consists "at least of two bones", says: "In Hinsicht auf die Grösse ist sie bei den *Syngnathen* vielleicht am ansehnlichsten. Hier wird der bei weitem gröste Theil des Unterkiefers nicht durch das eigentliche Unterkieferbein, sondern durch sie gebildet. Das oberste Stück (i. e. the hyomandibular) ist klein und bildet kaum den dreissigsten Theil der ganzen Knochensammlung, die aus mehreren länglichen, einander ganz oder zum Theil von innen nach aussen bedeckenden besteht." With these words M. only shows that he did not partake in the old mistake, involved in the name "*Syngnathus*", viz. that the upper and lower jaws were partly coalesced; but M. does not attempt to analyse these parts which even to the latest authors have been most difficult to make out and have almost never been correctly interpreted.

The brain-case proper is not at all mentioned by M. But in the last volume of his work, completed much later than the first (1833), several more or less correct statements concerning the opercular and branchial apparatus are given. Thus he correctly describes the three opercular bones (p. 110); further he gives the number of branchiostegal rays as 2–3 in *Syngnathus* and *Hippocampus* (p. 118; later, p. 129, he says 3–4); he says (p. 126) that the hyoid only consists of one piece, that a urohyal ("das mittlere oberflächliche Zungenbein") is present (p. 135), in *Hippocampus* very short and slender, and that it does not reach the clavicles (p. 142, 144); on the other side he does not find any glossohyal ("der vor der Vereinigung der vorderen Seitenäste liegende Knochen oder Knorpel"); it is absent together with all the other unpaired parts lying behind the hyoid (the basibranchials, which he names "die tiefe mittlere Zungenbeinschicht") or at most developed in the shape of a slender and long cartilage (p. 145, 148). The branchial arches, which TIEDEMANN (Deutsches Archiv T. 2, p. 111) had declared to be cartilaginous, he correctly regards as ossified (p. 135, 155). The presence of gill-rakers he denies on p. 162, but later, p. 168, he states their presence.

Before the publication of the last volume of MECKEL's work CUVIER and VALENCIENNES (10, T. 1, p. 296) had declared the branchiostegal rays to be absent, and in the excellent work on the branchial apparatus in the Vertebrates, published about at the same time (1832) as the 6th volume of MECKEL's work, RATHKE too was of this opinion (44, p. 6); and he — like MECKEL — thought that the hyoid consisted of only one piece (p. 3). Among fishes lacking the copula for the hyoid (i. e. my first basibranchial) R. mentions *Syngnathus*, while the glossohyal is present as a slender rod as well as the urohyal ("Zungenbeinkiel") (p. 4); he found no basibranchials (p. 12), and no teeth on the lower pharyngeals, which are "schmale und schlanke Bogen." On p. 76 he regards the opercular apparatus as only consisting of one piece. In the tabular view on p. 20 he resumes his observations of the branchial skeleton in *Syngn. rondeletii* in the following way:

Verbindungs-glied	Erster Kiemenbogen				Zweiter Kiemenbogen				Dritter Kiemenbogen				Vierter Kiemenbogen				Schlund-kiefer	
	1stes Glied	2tes Glied	3tes Glied	4tes Glied	1stes Glied	2tes Glied	3tes Glied	4tes Glied	1stes Glied	2tes Glied	3tes Glied	4tes Glied	1stes Glied	2tes Glied	3tes Glied	4tes Glied	Mittelstück	Seitenstück
1	1	1	1	1	—	1	1	1	—	—	1	1	1	—	—	—	—	1

Transcribed into the formula used by me in the present paper the above formula would be:

Gill arch	Basibranchial	Hypobr.	Ceratobr.	Epibr.	Pharyngobr.
I	+	+	+	+	+
II		+	+	+	
III		+	+	+	
IV			+		
V		+			

If we compare my formula on p. 307 [41] of the present paper the difference will be easily perceived at once.

CUVIER (LAURILLARD) (9 b, p. 646) gives the following account of the Lophobranches: "Ces poissons ont ... le squelette plutôt fibreux qu'osseux; cependant la composition du crâne ne s'écarte point de celle des poissons osseux. Dans le *syngnath*, l'orbite est complètement fermé, en avant, en haut et en arrière, par les frontaux, et en bas par le temporal (= hyomandibular) et le préopercule, qui font l'office de sous-orbitaires; le museau est très allongé."

L'*hippocampe* a le museau moins long, les frontaux étroits, et portant au dessus de l'orbite chacun une apophyse presque verticale qui forme une sorte de corne. La partie postérieure du crâne est pyramidale et creusée de chaque côté à la face occipitale d'une fosse profonde formée par le mastoïdien (= pterotic) et l'occipital externe (= epiotic)." Nothing is found about the other cranial structures, neither in the volume quoted nor in the following volumes.

The work of KÖSTLIN (30) contains some scattered remarks (pp. 309, 317, 337, 338, 342, 356, 361, 370, 378, 394, 400) concerning the skull, but they are so defective and incomplete, that it seems hardly possible to decide, if he had a tolerably correct understanding of its structure or not. The suspensorial and branchial parts are not mentioned.

HOLLARD (18, p. 565), who is of the opinion that the "Lophobranches" are to be combined with the "Ganoïdes proprement dits", only mentions the opercular apparatus in the Syngnathids. He describes the large operculum as well as the small suboperculum; the interoperculum apparently is overlooked. Regarding the preoperculum is said: "Confondu en avant avec la série sous-maxillaire, il n'est reconnaissable qu'à ses rapports avec l'hyoïde. Ce dernier lui-même ne porte plus ici que deux ou trois rayons branchiostégés filiformes."

KRÖYER (29) in describing the single species of Pipefishes found at the Danish coasts, has given some osteological information which must be said to be of value and, taken together, to render a more complete and correct account of the structure of the skull than it would be possible to gather from any of his predecessors.

On p. 679 (*Siphonostoma typhle*) he states that he could only observe two long, very

slender, bristle-like branchiostegal rays on each side; and four pair of branchial arches, provided with gill-rakers in the shape of short spines (p. 680). The mandibular and suspensory parts are mentioned in the following words (translated by me) (p. 685): "The intermaxillaries, situated over and a little in front of the maxillaries, form the whole upper border of the mouth; they are very slender, almost like bristles, except at the middle of the upper border of the mouth, where they meet. Here they expand like a club, but an ascending part is completely lacking. The maxillaries are hardly longer than the intermaxillæ, but much stouter, flat, expanded behind or oarshaped. The lower jaw very broad in proportion to its length (its greatest width behind larger than half of the length), plate-shaped, with a longitudinal crest on the outer face, the anterior margin semilunar and convex, the posterior semilunar and concave. The temporal bone (i. e. the hyomandibular) has a very short, broad and flat shape. *Os tympanicum Cuv.** extremely elongated and slender, linear, in front deeply forked, the lower branch longer and horizontal, the upper one somewhat curved upwards. Symplecticum large, elongated, plate shaped, somewhat obliquely-foursided, in front drawn out into a long point." It will be seen that KRÖYER here regards the real symplectic as a metapterygoid; but what is meant with "Symplecticum" I am not able to decide (the infraorbitals?).

Describing *Syngnathus acus* KR. says (p. 700): "The intermaxillaries are about as in the preceding species (*S. typhle*), only smaller in proportion to the size of the body. Also the maxillæ are shorter than in *S. Typhle* but very much broader, curved somewhat like an S, the end expanded like a shovel or spade. The very small mandible is so short and broad that its shape almost forms a quadrant. The palatine consists of two branches, almost equal in length, the one (the articular part) somewhat stouter, the other slender and pointed; they meet at a somewhat obtuse angle. The temporal short, very broad (its width plainly greater than half its length), stout, flat, irregular. Tympanicum and Symplecticum about as in the preceding species. The vomer slender almost like a bristle. The ethmoid about equal in length with the vomer, but much broader and stouter than the latter, although of elongated and narrow, sword-like shape; behind it appears cleft like a fork. The preoperculum about of the same length as the snout, very strongly pointed in front, feebly curved shaped like a very elongated triangle or rather like a dagger. The opercular bone much vaulted, thin or scale-like, rounded behind, truncate in front, with a longitudinal crest or ridge a little over the middle of its height. The suboperculum hidden below the operculum, very elongated, narrow, sabre-shaped. The interoperculum, which contributes considerably to the formation of the snout and has the whole length of the latter, is strongly pointed, dagger-like behind, in front, however, broad, thin, plate-shaped, truncate. Eye-bones (*ossa infraorbitalia*) seem to be completely missing." Thus, with exception of the mistakes regarding the symplectic and "tympanic" and the infraorbitals, KRÖYER'S description — as far as it goes — is quite correct.

Under *Nerophis aequoreus* KR. (p. 709) mentions that he only found one branchiostegal ray; on p. 713 he correctly points out some small differences from the preceding species in the shape of the same cranial elements which were described in these.

Among distinctive characters common to all Syngnathids PETERS (41, p. 103) mentions: "der einfache Kiemendeckel ohne Suboperculum, die Verwachsung des Interoperculum mit dem Präoperculum", statements which it had been better to omit.

PARKER (39, p. 32, note¹) who had the notion that the Lophobranchii were in some way related to the "generalised Ganoids", supports this idea of the presence especially of "jugulars", "so rare in the Teleostei, namely in *Elops* and *Megalops*. These are well developed in *Syngnathus* and *Hippocampus*; although I am not aware that any other Ichthyotomist has observed this fact." The supposed "jugulars" of course are the interopercular bones.

* CUVIER uses the name "Tympanale", not "Tympanicum", for the Metapterygoid; KRÖYER elsewhere uses the name "Symplecticum" for the same bone, for which CUVIER and later authors have used the name.

DUMÉRIL describes briefly (12 a, p. 145, b, p. 478) the intermaxillaries, maxillaries and mandible; the latter articulated to the quadrate ("jugal" or "quadrato-jugal"), which is much elongated and forms part of the tubiform snout, together with the ethmoid, vomer and nasal and the coalesced sub- and interoperculum; a, p. 149, b, p. 481 he remarks that 2 or 3 branchiostegal rays are found and adds that the preoperculum is absent and repeats the wrong statement that the suboperculum and interoperculum are coalesced to form part of the tube. Some of these incorrect statements will be found still surviving in the later literature.

COPE (8, p. 457) states for his *Lophobranchii* (comprising *Solenostomidae*, *Syngnathidae*, *Hippocampidae*): "Mouth bounded by the premaxillary above; posttemporal simple, coossified with the cranium. Basis crani simple Inferior and superior pharyngeals and superior branchiophyls (i. e. epibranchials) wanting or unossified." To COPE's diagnostic skeletal characters RYDER (48, p. 193) makes the following, not very fortunate, addition: "Opercle a simple plate." On p. 196 he says regarding *Hippocampus*: "There appear to be no mesial hyal elements at all, which also seems to be the case with the adult, the medial skeletal elements of the tongue being suppressed." Further he (correctly) adds that the lower mesial elements of the branchial skeleton also appear to be absent.

POUCHET (42) in describing the development of the head skeleton in *Syngnathus* found 3 branchiostegal rays very early present. Regarding the adult structures so very little is mentioned that it is impossible to make out, how far P. had a tolerably complete or correct acquaintance with their peculiarities. p. 83 he says: "Chez l'adulte, quand on cherche à séparer par les procédés ordinaires, macération, cuisson, etc., le symplectique du jugal (i. e. the quadrate) la branche cartilagineuse se brise et son extrémité reste adhérente au jugal, dans lequel elle est fortement engagée. De façon que le cartilage qui constituait le temporal primordial (i. e. the cartilaginous rod representing the hyomandibular + the symplectic), se retrouve ici dans trois os chez l'adulte: 1^o le temporal (i. e. hyomandibular); 2^o le symplectique; 3^o le jugal." However correct this statement in itself will be found to be, it may still be open to doubt, if P. has really been acquainted with the peculiar shape and connections of the symplectie in the adult.

E. MOREAU (36, p. 29) describing the head of the *Syngnathidae* says: "La bouche est à l'extrémité d'un tube dont les parois sont constituées en bas par une aponévrose et les interopercules, latéralement par l'appareil tympanique, en dessus par les ptérygoïdiens, les palatins et le vomer La mâchoire supérieure est formée par les intermaxillaires très-grèles, très-courts, débordés en dehors par les maxillaires qui se terminent en une sorte de palette élargie. La mâchoire inférieure est constituée, d'une façon normale, par trois os, le dentaire, l'articulaire et l'angulaire; elle est articulée avec l'appareil tympanique composé par ses quatre osselets."

Here we meet for the first time with the correct statement that the mandible is composed of three pieces as usual; but unfortunately M. does not enter into an analysis of the suspensory parts. In saying, however, that the latter is composed of "its four bones", he shows that he cannot be quite right. Where 4 bones are present, these always are the hyomandibular, symplectic, quadrate and metapterygoid. But the latter is absent here; probably the infraorbitals, which M. nowhere mentions, have been taken among the suspensory bones. Under the "Appareil branchial" M. further (p. 30) mentions the operculum, suboperculum and interoperculum, but he states wrongly: "il n'y a pas de préopercule." He describes the hyoid (without mentioning its composition of pieces), carrying "two or three" branchiostegal rays, and an elongated urohyal ("sous-hyoïdien").

MC. MURRICH (34) has given a careful and in several points correct description of the head-skeleton in *Syngnathus peckianus*; it is partly supported on transverse sections, and due attention is paid to the cartilaginous parts of the developing young and of those preserved in the adult; furthermore this account is illustrated with figures. On p. 626 he describes the adult cranium. He has correctly seen that the orbitosphenoids, basisphenoid and nasals are wanting. The epiotics he takes to represent the parietals, but he seems to be inclined to

regard these bones as "dermo-epiotics", "for they directly overlie the epiotics, appearing like a parostosis formed upon these bones." Alisphenoids seem to him to be absent, and about the posttemporal he is undecided but inclined "to consider it homologous, to a certain extent at any rate, with the supra-temporal of *Amia*."

In the ethmoid he (p. 629) mentions a canal, which he (wrongly) takes "to be the continuation of the main slime canals, which also traverses the frontals." His account of the development of the visceral and suspensory parts in the young is good and correct; only, as far as I can see, the cartilage which according to MAC MURRICH represents the metapterygoid, must belong to the entopterygoid; and it seems hardly credible that only 4 cartilaginous branchial arches should be present, in as much as the adult possesses five. In the adult, however, M.'s interpretations apparently contain some graver errors. He recognizes the stylohyal ("interhyal") and finds the hyoid consisting of "a cerato- and hypohyal", "the epihyal being apparently absent"; but in saying (p. 638) that "the genio-hyoid element (i. e. the glossohyal) does not appear to ossify and in fact has disappeared", he certainly is wrong; and regarding the suspensory parts, he considers the posterior infraorbital (my true antorbital) as the metapterygoid, in spite of his observation of its being "separated from the symplectic by a quantity of muscular tissue." The anterior infraorbital he correctly regards as such. Further he did not understand the interoperculum, which he, however, has seen, but mentions as "a scale-like bone, which has no special representative in other Teleosts." He only describes one pterygoid, apparently my ectopterygoid, and denies the existence of intermaxillaries, and interoperculum, and about the preoperculum he says that it "appears to be absent, or at any rate very rudimentary."

Among the extremely detailed descriptions of the single bones, composing the skull of Teleosts, which are contained in the work of v. KLEIN (26 b and c), are some concerning the Syngnathids (*Syngnathus*, *Hippocampus*, *Gasterosteus*, *Leptoichthys*, *Phyllopteryx*). (b) p. 135 he correctly states that no eye-muscle-canal is found; p. 136, that the parasphenoid — as in *Fistularia* — does not reach the vomer anteriorly, which at all events does not hold good for *Syngnathus* and *Hippocampus*; p. 150 he mentions, that "alæ orbitales" (i. e. alisphenoids) may be separated from the "alæ temporales" (i. e. the prootic) in some Syngnathids; p. 234—36 the anterior, ethmovomerine, part is described at great length, but apparently correctly in most respects (that nasals are lacking is not mentioned). (c) p. 128 the basioccipital condyle is said to be about convex in *Syngnathus*, decidedly convex in *Gasterosteus* and *Phyllopteryx*; the first is certainly, the latter probably wrong. p. 157 under the lengthy description of the exoccipitals, parietals are mentioned in *Phyllopteryx*; but a thorough examination of the detailed description of the "occipitalia externa" (i. e. the epiotics), found on p. 197—98, reveals that the parietals in question must be the epiotics, while v. KLEIN's "occipitalia externa" (or epiotics) are really the posttemporals; and quite the same will be found to be the case with the parietals ascribed to *Hippocampus* on p. 197; they also are the epiotics, and the posttemporal is taken to be "occipitale externum." On the other hand v. K. declares on p. 217, where the supraoccipital is dealt with, that in *Syngnathus* the parietals are not separated from the frontals. Finally on p. 251, under the "squama temporalis" or pterotic, the following statement is found: "Bei den mir bekannten Syngnathidae reichen die Kiefersuspensionen, welche die Seiten der röhrenförmigen Schnauze bilden, nicht an die squamæ", which is wrong.

SCHÄFF (50, p. 12) describes the cranial skeleton of *Siphonostoma typhle* and figures the skull from above (Fig. 4, the vomer omitted), and the whole head seen from the side (Fig. 18). He regards the epiotic as parietal and (with MC. MURRICH) the posttemporal as a "supra-temporal." He rightly denies the existence of a nasal. In the suspensory part he, too, does not recognize the preoperculum, which he takes to be the symplectic; he has correctly interpreted the infraorbitals and the palatine, but about the remaining pterygo-palatine series he only says: "Innerhalb dieser Infraorbitalia liegen die Pterygoidea, die hier jedoch nicht berücksichtigt werden." The intermaxilla and maxilla are correctly observed, but regarding the lower jaw is said: "Das Mandibulare ist stark entwickelt, Articulare, Angulare und Dentale

jedoch nicht zu unterscheiden" (p. 14). Of *Hippocampus* the skull is figured from above (Fig. 11); the figure and the corresponding text (p. 21) show the posttemporal interpreted as a pterotic, the epiotic as a parietal.

LILLJEBORG (32, p. 437), in giving a diagnosis of the genus *Syngnathus* (including as subgenus *Siphonostoma*) says that all 3 opercular bones and 2–3 bristle-like branchiostegal rays are present (about the opercular apparatus L., however, is mistaken, cfr. below).

Describing *Siphonostoma typhle* L. (p. 443) states that the preoperculum is wanting, and 2 branchiostegal rays are present; p. 446 the skull is described in detail, upon the whole correctly; *inter alia* is said that the opisthotic, basisphenoid and orbitosphenoid are absent and the alisphenoid present. Incorrect is the following: "The ethmoid, lying on the fore part of the vomer in the shape of a keel, does not reach back to the anterior ends of the frontal. The visible parts of the parietals are small." In the interpretation of the suspensory bones (p. 447) some greater errors occur in as much as L. considers the preoperculum to be the interoperculum, while the preoperculum is said to be absent, and takes the real interoperculum to be the metapterygoid. The infraorbitals are correctly interpreted, but his statement, that the borders between them and partly the border against the "interoperculum" (i. e. the preoperculum) are obliterated, is wrong. He further seems inclined to see some more infraorbitals behind the posterior one (so in my figure). The pterygo-palatine bones and the mouth-parts are correctly observed and described (L.'s "mesopterygoid" is = my entopterygoid). About the branchial skeleton is only said that "os linguale" (the glossohyal) is very short, but the "basibranchiostegal bone" (presumably the urohyal) is long, slender and rod-shaped, and that according to MC. MURRICH the epihyal is wanting in the small and short hyoid.

