

ON THE DISTRIBUTION OF
THE FRESH-WATER EELS (*ANGUILLA*)
THROUGHOUT THE WORLD

II. INDO-PACIFIC REGION

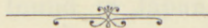
A BIO-GEOGRAPHICAL INVESTIGATION

BY

JOHS. SCHMIDT

WITH TWO CHARTS AND TEN TEXT-FIGURES

D. KGL. DANSKE VIDENSK. SELSK. SKRIFTER, NATURVIDENSK. OG MATHEM. AFD., 8. RÆKKE, X. 4.



KØBENHAVN

HOVEDKOMMISSIONÆR: ANDR. FRED. HØST & SØN, KGL. HOF-BOGHANDEL

BIANCO LUNOS BOGTRYKKERI

1925

ON THE DISTRIBUTION OF
THE FRESH-WATER EELS (ANGUILLA)
THROUGHOUT THE WORLD

A PACIFIC REGION

A BIOGEOGRAPHICAL INVESTIGATION

BY

JOHN SCHMIDT

WITH TWO CHARTS AND TEN TEXT-FIGURES

U. S. GOVERNMENT PRINTING OFFICE: 1925

KOBLENZ

NO. 1000

U. S. GOVERNMENT PRINTING OFFICE

1925

I. INTRODUCTION

It is now sixteen years since the first part of this work, dealing with the Atlantic Ocean and adjacent areas, was published (1909).¹ That the continuation has been so long delayed is due, partly to the Great War, partly to the fact that the biology of the two Atlantic species of eel still fully occupied those engaged in the work. Save for the result of a statistical investigation of the Japanese Eel (SCHMIDT, 1913, 1915) I have published nothing concerning the Indo-Pacific eels, and it is only of recent years that there has been time to resume work on them.

Our knowledge of the Indo-Pacific fresh-water eels still leaves much to be desired. Judging from the literature, it is still at about the same stage as that of the Eel question in Europe and America in 1870, when GÜNTHER published his survey of the genus *Anguilla* in the "Catalogue of the Fishes in the British Museum" — i. e. the delimitation of species is generally uncertain, distribution of the different species consequently also uncertain, and the biology altogether unknown.

To give an idea of this uncertainty, I may mention, that GÜNTHER had two European eel species: *Anguilla vulgaris* and *Anguilla latirostris*, of which the latter was said to be found also in America, China and Japan, and also in New Zealand. And for America, he had three species: *Anguilla latirostris*, *Anguilla texana*, and *Anguilla bostoniensis*, the last-named also said to be found in China and Japan.

An investigation of the eel found in Japan (*Anguilla japonica* Schleg.) which I was able to make some years ago (1913, 1915) showed that the eels of Japan, Europe and America are not identical, each of these areas having its own species of eel. At the same time, however, it was found that the differences were only slight — at any rate as regards the characters investigated — and that the modern methods of variational statistics would have to be employed, and a great number of specimens investigated, in order to characterise the species.

Up to the present, no such investigation has been made with any of the other *Anguilla* species in the Indo-Pacific areas, and I cannot but feel that this is the

¹ The First Part of this work (I. Atlantic Ocean and Adjacent Regions) was published in Danish in "Mémoires de l'Académie Royale des Sciences et des Lettres de Danemark, 7^{me} série, Section des Sciences, t. VIII No. 3, 1909" and in English in "Meddelelser fra Kommissionen for Havundersøgelser, Serie Fiskeri, Bind III, No. 7, Copenhagen 1909".

reason why the classification here remains in its present chaotic state. By operating with a greater number of specimens than hitherto employed, and including such characters as the number of vertebræ etc. it should undoubtedly be possible to arrive at as definite a characterisation of the Indo-Pacific *Anguilla* species as with the two Atlantic forms and the Japanese. On the other hand, this can hardly be done by any other means, for it is a remarkable fact that the species of this genus, though distributed throughout the greater part of the globe, are on the whole very closely related, and that the characters which have to be employed for specific distinction are subject to considerable individual variation.