SMITT (54) is, as far as I have seen, literally the only author, who almost without any mistakes has described the suspensory skeleton of a Syngnathid; I therefore think it just to quote his description in extenso:

"In the Deepnosed Pipefish (*Syngnathus typhle*) the elongation of the snout is produced in the following manner. The ethmovomerine part is elongated like a staff, and coated below by the long and narrow paraphenoid bone, while the frontal bones extend forward above in the form of long and narrow covering-bones over about half of the said elongation. The hyomandibular bone is an oblong, quadrangular but irregular, vertically set disk, which is united at a right angle below with the abnormally developed *os symplecticum*, which is directed forward, extends below the eyes, and sends out a branch obliquely upward towards the lateral ethmoid (prefrontal) bone, while a second, still longer, horizontal branch meets a process in a backward direction from the quadrate bone. This horizontal branch of the *symplecticum* is partly naked (without covering bones) externally, but is covered behind and below, throughout the greater portion of its extent, by the preoperculum. The vertical (posterior) branch of the preoperculum lies outside the hyomandibular bone and is united above to the inferior margin of the suborbital bones. The obliquely ascending branch of the *symplecticum*, on the other hand, is separated by a space, occupied by the masticatory muscles, from the two posterior suborbital bones, which bound the orbit below, but is united to the hind superior corner of the anterior suborbital (the preorbital) bone, where the latter meets the lateral ethmoid bone. The foremost suborbital bone forms the greater part of the side of the snout, being united in front as a covering bone to the ento-(meso-)pterygoideum and the quadrate bone, but leaving behind the latter an opening in the middle for about a third of the depth of the snout; the middle suborbital bone is united below to the *symplecticum*; the hindmost suborbital bone both to the *symplecticum* and, behind, to the preoperculum. We refer to the opercular apparatus a narrow, lancet-shaped, thin bone which lies along the inside of the horizontal, forward branches of the preoperculum and the *symplecticum* and the horizontal, backward branch of the quadrate bone. This lancet-shaped bone is united by ligaments behind to the upper part of the ceratohyoid bone and in front to the angular part of the lower jaw. The latter union clearly shows that the bone must be an interoperculum, corresponding most nearly in form and position to the inter-

operculum in *Tetradon* for example, though here it has passed within the symplecticum and become united behind to the upper part of the outside of the ceratohyoideum, instead of retaining its union to the suboperculum, which is here reduced to an extremely thin disk within the lower margin of the operculum.

The lower jaw is remarkable for its extraordinary depth behind and its sharply curved and toothless dental part. The maxillary bones are comparatively well-developed and their hind (lower) extremity is expanded; but the toothless intermaxillaries are small, styliform, and without nasal processes. The palatine bones are shorter than the maxillaries and of fairly uniform breadth. At the anterior angle of the union of each palatine bone to the top of the ascending branch of the quadrate bone we find the narrow pterygoid bone, which is bent at an obtuse angle, and behind the said union, close to the ridge of the snout, the entopterygoid bone, which is united in the same manner to the quadrate bone." On p. 664 S. adds: "The tongue is wanting, and the glossohyoid bone can hardly be discerned; but the urohyoid bone is comparatively long."

The only point, in which S. seems to be mistaken, is that he has found 3 suborbital bones; in fact his anterior sub- or infraorbital is only the anterior outer, plateshaped part of the entopterygoid.

SMITT's work, although it is translated into English, seems not to have been noticed by later authors, at any rate not so far as the Lophobranchiates are concerned; and all the later authors are far inferior to him in their interpretations.

GILL (14 b, p. 156) says: "Some erroneous conceptions have been entertained and misstatements made respecting features of the pipefish's structure. Only a few need be here noticed, however. Such are the statements that the preoperculum and interoperculum are wanting, that the intermaxillaries are also absent, and that the symplectic is a very important element. The preoperculum and interoperculum, as well as intermaxillaries, are developed, but I am unable to identify the symplectic. In no respect do the Lophobranchs deviate so materially from ordinary fishes as has been supposed. But, as long ago shown by PARKER, they manifest, in addition to the peculiarities generally noticed, deviations in the scapular arch. There is no posterotemporal, the posttemporal and proscapula being immediately connected, and the "coraco-scapular plate" is entire and not broken up into hypercoracoid and hypocoracoid bones." What GILL regards as preoperculum and interoperculum is not clear, but he undoubtedly did not recognize the large symplectic. In a later paper (14 c, p. 805) G. has adopted SCHÄFF's figures and interpretations, and accordingly he says: "the preoperculum is absent"; about the interoperculum and symplectic nothing is stated.

JORDAN and EVERMANN (21 a, p. 759) include among the distinctive characters for their order Lophobranchii the following cranial features: "Superior branchihyals (i. e. epibranchials) and pharyngeals, and basal branchihyals (i. e. hypobranchials) wanting or not ossified. Post-temporal simple, coossified with the cranium; basis of cranium simple ... Gillcovers reduced to a large simple plate." Most of these statements are probably taken from COPE, but they are not correct; they are repeated later by JORDAN and SNYDER (22, p. 3).

A. S. WOODWARD (59, p. 370) in the Synopsis of Families included under his Suborder Hemibranchii states for the *Lophobranchii* (*Solenostomatidae* and *Syngnathidae*) "opercular apparatus much reduced", and p. 380 for the Family *Syngnathidae*: "opercular apparatus reduced to operculum."

SWINNERTON (56 a, p. 554) referring to his fig. 50, copied below, says about *Syngnathus* (*Siphonostoma*): "The palatine bone (pa.) has the same characters as in the stickleback and like that is partially enclosed posteriorly by the single pterygoid (c.). The ethmoid region ... is seen to owe its great length to elongation, not of the hinder half, containing the mesethmoid cartilage, but to that of the front half, consisting purely of ethmoid plate. Nevertheless the mesethmoid bone (fig. 50 e. m.) has apparently extended quite to the anterior end, including the preethmoid cornu. The palatine bone (pa.) which is attached to the pre-ethmoid cornu (pa') between the mesethmoid bone and vomer is carried too far forward for it to bear any relationship to the parethmoid bone (e. p. b.)" To the above I would remark 1) that the pterygoid

in *Syngnathus* is not single, an ento- and an ectopterygoid being present*; 2) that the part of S.'s supposed ethmoid reaching about from e. m. in his figure to pa.' is really the vomer. Thus the palatines (in the adult) have no connection with the ethmoid at all. The "acratete" condition, upon which S. lays great stress, I think (with DARESTE, who many years ago observed the same) is of no great systematic value. p. 575 Sw. compares the head skeleton of *Gasterosteus*, *Fistularia* and *Syngnathus*. As I have previously under *Fistularia* quoted his words at some length and also noted some of the mistakes regarding *Syngnathus*, I may refer the reader to p. 353 [77] of this paper. Here I need only point out that Sw. has correctly observed the position of the pterotic, peculiar to all Lophobranchs as well as the whole group here under consideration, and furthermore some features in the branchial skeleton of *Siphonostoma*, regarding which he says (p. 577): "In Syngnathus the first and second basibranchials and the second hypobranchial alone are present; the fourth epibranchial has gone, but the edentulous pharyngobranchials, though rod-like, occupy the same position relatively to one another as in *Gasterosteus*."

Otherwise his interpretation of the visceral (incl. suspensory) skeleton is far from being fortunate. Thus, not only the statements concerning the absence of the basihyal (i. e. glossohyal) and the suboperculum are wrong, but also a good deal of the description quoted below,

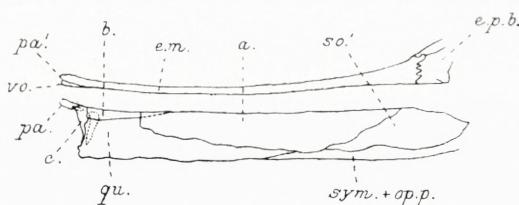


Fig. 1. Reproduction of SWINNERTON's fig. 50.

the combined symplectic and preoperculum (sym. + o.pr.). In front of the latter lies the greatly extended quadrate (qu.), of which only the small part indicated by the dotted line originated by ossification of cartilage. Along its upper and anterior borders lie three bones, a, b, c, whose homologies are uncertain; b. and c. together have all the relationships of the pterygoid in the stickleback, but as b. is developed in relation to the vestigial metapterygoid process, it must be the metapterygoid bone. a. is probably the nasal. The palatine is insignificant and edentulous." What Sw. here calls the inner lamina of s.o.' must be the symplectic (comp. my fig. 5 on Pl. V); the combined symplectic and preoperculum is simply the preoperculum alone; b. is the entopterygoid, c. the ectopterygoid. That his fig. 50 is wrong with regard to the vomer and mesethmoid, is already stated above.

HUOT (19) describes (p. 211) and figures the cartilaginous skeleton of the newly hatched young of *Syngn. dumerili*, *S. acus* and *Hippocampus guttulatus*. Regarding the skeleton of the adult he more *en passant* makes only the following remarks, which he ought to have omitted, p. 221: "Il n'y a pas de squelette operculaire ni de rayons branchiostiges", and p. 252: "Le squelette céphalique est en partie membraneux, en partie cartilagineux." (Perhaps the latter statement does not concern the adult, which seems not quite clear; but on p. 280 sub No. 11 of his "Conclusions", which certainly regard the adult, is said: "Le squelette est presque entièrement fibreux. On ne rencontre de cartilages nets que dans la région crânienne et dans les rayons des nageoires").

BOULENGER (4 a, p. 152 and b, p. 174) in the diagnosis of the Group III, *Lophobranchii*, of his Suborder *Catosteomi* includes the following osteological characters: "Præoperculum

* Neither is the pterygoid single in the *Gasterosteini*, but here anteriorly only the ectopterygoid is present, while posteriorly, joining the hyomandibular, is found a metapterygoid, which is overlooked by SWINNERTON.

which refers to his figure 50; the latter I have copied here, and it should be compared with my figures 4, 5, 9, 10, on Pl. V. "The true infraorbital, or rather the first bone of the suborbital series (fig. 50, s. o.'), articulates with the parethmoid (e. p. b.) above, and forms the lower border of the narial opening. Ventrally it appears to divide into two laminae, lying on the outer and inner sides respectively of the cheek muscles, and is attached by its lower border to

absent; symplectic much elongate; branchial apparatus more or less reduced ...; posttemporal simple, immovably attached to the skull."

REGAN (45 c, p. 8) wrongly states that "the head is capable of considerable movement in the vertical plane, the occipital condyle being convex."

Developmental stages of the head skeleton have been examined more or less thoroughly by POUCHET (43) (*Syngnathus*), RYDER (48) (*Hippocampus*), MC. MURRICH (34) (*Syngnathus*), SWINNERTON (56 a) (*Siphonostoma*) and HUOT (19) (*Syngnathus*, *Hippocampus*). With exception of MC. MURRICH and SWINNERTON (cfr. above) these authors seem not to have paid sufficient attention at the same time to the adult structures, and therefore some of their interpretations of the cartilages or incipient bones are not always quite correct, but it would lead too far here to enter into details regarding this matter.

²⁰ p. 308 [42]. The earliest remarks regarding the shoulder-girdle and scapular arch, known to me, are those of KRÖYER (29); under *Syngn. acus* he mentions on p. 699 that the nuchal plates, in the Pipefishes generally, are soldered together with the spinous processes of the underlying vertebrae and the shoulder-apparatus, the first nuchal also with the occipital bone; upon the whole the plates of the first ring are coalesced with the shoulder to such an extent, that they can only with difficulty be separated from the latter. p. 702 is said that the shoulder only consists of one bone (i. e. the clavicle), which is correctly described in details; of the scapular arch K. has only observed one bone, after his description evidently the coracoid; but it is regarded as the "upper arm"; "the remaining bones of the arm and hand are quite rudimentary." The same two parts KR. finds in *Nerophis aequoreus* (p. 714) "where the forearm and hand have completely vanished."

PARKER (40, p. 30) figures the shoulder-girdle, seen from the inner side, of *Syngn. acus*. He correctly observed the posttemporal and the clavicle; but, as already mentioned p. 303 [37] of the present paper, he did not understand the scapular arch: the coracoid he regards as two separate "interclavicular" bones; the scapula is completely overlooked, and the cartilaginous part of the scapular arch is considered to be the whole "true shoulder-girdle", "of extreme interest, as it is persistently soft, and has undergone no segmentation."

COPE (8. p. 457) has adopted the posttemporal and also the "well developed interclavicles."

MOREAU (36, p. 30) only says: "Ceinture scapulaire non attachée au crâne, mais à la colonne vertébrale et aux boucliers antérieurs." That v. KLEIN (26 c) takes the posttemporal to be the epiotic ("occipitale externum" v. Kl.) is mentioned above p. 353 [87]. On p. 251 he says: "Die Schultergürtel legen sich an den ersten Wirbel an"; a statement only partly correct.

SCHÄFF (50) does not examine the shoulder-girdle; but on p. 22 he describes in *Hippocampus* "die Platte, welche die Brustflossen trägt." From this description it is evident, that S. regards the dermal part of the clavicle, the "cover plate" and the "jugular" plate as one piece, and that he has no understanding of the attachment of the pectoral fin.

LILLJEBORG (32, p. 449) after a correct description of the posttemporal and clavicular bones says that "on the inner margin of the clavicle is found a thin, almost membrane-like, cartilaginous plate, which may represent the coracoid and scapular bones, and at the posterior margin of this plate is the attachment of the pectoral fin, which thus appears to be but weak." The ossified parts (coracoid, scapula and basals) are thus completely overlooked.

SMITT (54, p. 666) gives a figure, which is only a combined and somewhat altered copy of those of PARKER; the coraco-scapular part is introduced into PARKER's figure of the clavicular skeleton; the latter is corrected in so far that it has only one "interclavicle", but SMITT has not seen that this bone is really the coracoid. The four basals or pterygials are wrongly represented, only their basal parts, which are enclosed in the coraco-scapular cartilage, being present in the figure; evidently their distal parts, which PARKER compared with

"stag's-horns", have been broken off. Thus neither SMITT nor PARKER had any idea of the part these distal branched ends play as means of fixation of the pectoral fin.

The few remarks by GILL (14 b) and JORDAN and EVERMANN (21 a), apparently following PARKER, are quoted above. SIEBENROCK (53, p. 118) describes the posttemporal in *Hippocampus* and mentions the attachment of the clavicle to the two anterior vertebrae.

GOODRICH (15) ascribes (p. 414) to the Lophobranchii "very small pectoral radials", p. 415 adding for the subtribe B (including Syngnathidae and Hippocampidae): "with a row of distal cartilages." That his (original) figure 413 D is incorrect was stated on p. 303 [37] of the present paper.

REGAN (45 b, p. 79) characterizing the *Syngnathoidei* says: "post-temporal simple, suturally united to the cranium; no supracleithrum; cleithrum firmly attached to the transverse processes of the two anterior vertebrae." Later (45 c, 1910) p. 8 he states that "the clavicle is attached to the expanded transverse process of the first vertebra."

²¹ p. 308 [42]. Regarding the nuchal plates, the size and shape of which are often described by systematists, I may point out that most members of the Hippocampine group are possessed of three, a fact which does not seem to have been observed before. Thus MOREAU (36, p. 35) says for *Hippocampus*: "Il y a deux pièces nuchales"; the anterior is described in detail and its shape compared with a crown. "La seconde pièce nuchale est allongée, elle est étroite, elle fait une espèce de toit au-dessus de l'espace vide, qui reste entre les deux pièces latérales supérieures du premier anneau du tronc ou de l'anneau scapulaire (i. e. the upper parts of the clavicle)." From this description follows that the hindmost nuchal plate has escaped attention. SCHÄFF (50, p. 21) does not mention any number of nuchals in *Hippocampus*, but he seems not at all to understand the structures of the nuchal region: "Die Exoccipitalia und das Supraoccipitale bilden mehrere zu einem kronenartigen Gebilde verschmolzene Stacheln, an welche sich auf Nackenschildern noch einige Hervorragungen anschliessen." This seems to mean that S. regards the anterior nuchal, the "corona", as part of the skull. No better is the following: "Das erste Schild, welches auf den Kopf folgt, besteht aus zwei auf der Medianlinie des Rückens verschmolzenen, oberen Seitenschildern, deren Stacheln wie die der gewöhnlichen Schilder beschaffen sind. Auch die zugespitzte, nach unten gerichtete Fläche, die sich an den Körper legt, ist vorhanden. Dann aber tritt noch jederseits vorn ein schräg nach unten verlaufender Teil hinzu, der sich mit dem die Brustflosse tragenden Stück (i. e. the clavicle) verbindet. Nach vorn spitzt sich die Rückenfläche dieses ganzen Schildes zu und läuft in drei kleine Fortsätze aus, vor welchen die Nackenschilder mit ihren Erhebungen liegen."

DUNCKER (13, p. 21) correctly says that "Das stark bewehrte Pränuchale von *Hippocampus* wird als Corona bezeichnet"; but he only mentions a Pränuchale and a Nuchale in Lophobranchs generally.

²² p. 309 [43]. The presence of the pseudobranchia in the *Syngnathidae* has often been denied or overlooked. Thus MECKEL (35, 6. vol., p. 181) and KRÖYER (29, p. 679) deny its existence, while RETZIUS, KAUP, GÜNTHER, DUMÉRIL, RYDER, MOREAU, LILLJEBORG, JORDAN and EVERMANN, HUOT, perhaps still more authors, do not mention it at all. But already 1841 JOH. MÜLLER (37, p. 78) stated regarding the *Lophobranchii*: "Haben einige Federchen einer Nebenkieme vor dem ersten Kiemenbogen. Untersucht wurden die Gattungen *Syngnathus* Linn., *Hippocampus* C."

Solenostomus.

²³ p. 311 [45]. Only some of the cutaneous papillæ on the snout have been observed by previous authors, and only by the older, while later authors do not mention them. The mandibular barbel at the chin seems not at all to have been noticed.

SEBA (51, p. 106) in his definition of Solenostomus (paradoxus) says: "Solenostomus varius, rostro cirrato; pinnis dorsali et ventralibus praelongis" (or in Dutch: "Bonte Sole-

nostomus, met een gebaarden snuit, en zeer lange rug- en buikvinnen"); and the description l. c. p. 107 runs: "Ima rostri sede, per totam ejus longitudinem, sex paria nigricantium cirrorum aut barbularum propendent. Pari postremo oculi superimminent" (in Dutch: "Aan het onderrande van den snuit langs deszelvs lengte hangen 6 paar swartagtige baardtjes af. Booien het agterste paar staan de oogen").

PALLAS (39, p. 33) ".... rostrum subtus longitudinaliter bicostatum & ramentorum nigrorum tribus paribus æquidistantibus barbatum." His fig. 6 on Tab. IV is bad enough but better than that of SEBA; it shows 3 pairs of filaments below the snout but the hinder pair at some distance in front of the level of the eye. The slender shape of the snout and of the caudal peduncle ("Pone hos processus [i. e. the "hump" for D₂ and A] cauda attenuatior" etc.) proves sufficiently that his species really must be our *Solen paradoxus*.

BLEEKER (2 a, p. 308) describing "*Solenostoma paradoxum*" = our *S. cyanopterus* does not mention any cutaneous filaments; but later (2 b, p. 52) he states for "*Solenostoma paradoxum* Lacép. Rafin." = our *S. paradoxus*: "... rostro acuto ... sextuplo longiore quam parte gracilima alto, inferne multicirrato."

KAUP (25, p. 2) says about his "*Solenostomus paradoxus*"; "Some of the specimens have little skinny tags round the mouth and rostral tube, as represented in Pallas's figure." Of the 5 specimens known to Kaup, and by him called *S. paradoxus* (which all belong to the Museum of Paris), 3 are *Sol. cyanopterus* and 2 *Sol. paradoxus*.

²⁴ p. 316 [50]. Information about the vertebral column is only given by GÜNTHER, BOULENGER and REGAN.

GÜNTHER (16 b, p. 151): "The vertebral column is composed of eighteen abdominal and fifteen caudal vertebræ, the vertebræ gradually decreasing in length backwards, so that the shortness of the tail is caused not only by the smaller number of vertebræ, but also by their much lesser length. Neural and hæmal spines are developed." REGAN (45 c, p. 8): "The præ-caudal vertebrae have short transverse processes and the caudal vertebræ are much abbreviated; ribs are absent." BOULENGER (4 c, p. 633): "Anterior vertebræ elongate, without transverse processes; no ribs."

²⁵ p. 317 [51]. DUMÉRIL (12 b, p. 496) incorrectly states: "les rayons de toutes les nageoires non articulés."

About the number of fin-rays in the ventrals and first dorsal most authors agree; only BLEEKER gives for *S. cyanopterus* V=11, presumably having counted some of the bifurcated rays as two rays, and DUMÉRIL gives 8 rays in the ventrals of the male *S. paradoxus*. That SEBA gives 4 rays in the first dorsal, together with other apparent mistakes, I think is due to the bad state of his single, dried, specimen, which his figure clearly proves. The number 16, which without exception I have found in my specimens, I think will prove to be the normal number. I hardly believe that a variation between 12 and 20, as the table on p. 323 [57] shows, would be possible, where a caudal fin is developed and enlarged to such a degree, as is the case in the present genus. In the other fins, where the number of fin-rays are greater and their structure weaker, the numbers apparently vary slightly.

²⁶ p. 319 [53]. BOULENGER (4 c, p. 633) states: "no præoperculum; symplectic elongate", the only remarks about cranial structures found in the literature.

²⁷ p. 319 [53]. GÜNTHER (16 b, p. 150) states for the whole Order V. Lophobranchii, comprising Solenostomidae: "Gill-cover reduced to a large simple plate." A. S. WOODWARD (59, p. 379) for *Solen.*: "Opercular apparatus reduced to operculum and very few branchiostegal rays." Also JORDAN and SNYDER (22, p. 3) repeat for the Lophobranchs: "Gill covers reduced to a large simple plate."

²⁸ p. 319 [53]. GÜNTHER (16 b, p. 151): "Branchiostegals four, very thin." The same is repeated by JORDAN and SNYDER (22, p. 3).

²⁹ p. 321 [55]. C. TATE REGAN (45 b, p. 79) says: "pectoral arch normally attached to skull; post-temporal and supracleithrum similar to stellate ossifications on body"; and later (45 c, p. 8): "The membrane bones of the pectoral arch are a trifurcate post-temporal, loosely attached to the cranium, a supra-clavicle, and a clavicle. The pterygials are four in number, rather large, but very thin and similar to those of Syngnathus as figured by Parker."

³⁰ p. 322 [56]. GÜNTHER (16 b, p. 151): "The pelvis consists of two pairs of cartilaginous laminæ, the convex margin of the anterior fitting into an angle of a dermal bone which separates the pelvis from the well-ossified humeral arch."

³¹ p. 325 [59]. About the gill-apparatus the only previous statements are the following:
GÜNTHER (16 b, p. 151): "pseudobranchiaæ absent"; BOULENGER (4 c, p. 633): "gill-lamellæ small rounded lobes"; REGAN (45 b, p. 79): "gills lobate", and (45 c, p. 8): "The gill-fringes are reduced in number and thickened."

³² p. 326 [60]. About the alimentary tract PALLAS says (39, p. 35): "Ventriculus vesicularis. *Canalis alimentarius* amplius, æquabilis, fere recta a ventriculo ad anum deductus. *Hepar dexterius*, sub initio canalis alimentarii." GÜNTHER (16 b, p. 151): "Intestinal tract very simple, with a stomachic dilatation, without pyloric appendages."

³³ p. 327 [61]. PALLAS (39, p. 35): "Ovarium posterius duplex, ad dorsum longitudinalia, linearia, in anum terminata; referta ovulis flavescentibus, grano papavero sicco fere æquilibus." GÜNTHER (16 b, p. 151) only remarks: "Ova very small." The ova preserved in the ventral pouch of my specimen of *S. paradoxus* measure 0,64–0,69 mm., and they have been partly dried.

LITERATURE CITED.

1. AGASSIZ, L.: Recherches sur les Poissons fossiles. T. 2, T. 4. 1833—43.
- 2 a. BLEEKER, P.: Bijdrage tot de Kennis der Ichthyologische Fauna van de Moluksche Eilanden. Visschen van Amboina en Ceram. Natuurkundig Tijdschrift voor Nederlandsch Indie. Jaarg. 3. 1852.
- 2 b. — Vijfde bijdrag tot de kennis der Ichthyologische Fauna von Amboina. Ibid. Jg. 6. 1854.
3. BORCH (BORRICHIIUS), O.: Aci marini anatomie. Thomae Bartholini Acta medica et philosophica Hafniensia Anni 1673. Vol. 2. 1675.
- 4 a. BOULENGER, G. A.: Notes on the Classification of Teleostean Fishes. III. Ann. Mag. Nat. Hist. (7.) Vol. 10. 1902.
- 4 b. — A Synopsis of the Suborders and Families of Teleostean Fishes. Ibid. (7.) Vol. 13. 1904.
- 4 c. — Systematic account of Teleostei in the Cambridge Natural History. 1904.
5. BRIDGE, T. W.: The Mesial Fins of Ganoids and Teleosts. Journ. Linn. Soc. Lond. Zool. Vol. 25. 1896
- 6 a. BRÜHL, B. C.: Anfangsgründe der vergleichenden Anatomie aller Thierklassen. With Atlas. 1847.
- 6 b. — Osteologisches aus dem Pariser Pflanzengarten. 1856.
7. BURNE, R. H.: The Anatomy of the Olfactory Organ of Teleostean Fishes. Proc. Zool. Soc. London. 1909.
8. COPE, E. D.: Contribution to the Ichthyology of the Lesser Antilles. Transact. American Phil. Society. Vol. 14. (N. S.) Part 3. 1871.
- 9 a. CUVIER, G.: Le Règne Animal distribué d'après son organisation. Vol. 2. 1817.
- 9 b. — Leçons d'Anatomie comparée. Seconde édition. T. 1. 1835; T. 2. 1837; T. 7. 1840.
10. CUVIER et VALENCIENNES: Histoire naturelle des Poissons. T. 1. 1828.
11. DARESTE, C.: Études sur les ostéologiques des poissons osseux. Comptes rendus Acad. Sc. Paris. T. 75. 1872.
- 12 a. DUMÉRIL, AUG.: Les Lophobranches. Mémoires de la Société impériale des Sciences naturelles de Cherbourg. T. 15. (2^eme Série, Tome 5.) 1869—70.
- 12 b. — Histoire naturelle des Poissons. Tome 2. (Suites à Buffon.) 1870.
13. DUNCKER, G.: Syngnathiden-Studien. I. Mitteil. aus dem Naturhist. Museum in Hamburg. 25. (2. Beiheft zum Jahrb. der Hamb. wissenschaftl. Anstalten. 25.) 1908.
- 14 a. GILL, TH.: On the mutual relations of the Hemibranchiate Fishes. Proc. Acad. Nat. Sciences of Philadelphia. 1884.
- 14 b. — The differential characters of the Syngnathid and Hippocampid Fishes. Proc. U. S. Nat. Mus. Vol. 18. 1895.
- 14 c. — The life history of the Sea-Horses (Hippocampids). Ibid. Vol. 28. 1905.
15. GOODRICH, E. S.: Cyclostomes and Fishes. 1st Fasc. of Vertebrata craniata in Sir Ray Lankester's A Treatise on Zoology. 1909.
- 16 a. GÜNTHER, A.: Catalogue of the Acanthopterygian Fishes in the Brit. Mus. Vol. 3. 1861.
- 16 b. — Catalogue of Fishes. Vol. 8. 1870.
- 16 c. — Report on the Shore Fishes procured during the Voyage of H. M. S. Challenger. Rp. Sc. Res. of the Voyage of H. M. S. Challenger. Zoology. Vol. 1. 1880.
17. HILGENDORF, F.: Jugendcharakter der Fischgattung *Fistularia*. Sitzungsberichte der Gesellsch. naturforschender Freunde zu Berlin. 1877.

18. HOLLARD, H.: Coup d'œil sur l'ordre des Ganoïdes, et recherches sur les caractères des Lophobranches, pour déterminer leur véritable affinités zoologiques. Comptes rend. Ac. Sc. Paris. T. 31. 1850.
19. HUOT, A.: Recherches sur les Poissons Lophobranches. Ann. sc. nat. Zool. et Paléontol. 8. Série. T. 14. 1902.
- 20 a. HYRTL, J.: Beiträge zur Morphologie der Urogenital-Organe der Fische. Denkschriften d. k. Akad. d. Wissenschaften in Wien. Math.-naturw. Cl. 1. Bd. 1850.
- 20 b. — Das uropoëtische System der Knochenfische. Ibid. 2. Bd.
- 21 a. JORDAN, D. ST. and EVERMANN, B. W.: The Fishes of North and Middle America. Part 1. Bull. U. S. Nat. Mus. No. 47. 1896.
- 21 b. JORDAN, D. ST. and EVERMANN: The Aquatic Resources of the Hawaiian Islands. Prt. 1. The Shore-Fishes. Bull. U. S. Fish Comm. Vol. 23 for 1903. 1905.
22. JORDAN, D. ST. and SNYDER, J. O.: A review of the Hypostomide and Lophobranchiate Fishes of Japan. Proc. U. S. National Mus. Vol. 24. 1901.
- 23 a. JUNGERSEN, H. F. E.: Bidrag til Kundskaben om Kjønsorganernes Udvikling hos Benfiskene. Vidensk. Medd. Nat. Foren. Kjøbenhavn. 1889. Translated in: Arbeiten aus dem Zool.-Zootomischen Institut in Würzburg. Bd. 9. 1890.
- 23 b. — Ichthyological Contributions. (Amphisile and Centriseus.) Kgl. Danske Vidensk. Selsk. Skr. 7. R. Afd. VI. 2. 1908.
24. KASANZEFF: Über die Entstehung des Hautpanzers bei *Syngnathus acus*. Zool. Anzeiger. 30. Bd. 1906.
25. KAUP, J. J.: Catalogue of Lophobranchiate Fish in the Collection of the Brit. Museum. 1856.
- 26 a. v. KLEIN: Beiträge zur Osteologie der Fische. Jahreshefte des Vereins für vaterländische Naturkunde in Württemberg. 37. Jahrgang, 1881.
- 26 b. — Beiträge zur Bildung des Schädels der Knochenfische. I. Ibid. 40. Jahrg. 1884.
- 26 c. — — — — — II. — 41. — 1885.
27. KLUNZINGER, C. B.: Synopsis der Fische des Rothen Meeres. 2. Theil. Verh. zool.-botan. Gesellschaft Wien. 21. Bd. 1871.
- 28 a. KNER, R.: (Dorsal fin as locomotor apparatus in Syngnathidae.) Verhandl. Zool.-Botan. Verein. Wien. 5. Bd. 1855.
- 28 b. — Über den Flossenbau der Fische. II. Sitzungsber. der kaiserl. Akademie der Wissensch. Wien. 42. Bd. 1861.
29. KRÖYER, H.: Danmarks Fiske. 3. Bd. 1846—53.
30. KÖSTLIN, O.: Der Bau des knöchernen Kopfes in den vier Klassen der Wirbelthiere. 1844.
31. LACÉPÈDE: Histoire naturelle des Poissons. 3. Vol. 10. Vol. (Ed. in 12⁰). 1803.
32. LILLJEBORG, W.: Sveriges och Norges Fiskar. 3. Delen. 1891.
33. LÜTKEN, CHR. FR.: Spolia Atlantica. Bidrag til Kundskab om Formforandringer hos Fiske etc. Kgl. Danske Vidensk. Selsk. Skr. 5. Række, naturv. og mathem. Afd. 12, 6. 1880.
34. MC. MURRICH, J. PLAYFAIR: On the Osteology and Development of *Syngnathus Peckianus* (Storer). Q. Journ. Micr. Sc. (N. S.) Vol. 23. 1883.
35. MECKEL, I. F.: System der vergleichenden Anatomie. Zweiter Theil, erste Abth. 1824. 6. Theil. 1833.
36. MOREAU, E.: Histoire naturelle des Poissons de la France. T. 2. 1881.
37. MÜLLER, JOHANNES: Vergleichende Anatomie der Myxinoiden. 3. Fortsetz. Abhdl. d. Königl. Akademie d. Wissensch. Berlin. 1841.
38. OWEN, R.: On the Anatomy of Vertebrates. Vol. 1. 1866.
39. PALLAS, P. S.: Spicilegia zoologica, quibus novae imprimis et obscure animalium species iconibus, descriptionibus atque commentariis illustrantur. VIII. 1770.
40. PARKER, W. K.: A monograph on the structure and development of the Shoulder-girdle and Sternum in the Vertebrata. Ray Society. 1868.
41. PETERS, W.: Naturwissenschaftliche Reise nach Mossambique. Zoologie. IV. Flussfische. 1868.
42. PLAYFAIR, R. L. and GÜNTHER, A.: Fishes of Zanzibar. 1866.
43. POUCHET, G.: Du développement du squelette des Poissons osseux. Journ. de l'Anat. et de la Physiol. 14. Année. 1878.

44. RATHKE, H.: Anatomisch-philosophische Untersuchungen über den Kiemenapparat und das Zungenbein der Wirbelthiere. 1832.
- 45 a. REGAN, C. TATE: Biologia Centrali-Americanana. Pisces. 1906—08.
- 45 b. — The Classification of Teleostean Fishes. Ann. and Mag. of Natural History. Ser. 8. Vol. 3. 1909.
- 45 c. — Notes on the Classification of the Teleostean Fishes. The seventh International Zoölogical Congress. Boston Meeting 1907. 1910.
46. RETZIUS, A.: Anatomisk undersökning öfver några delar af Syngnathus Acus och Ophidion. Kongl. Vetenskaps Academiens Handlingar för 1833. (1834).
47. ROSENTHAL, FR.: Ichthyotomische Tafeln. Erste Lief., 2. Heft. 1816.
48. RYDER, J. A.: A contribution to the Development and Morphology of the Lophobranchiates; (*Hippocampus antiquorum*, the Sea-Horse). Bull. U. S. Fish Commission. 1881 (1882).
49. SCHNEIDER, JOH. G.: Petri Artedi Synonymia Piscium Graeca et Latina emendata aucta et illustrata. 1789.
50. SCHÄFF, E.: Untersuchungen über das Integument der Lophobranchier. Inaugural-Dissertation. Kiel. 1886.
51. SEBA, ALB.: Locupletissimi rerum naturalium thesauri accurata descriptio et iconibus artificiosissimis expressio per universam physices historiam. Vol. 3. 1758.
52. SEGOND, D.: Des affinités squelettiques des poissons. Journ. de l'Anat. et de la Physiol. 9. année. 1873.
53. SIEBENROCK, FR.: Über die Verbindungsweise des Schultergürtels mit dem Schädel bei den Teleosteen. Eine morphologische Studie. Ann. des k. k. naturhistorischen Hofmuseums. Bd. 16. 1901.
54. SMITT, E. A.: Skandinaviens Fiskar. 2. Del. 1895. (Fishes of Scandinavia. 2nd Vol. 1895.)
55. STARKS, E. CH.: The shoulder girdle and characteristic osteology of the Hemibranchiate Fishes. Proc. U. S. National Museum. Vol. 25. 1902.
- 56 a. SWINNERTON, H. H.: A contribution to the Morphology of the Teleostean Head Skeleton, based upon a Study of the Developing Skull of the Three-spined Stickleback (*Gasterosteus aculeatus*). Quarterly Journ. Micr. Sc. (New Series.) Vol. 45. 1902.
- 56 b. — Pectoral Skeleton of Teleosts. Quarterly Journ. Micr. Sc. (N. S.) Vol. 49. Pt. 2. 1905.
57. TANAKA, SHIGEHO: Descriptions of eight new Species of Fishes from Japan. Annotationes zoologicae Japonenses. Vol. 7. Part 1. 1908.
58. WINther, G.: Bidrag til Fiskeskjæltændernes Morphologi og Udviklingshistorie. Naturhistorisk Tidsskrift. 3. R. 8. Bd. 1873.
59. WOODWARD, A. S.: Catalogue of the Fossil Fishes in the Brit. Mus. Vol. 4. 1901.

List of reference letters.

Skull.

al: alisphenoid
 ao", ao', ao: preorbitals
 eo: exoccipital
 ep: epiotic
 f: frontal
 mes: mesethmoid
 na: nasal
 ob: basioccipital
 pa: parasphenoid
 pf: postfrontal
 prf: prefrontal
 pro: prootic
 pt: posttemporal
 so: supraoccipital
 sq: pterotic (squamosal)
 vo: vomer

Mouth parts.

an: angular
 ar: articular
 d: dentary

i: intermaxilla

mx: maxilla

Suspensory apparatus.

ect: ectopterygoid
 ept: entopterygoid
 hy: hyomandibular
 mt: metapterygoid
 pa: palatine
 pro: preoperculum
 qu: quadrate
 sy: symplectic

Opercular apparatus.

io: interoperculum
 o: operculum
 s: suboperculum

Hyoid.

ch: ceratohyal
 eh: epihyal
 gl: glossohyal

hy^I: lower hypohyal
 hy^{II}: upper hypohyal
 r: branchiostegal ray
 st: stylohyal
 u: urohyal

Branchial skeleton.

I—V: gill-arches
 c: ceratobranchial
 co: copula (basibranchial)
 e: epibranchial
 hy: hypobranchial
 ph: pharyngobranchial

Shoulder-girdle and pectoral arch.

ba: basals (pterygials)
 cl: clavicle
 co: coracoid
 pcl: postclavicle
 pt: posttemporal
 sc: scapula
 scl: supraclavicular

Plate I.

Plate I.

(For letters see List p. 364 [98].)

Figs. 1—4: *Aulostoma coloratum*.

- Fig. 1: Skull from left side. *: knob for attachment of ossified tendon.
— 2: Skull from above.
— 3: Skull from below.
— 4: Skeleton of head from left side.