In my Report of the Investigations into the Life-histories of the two Atlantic *Anguilla* species, I explained the great biological difference between them, the one species (*A. vulgaris*) having a larval period of 3 years, whereas the other (*A. rostrata*) has only one year. I also stated (1922, p. 200): "... the comparison of the life-history of the two species which our investigations have enabled us to make is, to my thinking, one of the most interesting chapters in the history of the eel. Indeed, it is hardly too much to say that the life-history of the European eel can only be properly understood at all by comparison with that of the American."

My reason for repeating this statement here is, that in my opinion, a comparison of the biology of the Indo-Pacific *Anguilla* species, and of the same with that of the two Atlantic species, should prove similarly interesting. It is just in this peculiar genus, distributed throughout all the oceans, and with species sometimes so closely related that the earlier classification was unable to characterise them separately, that a description of the biological conditions will probably throw new light on our European eel; possibly, indeed, we may only then arrive at a complete understanding of its biology, history and distribution.

Probably, then, the solution of the "Eel Question" calls for the solution of the numerous "eel questions" to be found in the Indo-Pacific region. And we have here a very interesting task for biological research.

Prior to the biological investigation, however, we must have a proper classification of the species and a survey of their geographical distribution. Our work on the task of classification has made good progress during recent years, and a preliminary survey has already been obtained, thanks to the liberal assistance of the various Museums in placing their material of Indo-Pacific *Anguilla* species at our disposal.

In the present work, I shall, as a rule, deal only with the geographical distribution of the genus *Anguilla* in the Indo-Pacific region. Part I, (1909) and this present Part II will then give a survey of what is known to date regarding the geography of the genus.

Before proceeding to the Indo-Pacific region, I must mention that since the publication of Part I there has appeared, in Russia, a work by L. S. BERG on the distribution of the Eel in that country, showing that the eel there is more widely distributed, both in the north and in the south, than noted on my chart in Part I of the present work. I am much indebted to Professor L. S. BERG, of Petrograd, for the following extract from his work, the paper itself being in Russian (BERG 1917):

Russia.

"The fresh-water eel (*Anguilla anguilla*) is also found in the White Sea. Professor S. ZERNOV (Moscow) sent me a specimen 96 cm. long, taken by him on the 17th of June 1915 in the northern part of the river Dwina, near Archangel. This is the first authenticated instance of occurrence of the eel in the northern portion of the Dwina. In 1915, eels were very scarce here, but the fishermen knew them well. It is interesting to note that as early as 1771, the eminent Russian traveller, LEPECHIN (Reise, III, 1780) observed the eel in the basin of the North Dwina, namely, in the river Sysola, a tributary of the Vychegda.

On the Murman Coast, eels are very rare.

All the shores of the Black Sea are visited by the eel; it is a mistake to suppose that eels are lacking here. As early as 1774, GÜLDENSTÄDT (Reise, II, 1791, p. 363) noted its occurrence in the river Ostyor, a tributary of the Dessna, near Niezhin (Gov. Tchernigov). In 1863, a specimen was taken in the Dniepr, near Kief (KESSLER: Fishes of the St. Petersburg Gov. 1864, p. 201; in Russian); several finds from the same locality are also noted for 1907 and 1913 by D. BELING (Trav. Stat. Biol. de Dniepr, I. Kief, 1914; in Russian). A specimen was caught in the Dniepr near Mohilev (BELING, l. c.). The eel is found at Otchakof (MAKSIMOV, Annuaire Mus. Zool. Ac. Sci. Pétersbourg XVIII, 1913, p. 34; in Russian), and it is taken annually in the Dniepr Liman at Stanislav (RIABKOV, Fisheries of the Kherson Gov. I. 1896, p. 91; in Russian). KESSLER (Bull. Soc. Nat. Moscou 1857, I. p. 476) mentions the capture of an eel abt. 1850 in the Dniestr above Yampol, but as far as I have been able to ascertain, eels are not uncommon in the lower reaches of the Dniestr. Small quantities of eels are captured every year in nearly all the »limans«, or bays, of Bulgaria, Roumania and Russia as also in the Danube delta; in the Bay of Mandra, near Bourgas in Bulgaria, 10 eels were caught in the fishing season of 1907—08 (MAKSIMOV l. c. p. 34). According to ANTIPA (Fauna ichtiologica a Românici, Bucuresti 1909 p. 236) eels of 20—130 cm. long are taken in the Danube delta, though only rarely, and also in the lakes near the coast, e. g. Lake Mangalia. The occurrence of eels in the Danube (Linz, Krems, Vienna) is recorded as early as the 17th century (by MASSILI). They are found near Odessa, ("Vestnik Ryboprom yshl", 1899, p. 527; in Russian); at Sevastopol, abt. 20 are captured every year, up to 1 m. long (ZERNOV, Mem. Acad. Sci. XXXII, No. 1, 1913, p. 166; in Russian).

The eel also visits the Sea of Azoff; there are records of the capture of eels at Berdiansk (PENGO, Trav. Soc. Nat. Kharnov VI, 1872, p. XXXI; in Russian), at Belosaraiskaia Hook (OSTROUMOV, Bull. Acad. Sci. St. Pétersbourg VII, 1897, p. 26; in Russian). Here also an eel was captured by ZERNOV, on the 29th of May 1900; length 89 cm. Also at Taganrog (KAWRAJSKY, „Izw. Obshch. Liub. Est", LVI, fasc. 1, 1889, p. 43; in Russian).

There is no doubt that eels occur in the Black Sea area without having penetrated via the artificial waterways connecting the Baltic and the Black Sea. I may add that eels are found in the Sea of Marmora; and in the northern parts of the Ægean (Burughel Bay) there are regular eel fisheries.

It may be mentioned that there are records of the capture of eels in the Volga. KESSLER (Trav. Soc. Nat. St. Pétersbourg, I, 1870, p. 284; in Russian) mentions the following places in

the upper and middle reaches of the Volga: Vyshni-Volochek, Tver, Rybinsk Yaroslavl, Youryevetz and Saratov. The Fishery Laboratory of Astrakhan possesses two specimens of eels taken in the Volga delta (Trav. Labor. Ichth. Astrakhan I, fasc. 1, 1909, p. 72; in Russian) and BERG l. c. p. 346). But there can be no doubt that these are in all cases individuals which have penetrated in the Volga system through the artificial waterways connecting this system with rivers flowing out into the Baltic.

No observations are on record as to the ascent of eelers in Russian rivers, either in the White Sea, Baltic or Black Sea.

No eels occur in Turkestan and Siberia."

I have quoted Professor BERG's information in detail, as nearly all the references he gives are to works published only in Russian, and therefore hardly accessible, perhaps, to ichthyologists outside that country.

America.

Since the publication of Part I an interesting addition to the distribution of *Anguilla* on the continent of America has been recorded by SEALE (1917), who found four specimens from the Republic of Panama in the collection of the Museum of Comparative Zoology, Cambridge, Mass. In consideration of the fact that larval specimens, though not numerous, were caught in the Caribbean by the "Dana"-Expedition (SCHMIDT 1925), SEALE's record of eels in Panama would not seem strange. But when the author says (SEALE 1917, p. 79): "A study of the measurements of these eels revealed the fact that certain ones, M. C. Z. 9162 from the West Indies and M. C. Z. 22. 440 (four specimens) from Panama, did not differ in the slightest degree from *Anguilla vulgaris* Turton of Europe, while all other American specimens were undoubtedly *Anguilla rostrata* Lesueur", I should say that measurements alone hardly suffice, in all cases, to distinguish the American eel from its European relative. The case is of much interest since the presence of *Anguilla vulgaris* in Panama would mean the first authenticated instance of occurrence of the European eel in America. The question can easily be decided through an examination of the number of vertebrae in the specimens concerned.

I will now proceed to consider the Indo-Pacific region. The Indian section has already been partly dealt with in Part I, to which, with the addition of various corrections and supplementary remarks, I would refer.

My object is to ascertain whether the genus *Anguilla* is present or lacking in the various areas. I have here had recourse preferably to more recent works, as these generally pay more attention to precise statement of locality than older ones. (An indication of locality such as "Australia" for instance, is practically valueless for our present purposes). For the rest, I do not aim at noting every work in which the occurrence of *Anguilla* is recorded. When I have one well authenticated record, I often take this as sufficient.