Figs. 5—6: *Fistularia tabacaria*.

- Fig. 5: Skeleton of head from left side.
— 6: Skull from above. k: rugosity for attachment of ligament to first vertebra (cfr. p. 289 [23]).

Figs. 7—8: *Fistularia petimba*.

- Fig. 7: Skull from below. 1: lamelliform process from parasphenoid.
— 8: Front view of posterior wall of orbit. Frontals and parasphenoid cut through transversely.

Figs. 9—10: *Aulostoma coloratum*.

- Fig. 9. Anterior four coalesced vertebræ and foremost free vertebræ, from below. b: articular process; t: transverse process; *: attachment for ligament to posttemporal; n: openings for passage of nerves and blood-vessels.
— 10: the same, from left side. n': openings for nerves and vessels; a: anterior part of neural arch (cfr. p. 272 [6]).

Fig. 11: *Fistularia petimba*.

- Fig. 11: Anterior four coalesced vertebræ and foremost free vertebræ from below. **: furrow for aorta crossing over to left side. *: attachment for ligament connected with posttemporal.

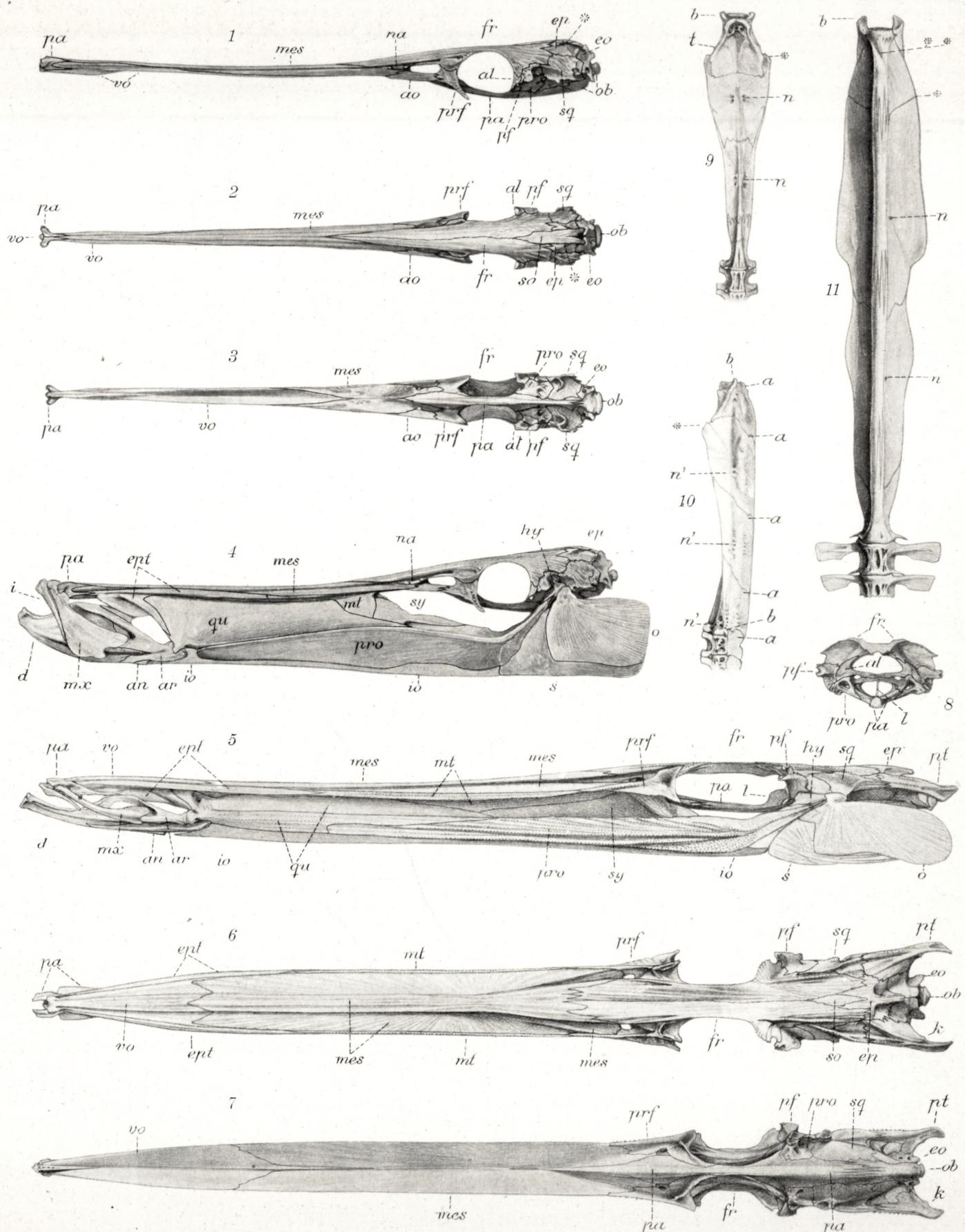


Plate II.

Plate II.

(For letters see List p. 364 [98].)

Figs. 1—2: *Fistularia petimba*.

- Fig. 1: Pharynx partly dissected to show branchial skeleton; upper pharyngeal wall cut through along its middle line and turned outward.
— 2: Upper part of branchial skeleton and gills, from right side.

Figs. 3—4: *Aulostoma coloratum*.

- Fig. 3: Pharynx prepared in similar way as in Fig. 1, showing gill-clefts, tooth-plates representing gill-rakers etc.
— 4: Upper parts of branchial skeleton and gills, right side. v: branchial vessels.

Figs. 5—6: *Fistularia petimba*.

- Fig. 5: Right hyoid, outer face. (st): stylohyal coalesced with epiphyal eh.
— 6: The same, inner face.

Figs. 7—8: *Aulostoma coloratum*.

- Fig. 7: Right hyoid, inner face.
— 8: The same, outer face.

Fig. 9: *Fistularia petimba*.

- Fig. 9: Anterior part of vertebral column; left side. 1—3: nuchal plates; td: ossified tendons (posterior ends cut away).

Fig. 10: *Aulostoma coloratum*.

- Fig. 10: Abdominal and anterior caudal vertebrae; left side. a, b, t and * as in Figs. 9—10 on Pl. I;
1—3: nuchal plates; 4—16: interspinous bones; s: spinous rays of dorsal fin.

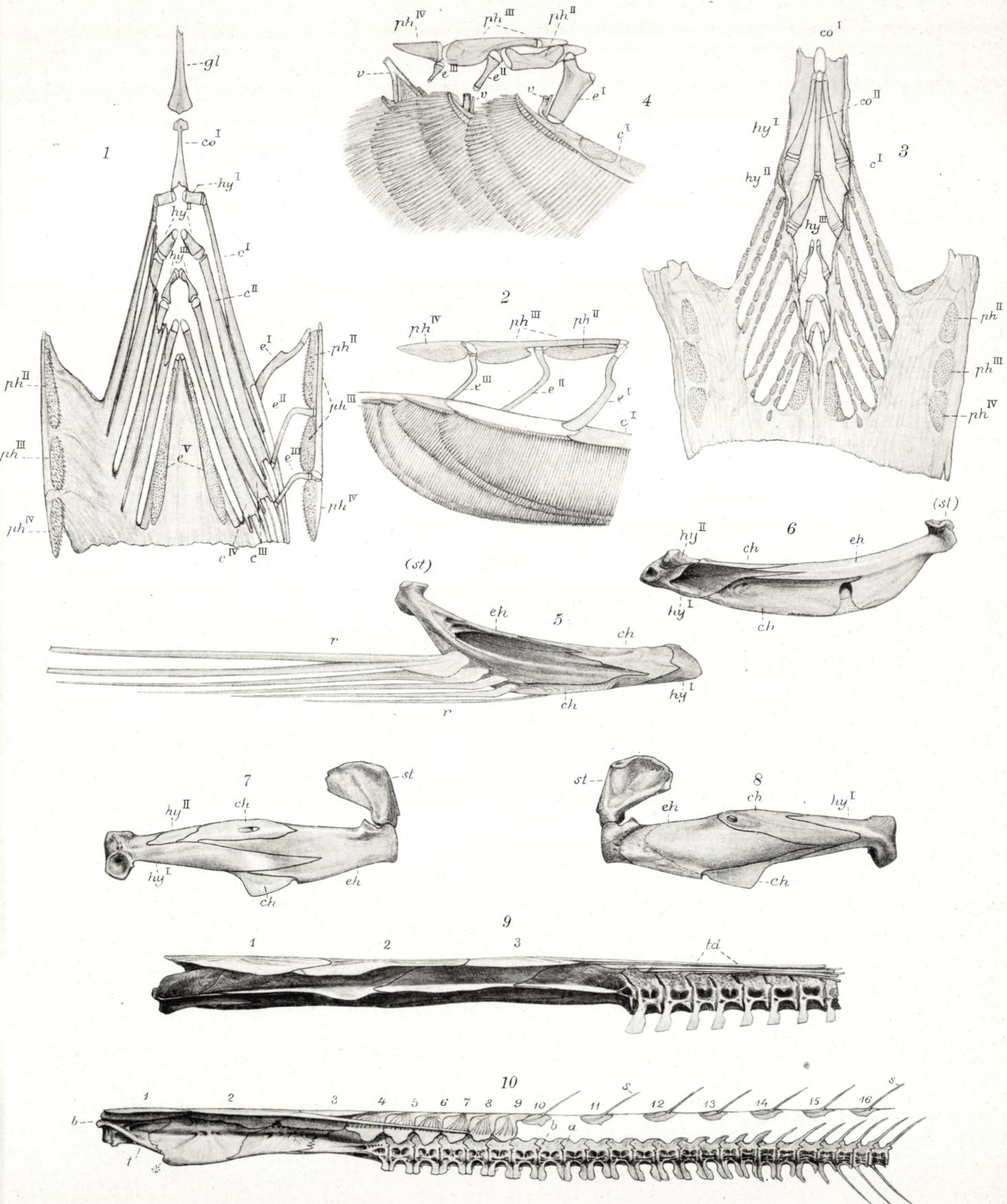


Plate III.

(For letters see List p. 364 [98].)

Figs. 1—2: *Siphonostoma typhle*.

- Fig. 1: Left shoulder-girdle and pectoral arch, anterior vertebræ and part of dermal skeleton; inner side.
I—III: anterior vertebræ; t: transverse processes; ml, il: median and inferior lateral plates;
j: jugular plate; o: outer, i: inner fork of clavicle; co': posterior part of coracoid.
— 2: Same parts, outer aspect. n': prenuchale; n: nuchale; sl, ml, il: superior, median and inferior
lateral plates; c: cover plate; j: jugular plate; i: intermedial scutes; p, p': processes of
clavicle cl.

Fig. 3: *Hippocampus sp.*

- Fig. 3: Left shoulder-girdle and anterior part of dermal armour; outer aspect n': "corona" (prenuchale);
n": posterior nuchale; I: body of foremost vertebra; v: ventral dermal plates.

Figs. 4—5: *Aulostoma coloratum*.

- Fig. 4: Left shoulder girdle, without posttemporal; outer aspect.
— 5: The same, inner aspect. f: opening between inner (i) and outer (o) fork of clavicle and coracoid (co).

Figs. 6—7: *Siphonostoma typhle* (juv.).

- Fig. 6: Left shoulder girdle and pectoral fin; inner aspect.
— 7: The same; outer aspect.

Figs. 8—9: *Fistularia petimba*.

- Fig. 8: Left shoulder girdle, from inner side; without supraclavicular and posttemporal; i, o, f etc. as
in Fig. 5.
— 9: The same, outer aspect.

Figs. 10—11: *Solenostomus cyanopterus*.

- Fig. 10: Part of musculature, visceraetc. of ♂. ps: Pseudobranchia; I—IV: first to fourth row of gills;
o: opening between gill-chambers; c: heart; oe: oesophagus; i: intestine; r: rectum; bd: entrance of bile-duct; *, **: comp. p. 325 [59]; l: liver; td: ossified tendon; k: kidney;
bl: air-bladder; te: testis.
— 11: Filament (magnified) from brood-sac of ♀, showing suckers on ends of branchlets; ax: bony
axis.
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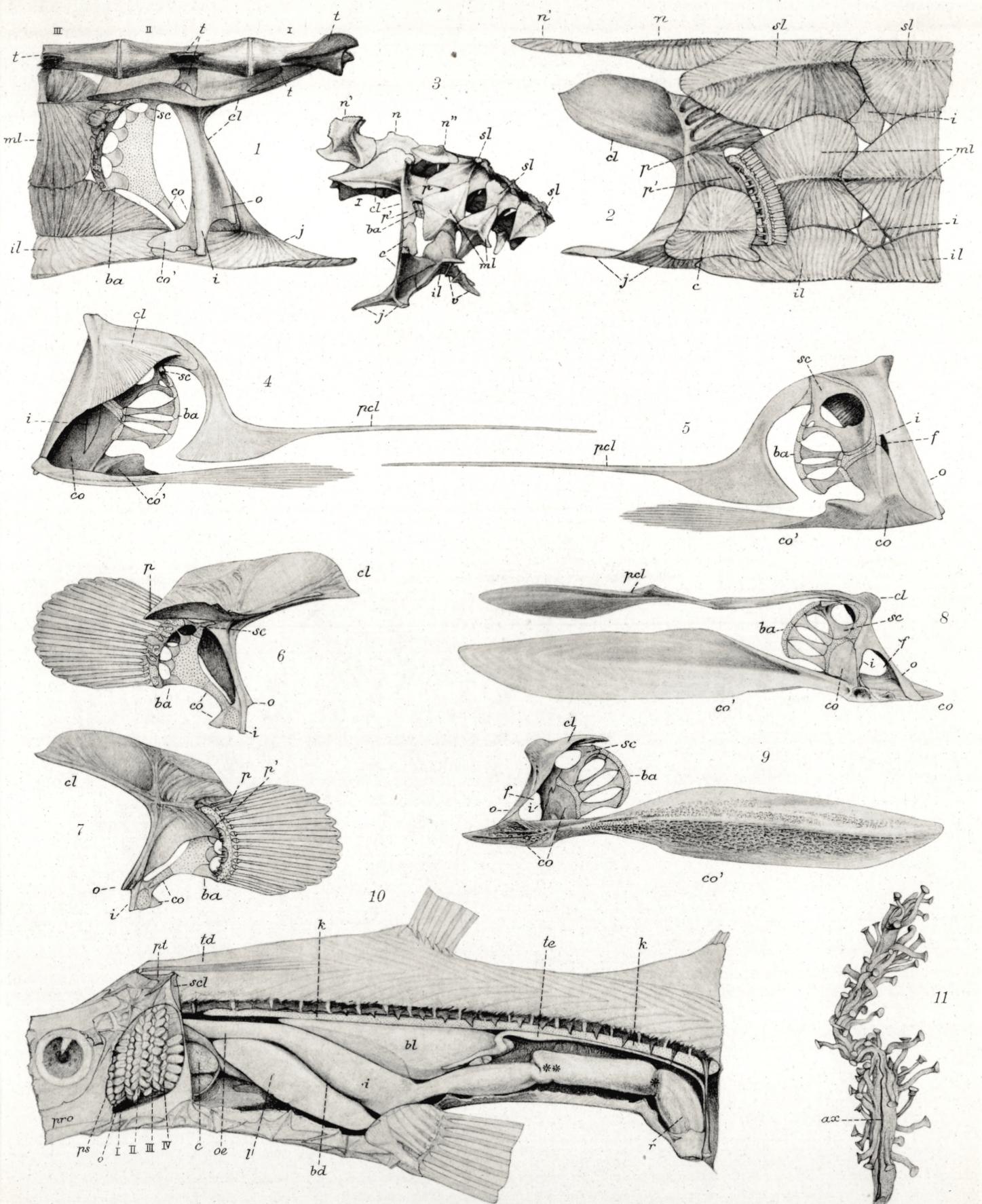


PLATE IV.

Plate IV.

MICHIGAN HERBALS

Michigan has a large number of fine old herbaria, and it is a great service to the state to have them all represented here. The author has been greatly gratified by the interest shown in the project by the curators of these collections, and by the many kind messages received from them. The author wishes to thank especially Dr. J. C. Gray, of the New York Botanical Garden, for his assistance in the preparation of the plate.

The author wishes to thank also Dr. W. L. Hodge, of the University of Michigan, for his assistance in the preparation of the plate.

The author wishes to thank also Dr. W. L. Hodge, of the University of Michigan, for his assistance in the preparation of the plate.

(For letters see List p. 364 [98].)

Fig. 1: *Siphonostoma typhle*.

Fig. 1: Last two abdominal and anterior caudal vertebrae with dorsal and anal fins, from left side; showing interspinous bones arranged in fan-shaped groups. t: transverse process; v: wing-shaped secondary process for attachment of fin-muscles; sp: inferior spine; a: anus; between the latter and the abdominal vertebrae part of viscera is seen.

Fig. 2: *Hippocampus brevirostris*.

Fig. 2: Corresponding part to that of Fig. 1, from left side.

Figs. 3—4: *Siphonostoma typhle*.

Fig. 3: Anterior three vertebrae, from below (much enlarged); a: articular process, connecting with skull; t: transverse process.

— 4: The same, from left side.

Fig. 5: *Syngnathus acus*.

Fig. 5: Anterior three vertebrae, from left side. n: nuchale in situ (part of the laterally expanded plate cut away).

Figs. 6—11: *Siphonostoma typhle*.

Fig. 6: Last abdominal vertebra, from right side. i, i: incisions in spinous process, for insertion of interspinous bones. Other letters as in Fig. 1.

— 7: The same from above.

— 8: First caudal vertebra, from left side. i: interspinous bone; u: its terminal upper end; e: bony expansion just below the latter.

— 9: The same, seen from behind. ia: inferior (open) arch. Other letters as in Fig. 8.

— 10: Last caudal vertebra, left side. h₁ h₂: upper and lower hypural bones.

— 11: Coalesced interspinous bones for anal fin with cartilages removed (much enlarged). e: bony expansions for connection with dermal scutes, originating just over terminal end u.

Fig. 12: *Nerophis aequoreus*.

Fig. 12: Three groups of interspinous bones for dorsal fin, from above; showing lateral bony expansions (e) on the left side, and on the right side the same overlapped by the superior lateral (sl) and upper intermedial scutes (i). The posterior 3 interspinous bones belong to one vertebra; the 2 other groups each of 4 interspinous bones are supported each by one vertebra, the smaller interneurals connected with the intermedial scutes i being the hindmost of each group. u: terminal end of interspinous bones.

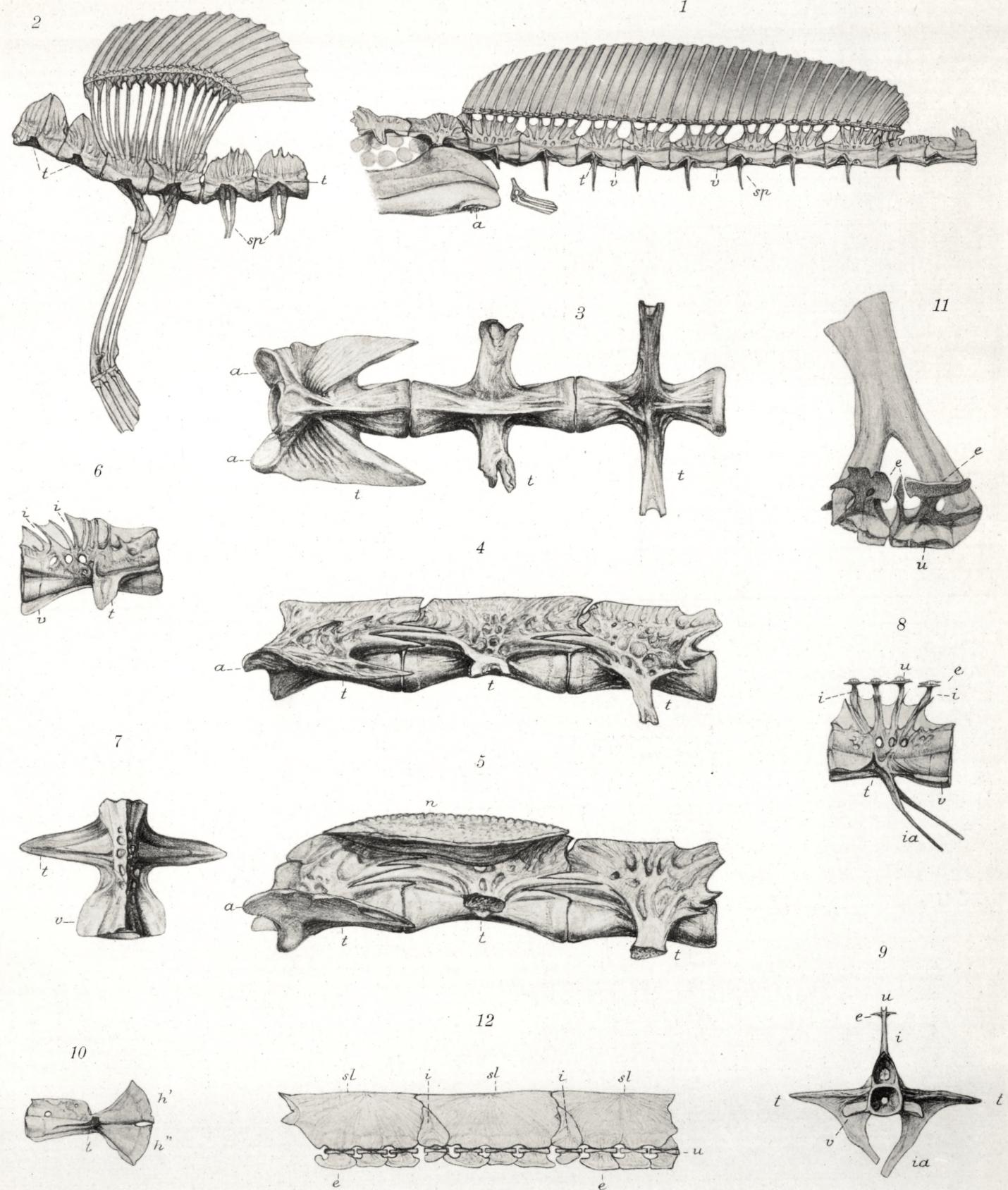


Plate V.

(For letters see List p. 364 [98].)

Figs. 1—5: *Siphonostoma typhle*.

- Fig. 1: Skull from above (magnified). c: snout-cartilage.
— 2: The same from below.
— 3: Skull from behind.
— 4: Head skeleton from left side. Entopterygoid (ept) and preorbitals (ao' ao) are removed a little from contact with the cranial beak.
— 5: Mouth-parts, suspensory and opercular parts and hyoid from right side, inner aspect. l: ligament between symplectic (sy) and stylohyal; li: ligament between angular (an) and interoperculum (io); li': ligament between interoperculum and hyoid (h). Through the transparent interoperculum (io) the skeletal parts covered by the latter are visible.

Figs. 6—7: *Hippocampus brevirostris*.

- Fig. 6: Skull from left side. *: groove for attachment of nuchal tendon; p: branch of posttemporal (pt) connecting with exoccipital (eo).
— 7: Suspensory parts and preorbitals from left side, outer aspect.

Fig. 8: *Phyllopteryx foliatus*.

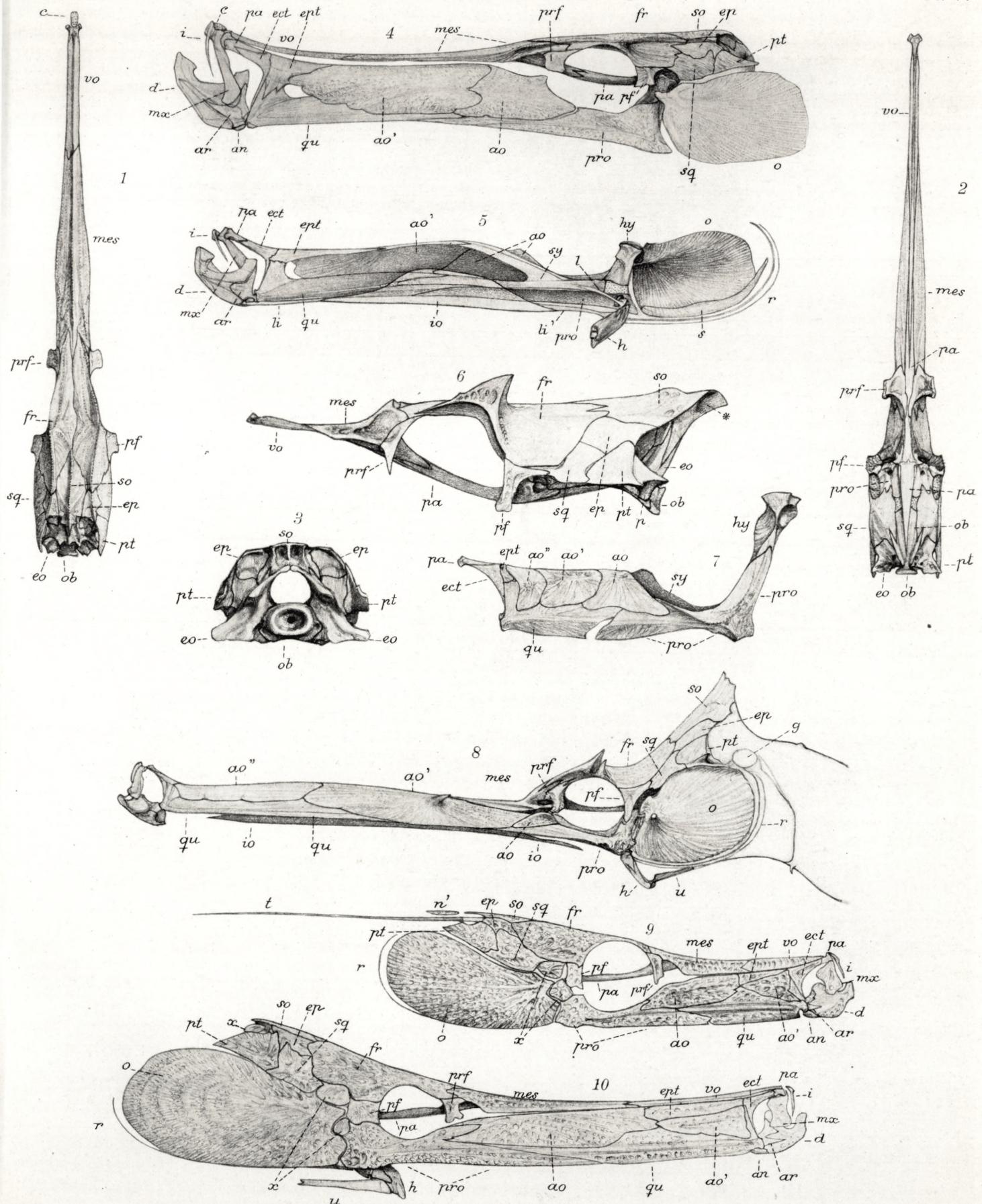
- Fig. 8: Head-skeleton from left side. g: gill-opening; h: hyoid; u: urohyal.

Fig. 9: *Nerophis ophidion*.

- Fig. 9: Head-skeleton from right side. n': prenuchale; t: ossified tendon of nuchal muscles; x: dermal plates.

Fig. 10: *Nerophis æquoreus*.

- Fig. 10: Head-skeleton from right side. x: as in the preceding figure; h: hyoid; u: urohyal.



the first time, and the author has been compelled to do so, in order to give the reader a clear idea of the nature of the work. The author has endeavored to make the figures as clear and distinct as possible, and to give the reader a clear idea of the nature of the work. The author has endeavored to make the figures as clear and distinct as possible, and to give the reader a clear idea of the nature of the work.

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Plate VI.

(For letters see List p. 364 [98].)

Fig. 1: *Siphonostoma typhle*.

Fig. 1: Hyoid and pharynx showing gill-clefts and branchial skeleton, from right side. Ends of branchiostegal rays (r) cut away.

Figs. 2—3: *Solenostomus cyanopterus*.

Fig. 2: Hyoid and branchial skeleton from left side, outer aspect.

— 3: Left hyoid, inner aspect.

Figs. 4—5: *Siphonostoma typhle*.

Fig. 4: Right hyoid, inner aspect. Greater part of branchiostegal rays cut away.

— 5: The same, outer aspect.

Figs. 6—9: *Solenostomus cyanopterus*.

Fig. 6: Left maxilla inferior, outer aspect.

— 7: Upper pharyngeals from right side, lower aspect.

— 8: The same, from above.

— 9: Branchial skeleton. Upper pharyngeals showing lower face (comp. Figs. 1 and 3 on Pl. II).

Fig. 10: *Siphonostoma typhle*.

Fig. 10: Pharynx and branchial skeleton, prepared in a similar way as Figs. 1 and 3, Pl. II.

Fig. 11: *Hippocampus longirostris*.

Fig. 11: Branchial skeleton, prepared as the preceding.

Fig. 12: *Nerophis aequoreus*.

Fig. 12: Hyoid and branchial skeleton, prepared as in Figs. 10 and 11.

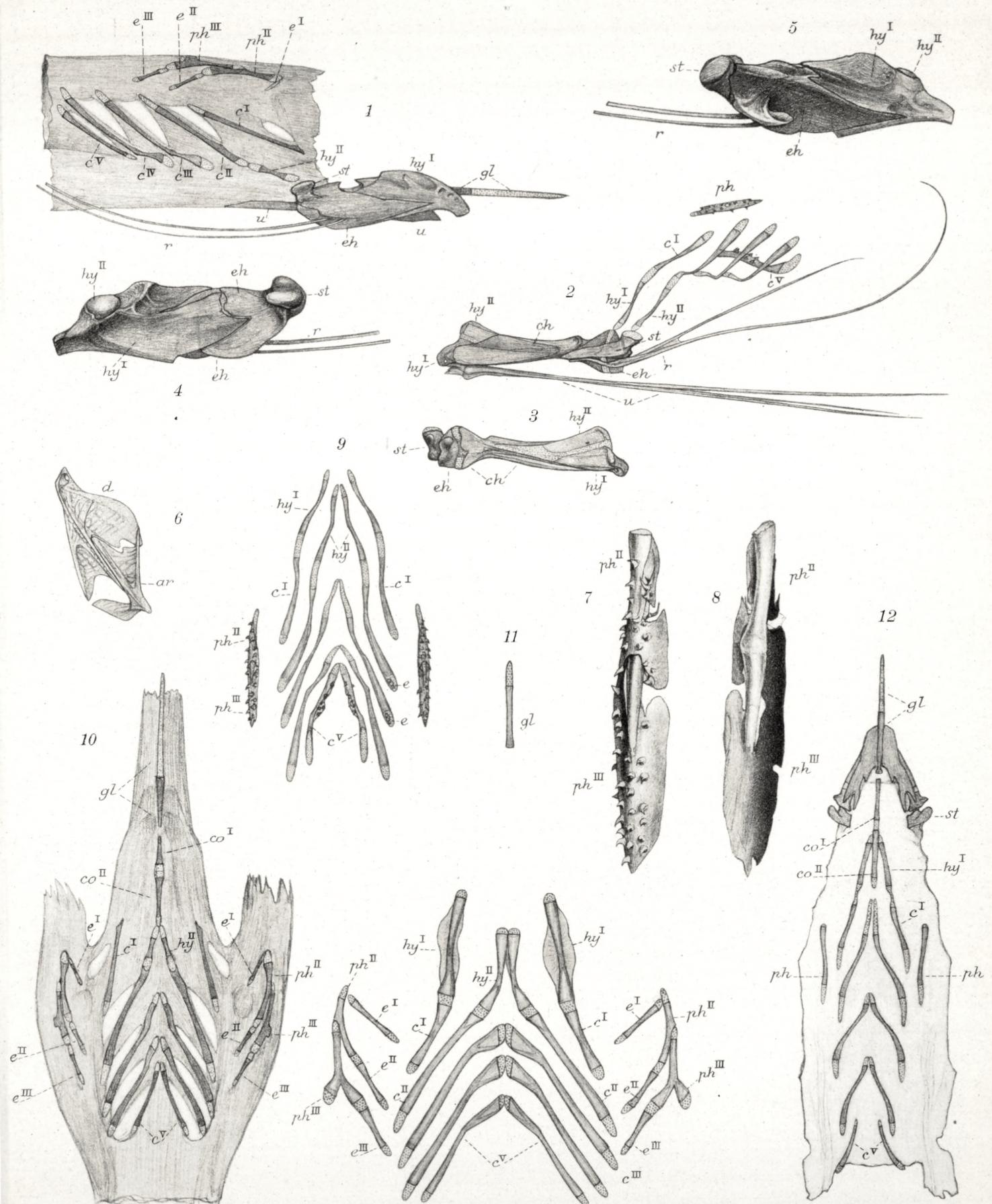


Plate VII.

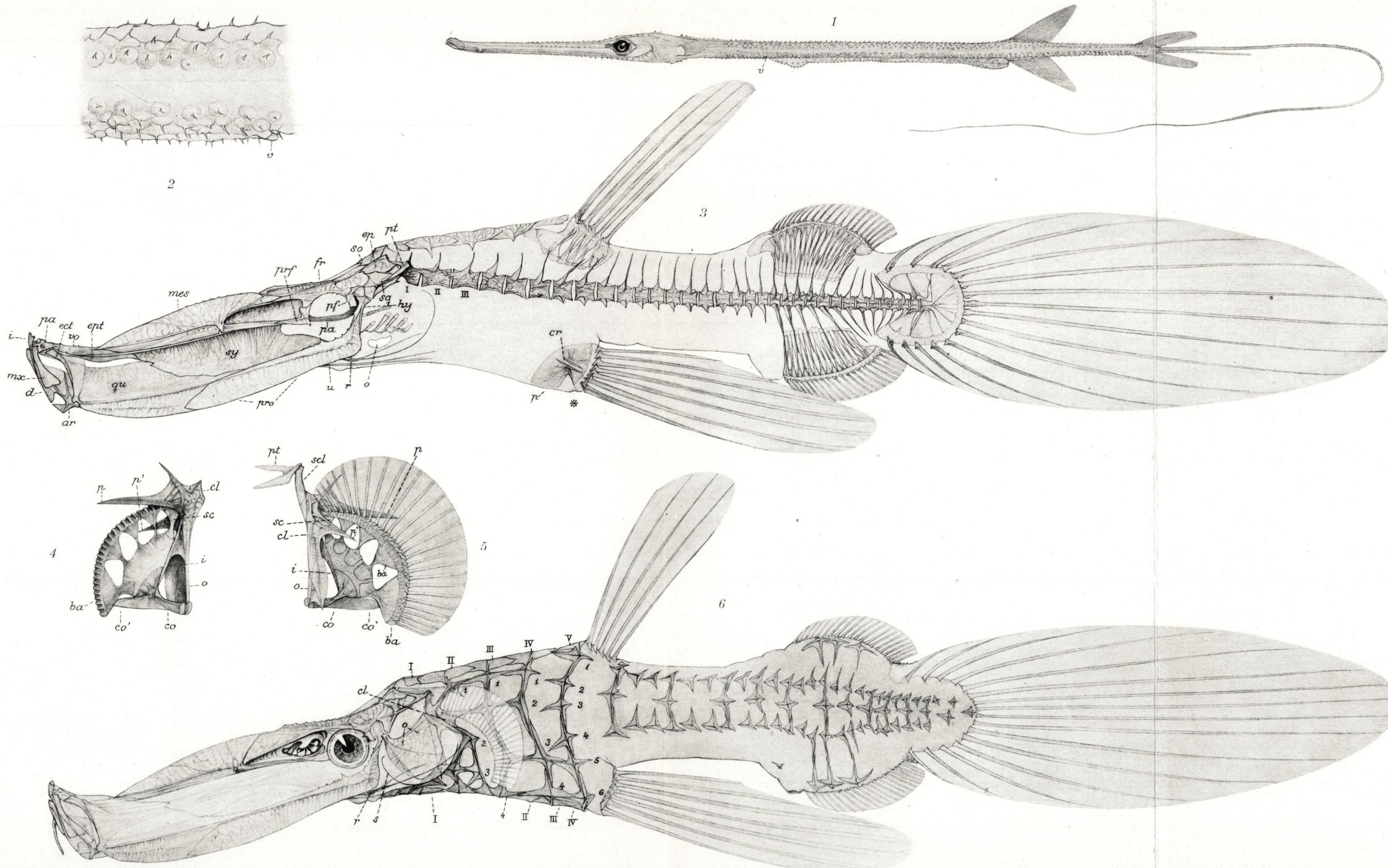
(For letters see List p. 364 [98].)

Figs. 1—2: *Fistularia tabacaria*.

- Fig. 1: Young *Fistularia* of 43 mm. length (without the caudal filament). v: rudiment of ventral fin.
— 2: Part of skin of the same, more strongly magnified, showing dermal hooklets. v: ventral fin.

Figs. 3—6: *Solenostomus cyanopterus* ♂.

- Fig. 3: Skeleton, from left side. Operculum and shoulder-girdle (except posttemporal) removed; I—III: anterior three immovable vertebrae; o: indication of opening between branchial cavities; p: pubic bone; cr: muscular crest on the same; * lower posterior part of pelvis.
— 4: Left shoulder-girdle and pectoral arch, inner aspect; without posttemporal and supraclavicular. p and p': processes on clavicle (comp. Figs. 1, 2, 3, 6 and 7 on Pl. III).
— 5: Left shoulder-girdle and pectoral fin, outer aspect.
— 6: ♂, showing dermal skeleton, nasal organ, operculum (o) and suboperculum (s), branchiostegal ray (r) etc. I—V: superior row of unpaired median scutes; I—IV: lower row of unpaired scutes; 1—6: members of the thoracic transverse rows of scutes.
-



OM

SIMPLE CYKLISKE KURVER

AF

C. JUEL

D. KGL. DANSKE VIDENSK. SELSK. SKRIFTER, 7. RÆKKE, NATURVIDENSK. OG MATEM. AFD. VIII. 6



KØBENHAVN

HOVEDKOMMISSIONÆR: ANDR. FRED. HØST & SØN, KGL. HOF-BOGHANDEL

BIANCO LUNOS BOGTRYKKERI

1911

Ved en simpel plan Kurve skal her forstaas en Kurve, der er sammensat af et endeligt Antal simple Buer. En simpel Bue er en overalt konveks Bue, der i hvert Punkt har en bestemt med Punktet kontinuert varierende Tangent og tillige en bestemt kontinuert varierende Krumningsradius; denne skal i ethvert indre Punkt af Buen være endelig og forskellig fra nul. I Overgangspunkterne mellem paa hinanden følgende simple Buer skal Tangent og Krumningsradius gaa kontinuert over fra den ene Bue til den anden. I disse Punkter kan Krumningsradius ogsaa blive nul eller uendelig, men vi forudsætter tillige udtrykkelig, at Krumningsradius kun maa være nul i en Spids og kun uendelig i et Infleksionspunkt.