It will be noticed that I have endeavoured wherever possible to point out any data showing the quantity of eels found in the various parts.

Where a statement of locality is followed by a parenthesis as for instance (Mus. Paris!), (Brit. Mus.!) etc., this means, that the specimens in question are preserved in the Muséum d'Histoire Naturelle, Paris, the British Museum, London, etc., and have been seen by myself or my Assistant, Hr. mag. sc. VILH. EGE. The results of the further systematic investigation will not, as a rule, be stated in the present work, which is concerned with the geography of the genus *Anguilla*. I take this opportunity, however, of expressing at once my cordial thanks to the authorities of the many Museums who have so liberally opened their collections to us; in addition to the two already mentioned, also those of Amsterdam, Bale, Berlin, Bremen, Brussels, Copenhagen, Frankfort on M., Genoa, Hamburg, Honolulu, Leyden, Lübeck, Oslo (Christiania), Stockholm, Stuttgart, Washington, Vienna.

As will be seen from the text, I have received assistance from several colleagues abroad in the form of information as to finds of *Anguilla* specimens, literature references, etc., and I have pleasure in putting on record here my grateful acknowledgement to all. I am particularly indebted to Professor MAX WEBER, of Eerbeek, near Amsterdam, who has on numerous occasions assisted me with information as to the occurrence of eels in the Dutch East Indies.

Last, but not least, I thank those who have taken part with me in the work of examining the specimens, especially Hr. mag. sc. VILH. EGE.

II. THE INDIAN OCEAN

A. Western Section (Africa).

As noted at length in Part I, *Anguilla* is not found in West Africa, but occurs on the East Coast. Coming from the West Coast, the Orange River is the first locality where eels have been met with, but it is only east of Cape Agulhas that they are of more regular occurrence (see I, p. 24 and foot-note ¹), and GILCHRIST & THOMPSON, 1917, p. 468). For the rest, they are known along the whole east coast of Africa as far as the Juba River in Somaliland to the north; also from the islands east of Africa (Madagascar, Comoro Islands, Seychelles, Mascarenhas), and we have been able to examine specimens from nearly the whole of this area. I have not much to add to what was noted in Part I.

¹ "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 Elisabeth 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." (Professor GILCHRIST, Capetown, in letter dated 29/12 1908).

BARNARD (1925, p. 176) mentions the *Anguilla*-specimen caught by Dr. Kannemeyer in the Orange River at the junction of the Orange and Caledon Rivers, N. E. of Burghersdorp (cf. GILCHRIST & THOMPSON 1917, p. 468) and says: "... there is the possibility of an overland migration from the upper reaches from one of the east-flowing streams rising near the head waters of the Caledon and Orange Rivers, as the European eel has often been found in damp meadows away from water." Further: "Gilchrist and Thompson state that large specimens are occasionally reported from the mouth of the Orange River. They do not specify the species, however, and it is not improbable that these are reports by an unqualified observer and refer not to an *Anguilla*, but to a species of *Ophichthys*."

After this it will perhaps be best to cancel the suggestion as to eels ascending the Orange River and any other west-flowing stream north of Table Bay (near Cape Town). (Note added during press.)

BOULENGER'S "Cat. Fresh Water Fishes of Africa", Vol. III, which appeared in 1915, mentions all the specimens from East African waters preserved in the British Museum. Geographically speaking, they tell us nothing essential beyond what was already known. They are referred to 3 species: *Ang. mossambica* Peters (uniformly coloured, long-finned), *Ang. australis* Rich. (uniformly coloured, short-finned), *Ang. bengalensis* Gray (mottled). I do not agree with BOULENGER as to the delimitation of species. The mottled African form *A. labiata* Peters is not identical with the *A. bengalensis* met with in India, nor is the short-finned African eel (*A. virescens* Peters) the same as the Australian *A. australis* Rich.

On the island of Rodrigues, 350 miles east of Mauritius, it is stated (SNELL & TAMS, 1920, p. 287) that "freshwater fishes were found in many of the streams, in which eels were quite common". We have ourselves examined specimens from this island, preserved in the British Museum, and found that they belonged to the short-finned *Anguilla bicolor* M.Cl. and the mottled *Ang. mauritiana* Benn.

PELLEGRIN (1922 p. 418) notes from Madagascar: *A. mossambica* Peters, *A. bengalensis* Gray and *A. australis* Rich, without further comment. The nomenclature seems to be the same as that employed by BOULENGER (1915).

The following interesting information regarding the eels in the East African Highlands was communicated by Mr. R. E. DENT, Fish Warden, Nairobi, Kenya Colony, who writes me in a letter dated 23/9, 1924:

"I am in charge of the Trout which means that I deal with the colder water chiefly above the highest point where eels get. No. 1 of your Plate (*Anguilla labiata* Peters) I know very well; this eel is numerous in most of the rivers flowing off East Kenya mountains and the Aberdares and Kikuyu escarpment. These eels come up the Athi and Tana Rivers and then work up the small streams. No eels appear to go up the rivers where the water temperature goes below 64° F. which is at about 5000 ft. to 5500 ft. The green and yellow eel (No. I, *Anguilla labiata* Peters) does not grow as large as No. IV? (*Anguilla mossambica* Peters). I have caught specimens of No. I up to about 6 lbs. and No. IV up to 15 lbs." (Mr. Dent is here referring to some figures I had sent him).

I have seen a giant specimen of *Anguilla labiata* Peters from Lake Nyasa (Mus. Berlin; head weighing abt. 1050 grammes); it must have got there via the Zambezi River.

Red Sea.

There is in the Berlin Museum an eel determined as "*Anguilla nilotica* Heck.", from the "Rotes Meer", collected 1820—1825 by HEMPRICH and EHRENBERG. Unfortunately, no further data are available as to where precisely in the Red Sea this specimen was caught (Professor P. PAPPENHEIM in letter). It seems to belong to *A. labiata* Peters, though it is not typical.

The Museum at Genoa has a number of specimens of *Anguilla* labelled "Massaua, Prof. ISSEL 1870", kindly sent me for examination by Professor D. VINCIGUERRA. The specimens belong to the European eel (*Ang. vulgaris*). Unless labels have got

mixed by accident, these eels must apparently be supposed to have immigrated through the Suez Canal, (which, according to information from Professor J. STANLEY GARDINER, Cambridge¹, was opened on August 18, 1869) from the Mediterranean to the Red Sea, and southward again along the western shore to Massaua in Eritrea.

In view of the fact that eels occur in great quantities at the mouth of the Nile, where PAGET (1924) for instance, has found them by the million as elvers, there would perhaps be nothing impossible about specimens of the European eel straying through the Suez Canal into the Red Sea, just as stray specimens of Indian species like the above-mentioned *A. labiata* might have entered that water from the south. Still the case must be considered very doubtful.

The conditions on the shores of the Red Sea, however, are exceptionally unfavourable for fresh-water eels, owing to the absence of permanent fresh-water streams and lakes. For this reason alone it seems out of the question that this enclosed sea should harbour an indigenous stock of eels.

B. Northern Section (Asia).

The Persian Gulf.

In Part I, p. 151, I note that "according to PALACKY (1891) p. 185, the Chesney Expedition found eels in the Tigris." As I had not been able to consult the Report of the Expedition myself, and as this record of the occurrence of *Anguilla* in the Tigris seemed rather doubtful, I asked Mr. C. TATE REGAN, of the British Museum, London, to look into the question if possible. In a letter dated ¹³/₃ 1924 Mr. REGAN kindly informs me that: "The list of fishes occupies one page at the end of the book on the Chesney Expedition, and is anonymous. The inclusion of Eel (*Muraena anguilla* L.) need not be taken to mean more than that somebody had heard eels (probably *Mastacembelus*) occurred in the Tigris; we have no *Anguilla* from there."

After this it will be best to cancel the suggestion as to occurrence of eels in the Persian Gulf.

India.