Jeg har i tidligere Arbejder undersøgt de simple og lukkede plane Kurver op til fjerde Orden. Paa dette Sted vil jeg betragte de simple og lukkede Kurver, der af en Cirkel højest skæres i 4 Punkter, men ogsaa af mindst én Cirkel virkelig i 4 Punkter; de skal kaldes cykliske Kurver. Da en ret Linie sammen med den uendelig fjerne rette Linie er at opfatte som en Cirkel, maa en cyklisk Kurve være af 2den, 3die eller 4de Orden, og de her betragtede Kurver danner altsaa en Undergruppe af de tidlige.

En Undersøgelse af plane cykliske Kurver giver tillige Besked om de Rumkurver af fjerde Orden, der ligger paa en Kugle. Stereografisk Projektion af en saadan Rumkurve maa nemlig give en plan cyklisk Kurve, og omvendt. Forsaavidt de fundne Resultater er af projektiv Natur, faar man ad denne Vej noget at vide om Rumkurver af fjerde Orden beliggende paa en vilkaarlig konveks Keglesnitsflade. Dette giver et Supplement til mine tidlige Undersøgelser af visse Typer af Rumkurver af fjerde Orden, thi disse laa alle paa Keglesnitsflader med retliniede Frembringer.

Er nu en plan-cyklisk Kurve af fjerde Orden, kan den ikke gaa i det uendelige, thi den uendelig fjerne rette Linie sammen med en passende valgt anden ret Linie vilde da skære Kurven i mindst 6 Punkter; derimod behøver en cyklisk Kurve af anden Orden ikke at ligge helt i det endelige. Vi kan altsaa begynde med:

- (1) En cyklisk Kurve af fjerde Orden maa ligge helt i det endelige; er Kurven af tredie Orden, kan den kun have ét uendelig fjernt Punkt, men er den af anden Orden, kan den have ingen eller to (sammenfaldne eller adskilte) uendelig fjerne Punkter.

En cyklisk Kurve af anden Orden, der ligger helt i det endelige, skal kaldes en cyklisk Ellipse. Har Kurven uendelig fjerne Punkter, vil vi for Kortheds Skyld kalde den en cyklisk Hyperbel eller Parabel, eftersom de uendelig fjerne Punkter er adskilte eller sammenfaldne.

En cyklisk Kurve af tredie eller fjerde Orden kan have ét men ogsaa kun ét Dobbelpunkt. Vi vil først betragte de Kurver, der hverken har Dobbelpunkt eller noget uendelig fjernt Punkt.

Det første, vi vil søge at bestemme, er Kurvens Toppunkter d. v. s. de Punkter, hvor Krumningscirklerne har Røring af tredie Orden med Kurven. Disse Punkter har i flere Henseender særlig Interesse. Saaledes ved man fra bekendte infinitesimalgeometriske Undersøgelser, der bygger paa de samme Forudsætninger som de her benyttede, at de firpunktsrørende Cirkler giver Maxima og Minima af Krumningsradierne. Ligeledes ved man sammesteds fra, at disse Krumningscirklers Centrer vil være Spidser paa Kurvens Evolut.

For at bestemme Toppunkterne bemærkes, at Krumningscirklen i et Punkt R desuden skærer Kurven i ét og kun ét Punkt P ; de søgte Punkter er de, hvor R og P falder sammen. For at kunne bestemme Antallet af Sammenfaldspunkter, maa vi først finde, hvormange Punkter R der svarer til et givet P . For at se det, er det simplest at invertere den givne Kurve γ med P som Inversionscentrum. Derved gaar γ , hvad enten den er af 2den, 3die eller 4de Orden, aabenbart over i en Kurve af 3die Orden. Udelukkes de ovenfor nævnte Tilfælde, har denne intet Dobbelpunkt og derfor tre Vendetangenter. Man ser heraf, at der gennem hvert Punkt P af Kurven γ gaar 3 oskulerende Cirkler, der berører udenfor P , d. v. s. til hvert Punkt P svarer 3 Punkter R . For nu at kunne anvende det grafiske Korrespondanceprincip, maa man sikkre sig, at R og P løber i modsatte Retninger paa Kurven. Dette ses ved følgende Hjælpesætning:

Af to oskulerende Cirkler, hvis Centrer er forbundne ved en endelig Bue af Evoluten, der ikke indeholder nogen Spids, maa den ene ligge helt inden i den anden.

Differensen mellem de to Cirklers Radius er nemlig lig med den Bue af Evoluten, der ligger mellem Centrene og ikke indeholder nogen Spids, men denne Bue er større end sin Korde d. v. s. end Cirkernes Centerlinie.

Lad nu γ_1 og γ_2 være to oskulerende Cirkler, af hvilke γ_1 omslutter γ_2 . Idet ingen af disse er firpunktsrørende, vil Kurven γ i Røringspunkt R_1 eller R_2 med en af disse Cirkler gaa fra den ydre til den indre Side eller omvendt. Vi lader nu et Punkt M gennemløbe γ saaledes at det i R_1 udefra gaar ind i γ_1 . Vi kan endvidere antage γ_1 og γ_2 valgte saa nær ved hinanden, at M ved at fortsætte sin Bevægelse paa γ i samme Retning naar R_2 , inden det naar noget af de enkelte Skæringspunkter P_1 og P_2 mellem γ og henholdsvis γ_1 og γ_2 . M maa nu ved denne Bevægelse naa P_2 , inden det naar P_1 , thi γ_2 ligger indeni γ_1 . Paa γ følger altsaa Punkterne $R_1 R_2 P_2 P_1$ paa hinanden i denne Orden; da der til en lille Bue $R_1 R_2$ maa svare en lille Bue $P_1 P_2$, maa derfor R og P bevæge sig i modsatte Retninger paa γ .

Nu giver Korrespondanceprincippet:

- (2) En cyklisk Kurve, der hverken har noget Doppeltpunkt eller gaar i det uendelige, har altid 4 Toppunkter.

Toppunkterne kan ogsaa bestemmes paa en anden Maade som Sammenfaldspunkter, nemlig mellem Røringspunkterne for en dobbelt berørende Cirkel til Kurven. Lad en Cirkel berøre denne i M og skære den i N_1 ; Cirklen vil da skære endnu en Gang i et Punkt N_2 . Holdes M fast, medens N_1 varierer, vil ogsaa N_2 variere, og det er let at se f. Eks. ved Inversion med Hensyn til M , at N_1 og N_2 bevæger sig i modsatte Retninger. Der findes altsaa to Sammenfald. Af disse vil det ene falde i et uendelig fjernt Punkt, naar Kurven berører den uendelig fjerne Linie — den cykliske Parabel. Da de to Sammenfaldspunkter N , der svarer til samme M , aldrig kan falde sammen, fordi Kurven er cyklisk, har man altsaa:

(3) Til enhver cyklisk Kurve findes to adskilte Systemer af dobbeltberørende Cirkler, undtagen ved den cykliske Parabel, hvor der kun findes ét System.

Den sidste Del af Sætningen følger af, at Parabelen berører den uendelig fjerne Linie.

Toppunkterne bestemmes ved Sammenfald mellem et Punkt M og et tilsvarende Punkt N . Vi vil nu ikke give et nyt independent Bevis for (2), men gaa ud fra, at der findes mindst ét Toppunkt A , og ved Hjælp deraf udlede, at M og N maa bevæge sig i modsatte Retninger paa Kurven, saafremt denne ligger helt i det endelige. Lad M være valgt i Nærheden af A , og lad os lægge en Cirkel, der berører Kurven i M og desuden gaar gennem A . Det resterende Skæringspunkt A_2 mellem Kurven og Cirklen maa da ligeledes ligge i Nærheden af A ; lad os sige, at M og N begge ligger i et vist Omraade ω af Kurven omgivende A . Punkterne M og A_2 maa nu i ω ligge paa modsatte Sider af A .

Dette kan atter ses ved at inverttere om A . Derved gaar nemlig Kurven over i en Kurve af tredie Orden γ^3 , der har et uendelig fjernt Infleksionspunkt A^1 , medens Cirklen gaar over i en Tangent t , der berører γ^3 i et Punkt M^1 , der ligger i Nærheden af A^1 . M^1 og det enkelte Skæringspunkt A_2^1 mellem t og γ^3 maa da ligge paa modsatte Sider af A^1 i et vist Omraade af γ^3 omgivende A^1 . Inverterer man nu tilbage, ses Paastandens Rigtighed. Lad nu atter N_1 og N_2 være de to Skæringspunkter mellem Kurven γ og en Cirkel, der berører denne i M . Naar N_1 bevæger sig i ω fra A mod A_2 , maa N_2 efter det tidlige bevæge sig ud fra A_2 i den modsatte Retning; Sammenfaldspunktet N mellem N_1 og N_2 maa altsaa ligge paa ω mellem A og A_2 ; M og N vil derfor i ω ligge paa modsatte Sider af A . Men flytter nu M sig, maa ogsaa N flytte sig, og naar M bevarer sin Bevægelsesretning, maa det samme være Tilfældet med N , hvilket følger af Afhaengighedens gensidige Entydighed; de skal endvidere falde sammen i A ; deraf følger, at M og N bevæger sig i modsatte Retninger. Det er herved bevist, at to saadanne sammenhørende Punkter M og N , der kan falde sammen i et Toppunkt, bevæger sig i modsatte Retninger. Men ligger Kurven helt i det endelige, kan de to Punkter N ,

der svarer til samme Punkt M , ikke falde sammen; derfor maa disse Punkter, hvoraf hvert maa beholde sin Omløbsretning uforandret, naar M gør det, begge bevæge sig i modsat Retning af M . Man har altsaa:

- (4) De to Røringspunkter mellem Kurven og en dobbeltrørende Cirkel i et af Systemerne bevæger sig begge i modsatte Retninger paa Kurven, naar denne ligger helt i det endelige.

Vi vil nu opstille en Sætning, der alene gælder cykliske Ovaler, idet vi vil bestemme en saadan Kurves Dobbeltnormaler. Lad en Linie n være Normal til Ovalen i to Punkter M og P . Tangenterne i disse Punkter er da parallele. Vi betragter derfor den Korrelation (MQ) , hvor Tangenterne i tilsvarende Punkter er parallele. Den er aabenbart (1—1)-tydig, og tilsvarende Punkter vil gaa samme Vej. Men en Cirkel over MP som Diameter vil være en dobbeltrørende Cirkel, hvis Røringspunkter er M og P . Vi betragter derfor ogsaa Korrelationen (MN) , mellem Røringspunkterne for dobbelt-rørende Cirkler. Den er efter det foregaaende (2—2)-tydig saaledes, at tilsvarende Punkter løber modsat Vej. Korrelationen (QN) er derfor ogsaa (2—2)-tydig saaledes, at tilsvarende Punkter løber modsat Vej. Der vil derfor findes 4 Sammenfaldspunkter svarende til 2 Dobbeltnormaler:

- (5) En cyklist Ellipse har to Dobbeltnormaler.

Ved den algebraiske Ellipse gaar Dobbeltnormalerne gen-

nem Toppunkterne, men det er naturligvis i Almindelighed ikke Tilfældet.

Vi vil nu atter betragte en cyklist Kurve af 2den eller 4de Orden, der hverken har Dobbelpunkter eller gaar i det uendelige. Lad to Toppunkter, der paa Kurven følger paa hinanden, være A_1 og A_2 . Glider et Punkt langs Kurven fra A_1 til A_2 uden at overskride de andre Toppunkter, vil de tilhørende Krumningscirkler ifølge Hjælpesætningen Side 4 ikke kunne have noget Punkt fælles. Der vil derfor af de Krumningscirkler, der svarer til Punkter af Buen $A_1 A_2$, højest kunne gaa én gennem hvert Punkt af Planen. Da der nu er 4 Buer begrænsede af Toppunkter, har man, idet man let ser, at det ikke gør noget, om der paa Buen findes Infleksionspunkter:

- (6) Gennem et vilkaarligt Punkt af Planen gaar højest 4 oskulerende Cirkler til Kurven.

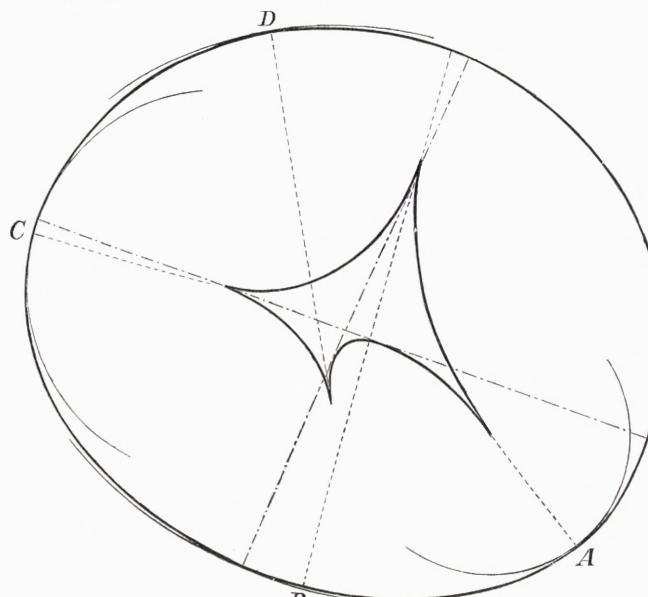


Fig. 1.

Lader vi det vilkaarlige Punkt rykke uendelig fjernt — eller erindrer vi, at den inverse Kurve til en cyklist Kurve atter maa være cyklist — faas heraf:

- (7) En cyklist Kurve af fjerde Orden, der ikke gaar i det uendelige og ikke har Dobbelt punkter, har højest fire Infleksionspunkter.

Da en Kurve af fjerde Orden altid maa have et lige Antal Infleksionspunkter, og en Kurve uden Infleksionspunkter under de her forudsatte Betingelser er af 2den Orden, ser man at Kurven maa have enten 4 eller 2 Infleksionspunkter. Da disse Infleksionspunkter maa ordne sig i Infleksionspar, følger heraf:

- (8) En cyklist Kurve af 4de Orden, der ikke gaar i det uendelige og ikke har Dobbelt punkter, har enten 2 eller 1 Dobbelt tangent.

Vi vil nu tage Hensyn til de ovenfor udelukkede Tilfælde, nemlig at Kurven gaar i det uendelige eller — naar Talen er om Kurver af tredie eller fjerde Orden — at disse kan have et Dobbelt punkt.

Lad os først betragte en cyklist Hyperbel. Ved Inversion om et Punkt P af selve Kurven faar man en Kurve af 3die Orden med et Dobbelt punkt, og denne har én Vendetangent. Forbindelsen mellem et Kurvepunkt R og det enkelte Punkt P , hvori Krumningscirklen i R paany skærer Kurven, vil altsaa her være (1—1)-tydig. Da man endvidere ligesom i Beviset for (2) ser, at R og P maa bevæge sig i modsatte Retninger, findes her allmindeligvis 2 Toppunkter. Ifald Kurven specielt berører den uendelig fjerne rette Linie, maa dog et af Sammenfaldspunkterne mellem R og P falde i det uendelig fjerne Røringspunkt, thi den dobbelt-regnede uendelig fjerne rette Linie er en speciel Cirkel. Man har altsaa:

- (9) En cyklist Kurve af anden Orden, der gaar i det uendelige, har to Toppunkter, naar Kurven er en Hyperbel, men kun ét, naar den er en Parabel.

Ved Bestemmelsen af Dobbeltnormaler maa vi erindre, at der til en Kurve af anden Orden med to uendelig fjerne Punkter ikke gaar Tangenter i enhver Retning. Ved de to uendelig fjerne Punkter U_1 og U_2 deles Kurven i to adskilte Buer σ_1 og σ_2 . Lad M være et Punkt af σ_1 . Den Cirkel med uendelig stor Radius, der berører Kurven i M , vil yderligere skære den i U_1 og U_2 ; deraf følger, at de to Punkter N_1 og N_2 , hvori en Cirkel, der berører i M , anden Gang kan berøre Kurven, maa ligge paa hver sin af de to Buer σ_1 og σ_2 ; lad N_1 ligge paa σ_1 , N_2 paa σ_2 .

Naar M gennemløber Buen σ_1 , vil N_2 gennemløbe hele σ_2 , og naar M falder i U_1 , maa N_2 falde i U_2 . En Cirkel, der skal skære Kurven to Gange i to sammenfaldende Punkter, hvoraf det ene er uendelig fjernt, maa nemlig være selve den

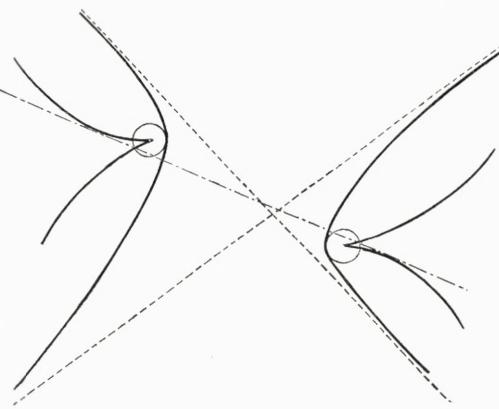


Fig. 2.

uendelig fjerne rette Linie regnet dobbelt. Naar M altsaa gennemløber σ_1 fra U_1 til U_2 , maa N_2 gennemløbe σ_2 fra U_2 til U_1 . Men er Tangenterne i M og Q parallele, og gennemløber M Buen σ_1 fra U_1 til U_2 , vil Q aabenbart gennemløbe σ_2 fra U_1 til U_2 . Forbindelsen mellem Q og N_2 er gensidig éntydig; der finder derfor kun ét Sammefald Sted \circ :

(10) En cyklist Hyperbel har én Dobbeltnormal (se Fig. 2).

En Kurve med en parabolsk Gren kan ikke have nogen Dobbeltnormal.

Inverterer man en cyklist Kurve af tredie Orden uden Dobbelpunkter om et Punkt, der ikke ligger paa Kurven, faar man en Kurve af fjerde Orden uden Dobbelpunkter. Da nu ved Inversion et Toppunkt maa gaa over i et Toppunkt har man:

(11) En cyklist Kurve af tredie Orden uden Dobbelpunkt har 4 Toppunkter.

Har man en Kurve af 3die eller 4de Orden med Dobbelpunkt, faar man ved Inversion om dette Punkt en Kurve af anden Orden med to uendelig fjerne Punkter. Heraf udleder man ved (10):

(12) En cyklist Kurve af 3die eller 4de Orden med ét Dobbelpunkt har 2 Toppunkter.