Eels are known to occur all the way from Bombay (KAUP, 1856) to Rangoon, in Burmah, (VINCIGUERRA, 1890), as also in Ceylon and the Andamans; I have myself seen specimens from all these places (Mus. Paris, Brit. Mus. etc.). They represent two species, the mottled, long-finned *Anguilla bengalensis* Gray and the

¹ "In the construction of the present canal, the waters of the Red Sea joined with those of the Mediterranean for the first time on August 18th 1869, in the small Bitter Lake." . . . "I have enquired of our people in the Suez Canal and they do not seem to have seen any fresh-water eels" (Professor J. STANLEY GARDINER in letter dated ³/₄ 1925).

short-finned, uniformly coloured *A. bicolor* M.Cl. In India also, we have instances of eels penetrating far up into the continent. I may mention, e. g. the finding of an eel (GÜNTHER 1870, p. 26) at Almorah on the southern range of the Himalayas (29° 37' N, 79° 40' E); it must have got there from the Bay of Bengal via the Ganges.

As regards the Arabian Sea, I have not yet been able to make certain whether eels are found here north of Bombay. We should certainly expect to find them, for instance, in the Indus delta, but nothing positive is known to me as to this.¹ It is to be hoped, that these remarks may lead to an investigation of the point; there are, one might say, not many places in the world of which so little is known in this respect as the northern shores of the Arabian Sea.

As regards the occurrence of eels in the Nicobar Islands nothing is known, as far as I am aware; I can see no reason why they should not occur here.

In the islands on the Chagos Ridge, as far as I am aware, no eels have been found (BOULENGER, 1907).

C. Eastern Section.

Malaya and Western Australia.

Thanks to the great and important work of WEBER & BEAUFORT (1916) we are well acquainted with the conditions on the eastern margin of the Indian Ocean, at any rate as regards the Dutch Colonies there. We find eels here, right from the northern extremity of Sumatra to Flores and Timor, i. e. on all the coasts running down to the Indian Ocean. The remaining portions of the Dutch East Indies will be dealt with later, when considering the boundary area between the Indian Ocean and the Pacific.

In north-western Australia also, fresh-water eels are found. As to this, an interesting report is given by the Norwegian zoologist, Dr. KNUT DAHL (1898, p. 435—437). The place where Dr. DAHL found them was at Broome, abt. 20 miles north of Roebuck Bay (abt. Lat. 18° S.) in Dampier Land. "The eels were found in a salt marsh, which, at very high spring tide, was connected up with the sea. They lived so deep down in the mud that we had to dig them up with spades." (Dr. KNUT DAHL, in a letter dated $\frac{8}{8}$ 1908). On p. 437 of his Report, again, this writer states: "The eel, which is very like the common European form (*Anguilla vulgaris*) lies buried in the mud, from $\frac{1}{2}$ to $1\frac{1}{2}$ metres down, with a passage abt. 30 mm. wide leading down from the surface of the mud to where it lies. It is extremely slippery and its eyes are deep set in the sockets, covered with a thick,

¹ In a letter dated $\frac{4}{6}$ 1925 Professor G. MATTHAI, Government College, Lahore, writes: "With reference to your letter, I am writing to say that, so far as I know, the genus *Anguilla* does not occur in the Indus System . . . I have made personal inquiries, but I regret to say that there is no authentic record of the genus in the river Indus."

transparent tissue running level with the epidermis of the body; i. e. the epidermis seems to close directly over the eyes. The place where we found these eels was situated abt. $1\frac{1}{2}$ miles from the nearest tidal inlet and perhaps 3 miles from the coast. The salt marsh itself is never reached by the salt water except at the highest spring tides, possibly twice or three times a year." It is further stated that the natives are well acquainted with these "mud eels" and manage to capture them by digging them out of the mud, which requires considerable skill. I have been able to examine the seven specimens brought home by Dr. DAHL, preserved at the Zoological Museum in Christiania; H. RENDAHL (1922, p. 175) refers them to *Anguilla australis* Rich. They are, however, not identical with the species living in eastern Australia, but nearer to the Indian *Anguilla bicolor* M.Cl.

Farther south along the west coast of Australia, eels are not known to occur, and the same applies to the greater portion of the south and north coast. For the rest, see the later section, dealing with occurrence of Eels in Australia.

III. THE PACIFIC

A and B. Eastern and Northern Sections.