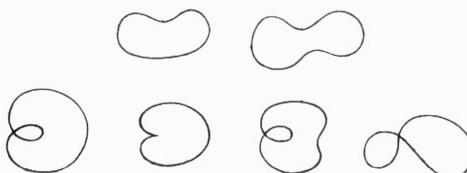


Fig. 3-8.

Som i Beviset for (6) ser man, at der gennem et vilkaarligt Punkt i Planen gaar 2 oskulerende Cirkler. Lader man Punktet være uendelig fjernt, følger heraf:

(13) En cyklist Kurve af 4de Orden med et Dobbelpunkt har intet eller to Infleksionspunkter.

For Kurven af 3die Orden findes kun det ene Infleksionspunkt som altid.

Af (12) og (13) i Forbindelse med den almindelige Teori for Kurver af fjerde Orden følger:

(14) En cyklist Kurve af fjerde Orden med ét Dobbelpunkt har 1 eller 2 Dobbelttangenter.

Ved det ovenstaaende i Forbindelse med min tidligere Opregning af samtlige Former for Kurver af fjerde Orden er Formen af samtlige cykliske Kurver af fjerde Orden bestemt. De findes i Fig. 3-8.

Vi vil nu atter holde os til en cyklist Ellipse og undersøge dens Evolut (sé Fig. 1 og Fig. 2). For at kunne gøre dette, maa vi ganske vist forøge vores Forudsætninger, idet vi ogsaa om Evoluten forudsætter, at den er en simpel Kurve. Dette er æquivalent med en Forudsætning om, at ogsaa 3die og 4de Differentialkvotient for den givne Kurve afdelingsvis — i et endeligt Antal Intervaller — har Værdier der er endelige og bestemte.

Særlig vil vi søge at bestemme Evolutens Orden. Det er nemmere til en Begyndelse at udvide Spørgsmaalet lidt ved at søge det højeste Antal af Krumningscirkler, der kan skære en vilkaarlig given Cirkel x under ret Vinkel. Vi bemærker

nu først, at der i Kurvens Plan altid findes Punkter, hvorigennem der ikke gaar nogen Krumningscirkel. Alle Krumningsradierne er nemlig efter vore Forudsætninger endelige, og ifølge (2) findes der 4 extreme Værdier af dem. De to af disse maa svare til Maksimum, to andre til Minimum, og Maksimum og Minimum maa følge paa hinanden, naar vi gennemløber Kurven i en bestemt Retning. Hver af Maksimumscirklerne omslutter begge Minimumscirklerne, thi de sidstnævnte maa ligge inden i Ellipsen, medens de førstnævnte maa omslutte den. Gennem et Punkt, der ligger udenfor begge Maksimumscirklerne, gaar altsaa ingen Krumningscirkel. Lad P være et saadant Punkt. Vi danner et Cirkelbundt, der indeholder x og en Nulcirkel, hvis Centrum er P , og betragter den Samling af paa hinanden følgende Cirkler μ i Bundtet, der begynder med Nulcirklen (P) og ender med x . Cirkler, der ligger tilstrækkelig nær ved (P), skærer ikke nogen Krumningscirkel. Det kommer nu an paa at se, i hvilke Overgangsstillinger der kan ske Ændring i Antallet af de Krumningscirkler, der skærer μ under ret Vinkel. Disse Overgangsstillinger maa være saadanne, hvor μ skærer to konsekutive Krumningscirkler orthogonalt. Dette vil for det første ske, naar μ skærer en af de hyperoskulerende Cirkler orthogonalt, thi i en saadan falder to konsekutive Krumningscirkler sammen. Naar μ skal skære to andre konsekutive Krumningscirkler orthogonalt, maa dens Centrum ligge paa disses Radikalakse; men en saadan er Tangent til Ellipsen, og μ maa tillige gaa gennem Røringspunktet. De søgte Overgangsstillinger af den sidstnævnte Art er altsaa de Cirkler i Bundtet, der skærer den givne cykliske Ellipse orthogonalt. Det samme kan ogsaa ses ved følgende Hjælpesætning, der ogsaa kan være nyttig ved andre Undersøgelser over algebraiske Kurvers Evoluter:

Er en plan Kurve stereografisk Projektion af en sfærisk Kurve, vil den plane Kurves Evolut være Projektionen fra samme Øje punkt af den sfæriske Kurves reciproke Polarfigur med Hensyn til Kuglen.

Dette Lemma er saa at sige selvfolgeligt, naar man erindrer den velkendte Bestemmelse af Centret for den stereografiske Projektion af en paa Billedkuglen liggende Cirkel.

De ovennævnte Paastande om Skiftet i Antallet af orthogonalt skærende Krumningscirkler ses nu at følge deraf, at Antallet af Oskulationsplaner til en Rumkurve gaaende gennem et Punkt P forandres med 2 derved (og for en R^4 kun derved), at Punktet overskrider enten en stationær Oskulationsplan eller Kurvens Tangentflade.

Af den første Art Overgange findes højest fire, da Kurven har 4 hyperoskulerende Cirkler.

Af den anden Art kan vi vise at der højest findes to. Inverterer man nemlig den givne Kurve med P som Inversionscentrum, maa den gaa over i en ny cyklisk Ellipse, da den inverterede Kurve ligger helt i det endelige og hverken har Dobbelt punkter, Vendepunkter eller Spidser. Systemet af Cirklerne μ gaar over i et System af koncentriske Cirkler, hvis fælles Centrum Q_1 er det inverse Punkt til Centret for den anden Nulcirkel i Bundtet. Men en Cirkel med givet Centrum Q_1 kan kun

skære den inverterede Oval orthogonalt i Røringspunktet for en fra Q_1 udgaaende Tangent; af saadanne Tangenter findes højest to.

Nu begynder μ i Nærheden af (P) med ikke at skære nogen Krumningscirkel, og er dens Radius bleven tilstrækkelig stor, vil den ende med det samme. Da der nu ved Cirklens Variation i hele Bundtet højest kan ske 6 Overgange, vil der ved Variationen af μ fra (P) til x højest tre Gange kunne være vundet to orthogonalt skærende Krumningscirkler, d. v. s. der findes højest 6 Krumningscirkler til Kurven, der skærer en given Cirkel orthogonalt. Dette gælder, hvor stor end den givne Cirkels Radius er — selve Methoden kan ogsaa bruges, naar man lader x være en ret Linie — og man ser herved, at der højest findes 6 oskulerende Cirkler, hvis Centrer ligger paa en given ret Linie. Ovalens Evolut er altsaa højest af 6te Orden. Men da Evoluten ligger helt i det endelige, maa den være af lige Orden, og da den har 4 Spidser svarende til Centerne for de hyperoskulerende Cirkler, kan den hverken være af anden eller fjerde Orden, thi en Kurve af fjerde Orden kan højest have 3 Spidser. Vi har altsaa bevist:

(15) Evoluten til en cyklisk Ellipse er i alle Tilfælde af 6te Orden.

Vi vil dernæst søge at bestemme Evolutens Klasse og bemærker først, at der gennem et vilkaarligt Punkt P i Planen maa gaa mindst to Tangenter til Evoluten eller Normaler til den cykliske Ellipse. Dette er en Følge af, at der sikkert maa findes baade et Maksimum og et Minimum af Afstande fra P til Kurvens Punkter, da Kurven ligger helt i det endelige. Heraf sluttes, at man sikkert kan bestemme en ret Linie, der gaar gennem P og højest skærer Evoluten i 4 Punkter; en saadan vil man i hvert Fald kunne bestemme som en Linie, der er nærliggende til en gennem P gaaende Tangent til Evoluten. Lad nu M være et Punkt, der gennemløber en saadan ret Linie m ud fra dennes uendelig fjerne Punkt. Til at begynde med gaar der da to og kun to Tangenter gennem M , da der i hver Retning gaar to Tangenter til Ellipsen. Efter at hele Linien er gennemløbet, vil der efter gaa to og kun to Tangenter gennem M . Da Evoluten ikke har Vendetangenter, kan der ved M 's Bevægelse kun være sket Ændring i Antallet af Tangenter gaaende gennem M derved, at dette Punkt har overskredet Evoluten, men da man skal ende og begynde med det samme Antal af Tangenter gennem M , kan der kun to Gange være vundet to Tangenter. Gennem intet Punkt af Planen vil der altsaa kunne gaa flere end $2 + 2 \cdot 2 = 6$ Tangenter. Da Evoluten ikke kan være af anden Klasse, har man altsaa:

(16) Evoluten til en cyklisk Oval er enten af 4de eller af 6te Klasse.

Vi maa dog sikkre os, at begge Muligheder eksisterer; at den første kan findes, ved man allerede fra den algebraiske Ellipse. Men man har i Almindelighed:

(17) Enhver i det endelige liggende Kurve af anden Orden (med endelige Krumningsradier), hvis Evolut er af 4de Klasse, maa være cyklisk.

Lad nemlig P være et Punkt, der ikke ligger paa Kurven, og lad det være Centrum for en Cirkel i Kurvens Plan. Betragter vi nu alle de Cirkler, der har P til Centrum, og lader Radien vokse fra en uendelig lille til en uendelig stor Længde, vil den begynde med ikke at have noget Punkt fælles med Kurven. Da der nu kun

kan ske Ændring i Antallet af Skæringspunkter mellem Kurven og en af Cirklerne derved, at Cirklen berører Kurven, og der efter Forudsætningen gennem P højest gaaar 4 Normaler til denne, vil Cirklen højest skære i 4 Punkter. Man ser let, at dette ogsaa gælder, naar Cirklens Centrum falder paa selve Kurven.

En Kurve af fjerde Orden, der skal kunne være Evolut til en cyklist Oval, er let at karakterisere (se Fig. 1). Den skal have 4 Spidser, og fra hvert Punkt i Planen skal der til den gaa to Tangenter. Deraf følger straks, at den ikke kan have noget Dobbeltpunkt, thi i Nærheden af et saadant Punkt vilde man kunne finde Punkter, hvorfra der ikke udgik nogen Tangent. I Henhold til min tidlige Klassification af alle Former af Kurver af 4de Klasse kan den ikke have anden Form end den, der er givet for Evoluten i Fig. 1.

Enhver lukket Kurve uden Spidser, hvis Evolut har denne Form, vil være en cyklist Oval. Den nødvendige og tilstrækkelige Betingelse for, at Evolventen til en saadan Kurve lukker sig, er, som man let ser:

$\neg AB + \neg CD = \neg AC + \neg BD$, hvor A, B, C, D er de paa hinanden følgende Spidser paa Kurven.

Er denne Betingelse opfyldt, har man i Evolventen til Kurven — forsaavidt da intetsteds Krumningsradius til denne bliver nul — en i det endelige liggende cyklist Kurve uden Spidser, Vende punkter og Dobbelttangenter, men en saadan maa være en Oval.

Som Eksempel kan nævnes, at enhver ydre Parallelkurve til en Ellipse er en cyklist Oval. Endvidere ser man, at enhver af 4 Cirkelbuer sammensat Oval, da højest en af Buerne kan være større end en Halvcirkel, vil skæres i højest 4 Punkter af enhver Cirkel, der ikke indeholder en af de sammensættende Buer. Ovenstaende indeholder tillige et Bevis for Eksistensen af ikke analytiske cykliske Ovaler.

Naar Evoluten til en Oval er af 6te Orden, af 6te Klasse, maa den ogsaa have 4 Spidser og 2 Dobbelttangenter. Men man kan endnu sige noget mere til Karakterisering af denne Kurve. Ved Evoluten er bestemt et endeligt Omraade ω , der er begrænset af Buer af Evoluten. Alle disse Buer maa vende deres konkave Side udad. Fra ethvert Punkt i Planen skal nemlig gaa mindst 2 Tangenter til Kurven, og fra et uendelig fjernt Punkt netop 2; hvis nu en Begrænsningsbue af ω vendte sin konvekse Side udad, vilde der fra et Punkt indeni ω men nær ved

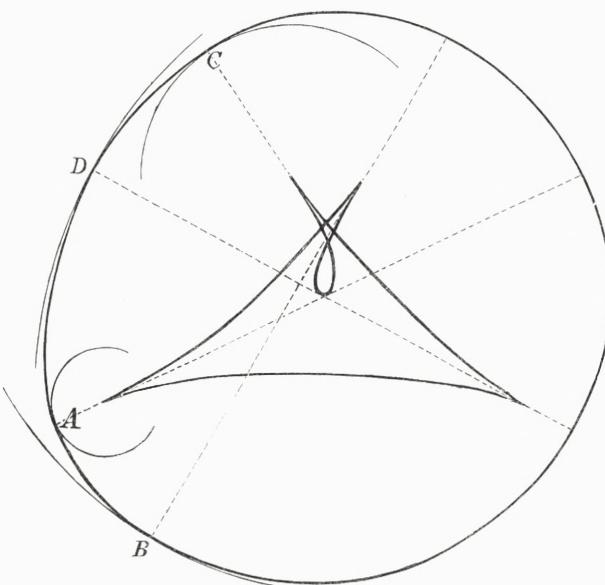


Fig. 9.

denne Bue ikke gaa nogen Tangent til Kurven. Kurven maa endvidere nødvendigvis have et Dobbelpunkt, thi ellers vilde hele Evoluten høre med til Begrænsningen af ω , og fra hvert Kurvepunkt altsaa udgaa 2 og kun 2 Tangenter, der berørte udenfor Punktet; Klassen blev da 4. Af eventuelle Dobbelpunkter kan kun ét høre til en Sløjfe, thi en Tangent, der ruller over hele Kurven, maa derved kun have drejet sig 360° .

Med disse Betingelser viser Prøve, at Evolutens Form maa være den, der er angivet i Fig. (9), men det maa udtrykkelig bemærkes, at Beskrivelsen er ufuldstændig og f. Eks. ikke kan maale sig med de Beskrivelser, jeg tidligere har givet af Formerne af Fjerdegradskurver. Betingelsen for, at en Evolvent til en saadan Kurve lukker sig, er, idet A, B, C, D er Kurvens Spidser i den Orden, hvori de følger paa hinanden paa Kurven:

$$\sim AB + \sim CD = \sim AC + \sim DA.$$

Er denne Betingelse opfyldt, ser man, som før, at en Evolvent til Kurven i Fig. (9), der ikke naar ind til denne Kurve, vil være en Oval.

Det kan endnu bemærkes, at to cykliske Ellipser γ_1 og γ_2 kan lægges saaledes i en Plan, at de tilsammen danner en cyklisk Kurve af 4de Orden. For at vise Muligheden heraf bemærkes, at en Cirkel, fra hvis Centrum der kun udgaar to Normaler til en Oval, ikke kan skære denne i flere end to Punkter. Dette bevises aldeles som den ovenstaaende Sætning (17). En tilstrækkelig Betingelse for, at en Cirkel, der skærer γ_1 i to Punkter, ikke kan skære γ_2 i flere end to Punkter, er altsaa den, at en Linie, der staar vinkelret paa Midten af et Liniestykke, der forbinder et Punkt inden i γ_1 med et Punkt inden i γ_2 ikke indeholder noget Punkt, hvorfra der udgaar flere end to Normaler til nogen af Ovalerne d. v. s. at en saadan Linie ikke gaar ind i de ovennævnte Omraader ω_1 og ω_2 svarende til de to Ovaler. Da ω_1 og ω_2 er fast knyttede til γ_1 og γ_2 , kan dette aabenbart naas ved at fjerne disse tilstrækkelig langt fra hinanden. Ved Inversion kan heraf udledes mere almindelige cykliske Kurver sammensatte af to Grene, hvis ikke-analytiske Eksistens herved bliver godtgjort.

Vi vil nu betragte en cyklisk Hyperbel (se Fig. 2). Her findes kun to hyperoskulerende Cirkler, og disse maa være numeriske Minima; de maa derfor ligge helt indeni hver sin af de to Pseudogrene, hvori Kurven deles af de to uendelig fjerne Punkter. Gennem et Punkt indenfor en af Minimumscirklerne gaar der ifølge Hjælpesætningen S. 4 ingen oskulerende Cirkel. For nu ogsaa her at bestemme Antallet af de Krumningscirkler, der skærer en given Cirkel x orthogonal, danner vi paa lignende Maade som før Side 9 et Bundt af Cirkler bestemt ved x og en Nulcirkel, hvis Centrum er et Punkt P indenfor en af Minimumscirklerne. De Overgangsstillinger, i hvilke der kan ske Ændring i Antallet af orthogonal skærende Krumningscirkler, er dels de Cirkler i Bundtet, der skærer de hyperoskulerende Cirkler orthogonal — og af dem findes to — dels de Cirkler, der skærer Hyperblen orthogonal. For at bestemme Antallet af de sidste, inverterer vi som før med P som Inversionscentrum og faar derved en Kurve af fjerde Orden med P til Dobbelt-

punkt. Fra P udgaar ingen Tangent til denne Kurve, den har ingen andre Dobbeltpunkter og har ingen Infleksionspunkter. Men Formen af en saadan Kurve er fuldstændig bestemt efter min tidligere Klassifikation, og til den udgaar der fra et Punkt højest 4 Tangenter (se Fig. 5)*. Der findes altsaa i alt 6 Overgangsstillinger, og heraf udledes som ovenfor, at Evolutens Orden enten maa være 4 eller 6. Men den første Mulighed maa her udskydes ligesom ved den cykliske Ellipse. Man vil nemlig se, at i hvert Fald den uendelig fjerne rette Linie skærer i 6 Punkter, idet den vil være Spidstangent to Gange. Den uendelig fjerne rette Linie u kan nemlig ikke have flere Punkter fælles med Evoluten end de to U_1 og U_2 , der er Krumningscentrer til Hyperblens uendelig fjerne Punkter. Disse Punkter U_1 og U_2 ligger i Retninger, der er vinkelrette paa Asymptoternes Retninger. Ved U_1 og U_2 deles u i to Dele; fra et Punkt af den ene Del udgaar to i det endelige liggende Tangenter til Evoluten, fra et Punkt af den anden Del udgaar ingen saadan Tangent. Da nu u maa berøre i U_1 og U_2 , thi Normalen i et uendelig fjernt Punkt af Hyperblen er selv uendelig fjern, følger heraf, at U_1 og U_2 maa være Spidsen med u til fælles Spidstangent (som ved en algebraisk Hyperbel).

Det samme kan ogsaa ses ved den Side 9 nævnte Hjælpesætning, da Billedet af en Rumkurve faar en Spids, naar Øjepunktet ligger paa en Tangent til Kurven. At U_1 og U_2 ligger uendelig fjernt i Retninger, der er vinkelrette paa Asymptoternes Retninger, følger efter denne Metode deraf, at konjugerede Tangenter til en Kugle staar vinkelret paa hinanden.

Vi har altsaa vist:

(18) **Evoluten til enhver cyklisk Hyperbel er af Ordenen 6.**

Af denne Sætning udleder man ligesom ved Ellipsen, at Klassen maa være 4 eller 6. Men her kan man i Modsætning til Forholdene ved den cykliske Ellipse vise, at Klassen maa være 4 i alle Tilfælde. Lad os lægge Figuren saaledes, at man kan sige, at den ene Pseudogren af Hyperblen ligger tilhøjre, den anden til venstre; dette kan f. Eks. ske ved, at vi lægger den Halveringslinie x af Asymptovinklen, der skærer Hyperblen, i en vandret Stilling. Minimumscirklerne ligger helt indeni hver sin Gren, og man kan derfor utvetydig sige, at Spidsen A for Evoluten til den højre Pseudogren vender til venstre, og at den anden Spids B vender tilhøjre. Efter vort Valg af Betegnelser vil retvinklet Projektion af BA paa x gaa tilhøjre. De uendelig fjerne Punkter af Evoluten ligger nu i Retninger, der er vinkelrette paa Asymptoternes Retninger. Lad os projicere BA i disse Retninger ind paa x . Da de to Retninger er symmetriske med Hensyn til x , vil Projektionen af BA for mindst én af disse Retninger gaa tilhøjre. Lad U_1 angive en Retning, hvor dette sikkert finder Sted.

Gennem U_1 kan ikke gaa andre Tangenter end u , thi til en Hyperbel gaar ikke andre Tangenter i Asymptotens Retning end selve Asymptoten. Drejer man nu en ret Linie m om U_1 , idet den har u til Begyndelsesstilling, vil den til at begynde med kun skære Evoluten i to Punkter, det ene i Nærheden af U_1 , det andet i

* Se. Om Ikke-analytiske Kurver, Kgl. D. Vidensk. Selsk. Skrifter, Naturv. og Math. Afd. I. 6, S. 304 (16).

Nærheden af U_2 . En Ændring i Antallet af Skæringspunkter mellem m og Kurven kan, da der fra U_1 ikke udgaar nogen Tangent, kun ske derved, at m overskridet en Forbindelseslinie mellem U_1 og en af Kurvens to Spidser. Men betragter man nu Figuren, og lader Linien bevæge sig parallelt med sig selv stadig til venstre, vil den først træffe den Spids A , der hører til den højre Pseudogren, og den Spids vender til venstre; der vil derfor tabes to Skæringspunkter derved, at m overskridet Stillingen $U_1 A$; disse vil vindes igen, naar m overskridet Forbindelseslinien mellem U_1 og den anden Spids. Enhver gennem U_1 gaaende Linie skærer altsaa Kurven i højest 2 Punkter foruden i selve U_1 .

Lad nu P være et vilkaarligt Punkt i Planen, og lad os forbinde P med U_1 med en ret Linie m . Gennemløber et Punkt M Linien fra U_1 til P , vil der, naar M er nær ved U_1 (d. v. s. naar M endnu ikke har overskredet Evoluten) gennem M kun gaa 2 Tangenter til denne. Dette Antal kan ved M 's Bevægelse højest vokse til 4, da man altid kan vælge en saadan Del PU_1 af m , at der paa den ligger intet eller højest ét Skæringspunkt med Evoluten. Man har altsaa her:

(19) Evoluten til en cyklisk Hyperbel er altid af Klasse 4.

Vi vil til Slutning endnu betrage den simple cykliske Parabel. Dens Evolut kan kun have ét Punkt U fælles med den uendelig fjerne rette Linie u , nemlig Krumningcentret i Parablens uendelig fjerne Punkt. Tangenten i U er u , og vi kan vise, at u maa være en Vendetangent. Fra hvert fra U forskelligt Punkt af u udgaar nemlig én og kun én i det endelige liggende Tangent til Evoluten, fra U selv ingen saadan Tangent. Deraf følger, at u enten maa være en Vendetangent eller en sædvanlig Tangent. Men Evoluten, der altsaa har én og kun én Spids, maa være af ulige Klasse, og hvis u var en sædvanlig Tangent, vilde der fra et Punkt i Nærheden af u (men ikke i Nærheden af U) udgaa to Tangenter til Evoluten; dette viser, at u maa være en Vendetagent. Dette kan ogsaa udledes ved Hjælpesætningen Side 9; Projektionen af en Rumkurve vil nemlig, naar Projektionscentret P ligger i Røringspunktet for en stationær Oskulationsplan, faa et Infleksionspunkt i Sporet af Kurvens Tangent i P .

Vi begynder nu som før med at søge det højest Antal af de Krumningscirkler, der kan skære en given Cirkel \times orthogonal, og betragter i den Anledning et Cirkelbundt (μ) bestemt ved \times og en Nulcirkel, hvis Centrum ligger indeni Parablens hyperoskulerende Cirkel. Varierer μ ud fra Nulcirklen, vil Opgaven til at begynde med ikke have nogen Løsning. Stillinger af μ , hvor der vindes eller tabes to Løsninger, er saadanne, hvor μ skærer orthogonal enten den hyperoskulerende Cirkel — hvilket giver 1 Mulighed — eller Parablen. For at finde Antallet af de sidstnævnte Cirkler inverteres Parablen med P som Inversionscentrum; derved faar man som bekendt efter Theorien for inverse Kurver en Kurve af fjerde Orden uden Vendetangenter og med en Spids, hvorigennem der ikke gaar nogen Tangent til Kurven. En saadan Kurve kan i Overensstemmelse med min tidlige Enumeration ikke være nogen anden end den, der er fremstillet i Fig. (6), og den er af 3die Klasse. Man faar altsaa i alt fire Overgangscirkler. Heraf udledes paa samme Maade som i de ovenstaende Tilfælde, at en Cirkel \times højest kan skære

4 Krumningscirkler til Parablen orthogonal. Lader man μ være en ret Linie, erindres om, at en i det endelige liggende ret Linie maa opfattes som Orthogonalcirkel til den uendelig fjerne rette Linie regnet dobbelt; dette ses ved Inversion at følge af, at en Cirkel er orthogonal til en Nulcirkel, hvis Centrum ligger paa den førstnævnte Cirkel. Men den uendelig fjerne rette Linie regnet dobbelt er en speciel Krumningscirkel til Parablen. En ret Linie kan altsaa højest have 3 Punkter fælles med Evoluten; denne, der er af 3die Orden og har en Spids, maa være af 3die Klasse 3:
 (20) En almindelig cyklist Parabels Evolut er af 3die Orden og 3die Klasse.

At der eksisterer ikke algebraiske cykliske Parabler og Hyperbler, følger af, at enhver lukket Kurve, hvis Evolut er bestemt som angivet ovenfor, maa være cyklist. Dette bevises som Sætning (17).

Vi vil nu se, hvad der af det foregaaende kan udledes om Kurver af fjerde Orden beliggende paa en Kugle. Det forudsættes om disse Kurver, at deres Projektioner er simple Kurver i den S. 1 givne Forstand.

Ved stereografisk Projektion gaar Rumkurven over i en plan cyklist Kurve. Da denne har 4 hyperoskulerende Cirkler, naar Kurven hverken har Dobbelpunkter eller gaar i det uendelige, faar man:

(21) En sammenhængende Kurve af fjerde Orden uden Dobbelpunkter beliggende paa en Kugle — eller en vilkaarlig konveks Keglesnitsflade — har 4 hyperoskulerende Planer. Har Kurven et Dobbelpunkt, findes kun 2 saadanne.

Da der gennem et vilkaarligt Punkt i en cyklist Kurves Plan højest gaar 4 Krumningscirkler og ifølge (8) og (14) højest to dobbeltrørende Cirkler, faar man:
 (22) Til en sammenhængende Kurve af fjerde Orden uden Dobbelpunkter beliggende paa en konveks Keglesnitsflade gaar gennem et vilkaarligt Punkt af selve Fladen højest 4 Oskulationsplaner og højest 2 Tangentplaner til den dobbelt omskrevne Developable.

Nøjere Bestemmelse af Klassen har jeg kun naaet ved de sfæriske Kurver, der er inverse til Kurver af anden Orden. Til denne Art hører enhver sfærisk Kurve af fjerde Orden med et Dobbelpunkt, thi fra dette vil Kurven projiceres ved en Kegleflade af anden Orden. Vi vil først finde det højest Antal af Oskulationsplaner, der kan gaa gennem et Punkt P udenfor Kuglen. Lad Polarplanen til P skære Kuglen i en Cirkel z ; de gennem P gaaende Oskulationsplaner vil da skære Kuglen i Cirkler, der er orthogonale til z . Da nu Vinkler overføres uforandrede ved stereografisk Afbildning, kan man af det tidligere (se Beviset for 15)) udlede, at der gennem P gaar højest 6 Oskulationsplaner; tillige har vi i det foregaaende vist, at dette højest Antal kan naas for mindst ét Punkt P .

Vi mangler blot endnu at tage Hensyn til Punkter indenfor Kuglefladen. Ændring i Antallet af Oskulationsplaner gaaende gennem et Punkt P kan nu, idet P bevæger sig kontinuert f. Eks. langs en ret Linie, kun ske ved, at P enten overskrider Kurvens Tangentflade eller overskrider en af Kurvens hyperoskulerende

Planer. Men Tangenterne kan ikke gaa ind i Kuglen, saa vi behøver kun at tage Hensyn til den sidstnævnte Mulighed. Men de to hyperoskulerende Cirkler til den cykliske Hyperbel, hvori Rumkurven projiceres stereografisk fra Dobbelpunktet, ligger udenfor hinanden. De dertil svarende Hyperoskulationsplaner maa derfor have en Skæringslinie, der ligger udenfor Kuglen. Forbindes nu P med et Punkt Q af denne Linie med en ret Linie, vil man langs denne kunne naa til Kuglens Overflade uden at skære nogen Oskulationsplan. Fra et vilkaarligt Punkt indeni Kuglen kan der altsaa højest udgaa to oskulerende Planer. Vi har altsaa bevist:

(23) En Kurve af fjerde Orden, som ligger paa en konveks Keglesnits-flade og har et Dobbelpunkt, maa være af Klassen 6.

Samme Resultat kan man faa, naar Kurven kan projiceres stereografisk i en cyklisk Ellipse. Her findes 4 hyperoskulerende Planer, men man kan i Henhold til ovenstaaende altid finde to af disse, hvis Skæringslinie s ligger udenfor Kuglen, og forbinder man P med Skæringspunktet Q mellem s og en af de øvrige Hyperoskulationsplaner, ser man, at der i dette Tilfælde ikke kan gaa flere end 4 Oskulationsplaner gennem et Punkt indeni Kuglen.

Projiceres Rumkurven stereografisk i en cyklisk Parabel, har den en Spids. Man kan da let ved de samme Slutninger som ovenfor udlede:

(24) En Kurve af fjerde Orden, som ligger paa en konveks Keglesnits-flade og har en Spids, maa være af fjerde Klasse.

Det vil ikke være til nogen Nutte at søge det højeste Antal af Dobbeltsekanter til en sfærisk Rumkurve af 4de Orden, der kan gaa gennem et givet Punkt. Man kan nemlig i et Eksempel vise, at dette Antal kan blive saa stort, det skal være. Lad os begynde med at konstruere en cyklisk Ellipse, der er symmetrisk om en lad os sige vandret Akse. Dennes Evolut er da ogsaa symmetrisk om samme Akse. Lad Punkter af denne, der ligger symmetrisk med Hensyn til Aksen, være $P_1 P_1^1, P_2 P_2^1 \dots P_n P_n^1$. Vi lader nu den øverste Del af Evoluten indeholdende Punkterne $P_1 \dots P_n$ uforandret, medens vi ændrer paa den nederste, dog saaledes, at Punkterne $P_1^1 P_2^1 \dots P_n^1$ samt Tangenterne i disse Punkter forbliver uforandrede. Men en Bue mellem to paa hinanden følgende Punkter P ændrer vi saaledes, at den vedbliver at være en elementær Bue med de samme Endetangenter, og at dens Længde forbliver uforandret, og endelig saaledes, at hele Evoluten forbliver af fjerde Klasse. Dette er øjensynlig muligt; Evoluten er nu ikke længere selv symmetrisk om Aksen. En Oval-Evolvente til den ændrede Ellipseevolut maa nu i Henhold til det foregaaende atter være en cyklisk Ellipse, og den indeholder $2n$ Punkter $P_1 P_1^1, P_2 P_2^1 \dots P_n P_n^1$, der ligger parvis symmetrisk med Hensyn til en Akse, der dog ikke er en Symmetriakse for Kurven. Tager man nu en stereografisk Projektion af denne Oval fra et Punkt O ind paa en Kugle, faar man en Rumkurve af fjerde Orden. Planen gennem O og den ovennævnte Akse har med Hensyn til Kuglen en Pol S . Gennem dette Punkt gaar alle Forbindelseslinerne mellem de Par af Punkter, hvori $P_1 P_1^1, P_2 P_2^1 \dots P_n P_n^1$ projiceres, uden at S er Toppunktet for en Kegle af anden Orden indeholdende Kurven.

RÉSUMÉ.

Par courbe simple je comprends une courbe fermée (dans le sens projectif) composée d'un nombre fini d'arcs élémentaires. Un arc élémentaire est un arc continue dont les tangentes et les rayons de courbure varient d'une manière continue le long de la courbe et qu'une droite arbitraire rencontre en deux points au plus. Nous supposerons en outre que les rayons de courbure (pour un point à une distance finie) ne sont infinis que pour les points d'inflexion et nuls que pour les points de rebroussement; ces points sont nécessairement des points communs à deux arcs consécutifs.

Mon but est d'étudier les courbes simples rencontrées par un cercle en quatre points au plus. Ces courbes, je les appelle cycliques.

Comme une droite quelconque jointe à la droite à l'infini est un cercle spécial, une courbe cyclique sera du quatrième, du troisième ou du deuxième ordre, c'est-à-dire qu'elle sera coupée par une droite arbitraire en 2, 3 ou 4 points ou plus.

On voit aussitôt qu'une courbe cyclique peut avoir un point double au plus. Une courbe cyclique du quatrième ordre doit rester dans la partie finie du plan; une courbe du troisième ordre aura un seul point à l'infini, mais une courbe du deuxième ordre aura 0, 1 ou 2 points à l'infini. Suivant ces cas, nous appellerons une courbe cyclique simple du deuxième ordre, une ellipse, une parabole ou une hyperbole cyclique.

Cherchons maintenant les sommets d'une courbe cyclique, c'est-à-dire les points où la courbe est rencontrée par un cercle en quatre points confondus. On trouvera:

Chaque courbe simple cyclique sans points doubles et sans points à l'infini aura quatre sommets.

Pour le démontrer, on considère la correspondance (3—1) entre les points R de la courbe et les points P où la courbe est rencontrée de nouveau pas les cercles osculateurs en R^1 . Les $1+3=4$ points doubles de la correspondance donnent les quatre sommets.

Dans les cas exclus dans ce théorème on démontre d'une manière analogue que:

Une cyclique du troisième ordre sans points doubles aura quatre sommets.

¹ Ici et souvent dans ce qui suit je m'appuie sur le principe suivant: Si sur une courbe fermée on suppose entre deux points X et Y une correspondance (p, q) où deux points Y (ou X) correspondants au même points X (ou Y) ne peuvent jamais se confondre et si les deux sens de X et Y correspondants sont contraires, alors on aura $p+q$ points correspondants qui se confondent (points doubles).

Dans chaque cas il faut une discussion détaillée de la figure pour s'assurer que les conditions mentionnées sont remplies. Dans ce résumé succinct, nous avons supprimé cette discussion souvent pénible.

Une cyclique du troisième ou du quatrième ordre à un point double et de même une ellipse ou une hyperbole cyclique auront deux sommets, mais une parabole n'en aura qu'un.

Il est facile de voir que deux cercles osculateurs à la courbe en deux points réunis par un arc de la courbe ne contenant aucun sommet seront situés l'un dans l'intérieur de l'autre. Par conséquent, si A et B sont deux sommets consécutifs sur la courbe, on ne pourra faire passer par un point arbitraire du plan plus d'un des cercles osculateurs à cet arc.

On en déduit en supposant le point à l'infini:

Une courbe cyclique du quatrième ordre sans point double aura deux ou quatre points d'inflexions, mais si la courbe a un point double il y en aura deux ou aucun.

De la théorie générale des courbes simples du quatrième ordre on déduit:¹

Une courbe cyclique du quatrième ordre aura un ou deux tangentes doubles.

Alors les formes des courbes cycliques du quatrième ordre sont celles des fig. 3—8.

En considérant les points variables M_1 et M_2 , où la courbe est rencontrée par un cercle tangent à la courbe en un point fixe, on a entre M_1 et M_2 une correspondance (1, 1). On en déduit:

A chaque courbe cyclique appartenant en général deux systèmes distincts de cercles doublement tangents à la courbe; seulement la parabole n'en a qu'un.

Dans ce qui suit nous nous bornerons aux courbes cycliques du deuxième ordre, principalement pour en étudier les développées. Il résulte de ce qui précède que la développée d'une ellipse cyclique aura quatre, d'une hyperbole deux et d'une parabole un point de rebroussement (correspondant au nombre de sommets).

Si un cercle est tangent en M et N à une ellipse cyclique et si les tangentes en M et P sont parallèles entre elles on aura entre N et P une correspondance (2, 2); on en déduit:

Une ellipse cyclique aura deux normales doubles.

Quant à l'hyperbole, une discussion un peu plus détaillée est nécessaire, mais la même méthode s'appliquera et on trouvera:

Une hyperbole cyclique aura une normale double; — une parabole n'en aura aucune.

Les normales doubles des courbes algébriques passent par les sommets, mais cela n'a pas lieu en général.

Pour trouver l'ordre de la développée, je commence par chercher le nombre des cercles osculateurs à la courbe qui coupent orthogonalement un cercle donné α . Si l'on fait varier un cercle μ dans un faisceau contenant α , le nombre cherché ne s'altérera que dans les cas où μ coupe orthogonalement soit le cercle osculateur en un sommet soit la courbe donnée. En s'appuyant sur cette remarque on trouve qu'il y a 6 cercles au plus qui coupent α orthogonalement. En supposant enfin α réduit à une droite on aura:

L'ordre de la développée d'une ellipse ou d'une hyperbole cycliques est 6; mais celui d'une parabole cyclique est 3.

Maintenant on est à même de chercher la classe de la développée et l'on trouve:

La développée d'une ellipse cyclique est de la quatrième ou de la sixième classe.

Il y a là une différence essentielle entre l'ellipse algébrique et l'ellipse cyclique, l'ordre de la développée de la première de ces courbes étant toujours 4.

Les deux formes possibles de la développée se trouvent aux fig. 1 et 9.

On peut encore démontrer:

Chaque courbe simple dont la développée est de la quatrième classe sera cyclique.

¹ Voir Det Kgl. danske Vidensk. Selsk. Skrifter 6, sér. X, 1: Indledning i Læren om grafiske Kurver.

Il est assez curieux de constater que la différence ci-dessus mentionnée ne se manifeste que pour les ellipses, car on a:

La développée d'une hyperbole cyclique est de la quatrième classe et la développée d'une parabole cyclique sera de la troisième classe.

Des théorèmes sur les courbes cycliques planes on déduit un moyen de projection stéréographique des théorèmes sur certaines courbes situées sur une sphère. On a p. ex.:

Une courbe simple sphérique du quatrième ordre sans points doubles aura toujours quatre plans stationnaires.

Une courbe simple du quatrième ordre à un point double est de la classe 6 c'est-à-dire que par un point arbitraire de l'espace passent six plans osculateurs au plus.

Il va sans dire que dans ces théorèmes on peut substituer à la sphère une surface convexe algébrique du deuxième degré.