As we have seen in Part I, *Anguilla* is lacking throughout the entire range of the Pacific coast of America. It may here be added, that EVERMANN & GOLDSBOROUGH (1907) give a list of the fishes of Alaska comprising 288 species, in which *Anguilla* is not found.

As regards the eastern and northern portions of Russia in Asia (Siberia, Kamschatka, also Saghalien) I take pleasure in quoting here the well-known Russian ichthyologist, Professor L. S. BERG of Petrograd, a distinguished authority on the fish fauna of these regions, concerning which he has published numerous works. As several of these, like those of other writers in that country, are published in Russian, which I cannot read myself, this authoritative information was particularly welcome. In a letter dated ³¹/₁ 1924, Professor BERG writes: "There are no fresh water eels (*Anguilla*) on the coasts of Siberia. As far as I am aware, the most northerly find in the Pacific is at Hakodate in Japan (JORDAN & SNYDER, 1901) and Seoul in Korea (STEINDACHNER, 1892). It is not impossible that eels may also occur on the east coast of Korea, but they have not been found there hitherto. So also, no eels have been found at Vladivostock though it cannot be asserted that specimens of the Japanese eel might not be able to stray so far north as to Vladivostock.

C. Western Section.

China.

STEINDACHNER (1892, p. 370) records *Anguilla vulgaris* Cuv. from the west coast of Korea. According to information from the Imperial Bureau of Fisheries in Tokyo, the yield of the eel fishery in Korea (Chosen) in 1920 amounted to 13,896 lbs.; it is added, that the eel fishery is not yet developed to any great extent, though eels are comparatively plentiful in Korea.

In China, the eel is found from the Liao-ho River (flowing into the Liao-tung Gulf near Newchwang) in the north, right down to the Canton River in the south. I have seen a specimen from the former water in the British Museum.

Eels are marketed in the larger towns, in north, middle and south China. With regard to Peking, BASILEWSKY states (1855, p. 246—247) that the eel (his *Muraena pekinensis*) "in foris Pekinensibus quoque tempore observatur, et chinensibus multo aestimatur."

From Shanghai I have received, through the Danish Consulate General there, 85 eels, bought in the market by Mr. ARTHUR DE C. SOWERBY, a well-known naturalist resident in Shanghai.

The most southerly part of China from which eels are known is the Canton river. I have seen specimens from Canton, brought home by the Swedish "Vega" expedition (Mus. Stockholm!), and it is repeatedly mentioned from here in the literature. Eels from the Canton River are sold in the market in Hongkong, and they must be of fairly frequent occurrence, for Captain H. E. FRANDSEN, of the Danish East Asiatic Company, in Bangkok, who has sent me specimens for investigation, was able to purchase 64 specimens — all typical silver eels — in the Hongkong Market from the 10th to the 12th of November 1924. It seems likely then, that *Anguilla* actually occurs still farther to the west on the coast of southern China, but I know of no record from there.¹

The great majority of eels in China belong to the species *Anguilla japonica* Schleg. as I have been able to ascertain by examination of the mentioned samples, and numerous specimens preserved in the various Museums.

That eels in China, as elsewhere, penetrate far up into the interior is shown by GÜNTHER (1889, p. 219) where specimens are recorded — under the name of *Anguilla vulgaris* Cuv. — from Kiu-Kiang, on the upper Yangtse Kiang (29° 44' N, 116° 8' E).

RICHARDSON (1845, p. 312) gives the Chinese name of the eel at Canton as "Woo uhr shen", translated by "Crow-ear eel" (BIRCH) or "Black-eared eel" (REEVES). According to Captain H. E. FRANDSEN the local name of the eel is "Hong-sin" in Canton and "O-bi-moa" in Swatow.

Japan.

Common as are eels in China, they are nevertheless far from attaining there the same importance as in Japan, where "*unagi*", as the common eel is called, is a fish of great economical value.

The occurrence of *Anguilla* in Japan is noted by many writers, both Japanese and others. I will here only mention SCHLEGEL (TEMMINCK & SCHLEGEL, 1846) who described the common Japanese eel under the name of *Anguilla japonica*, ISHIKAWA & MATSUURA (1897, p. 7) who give a list of the specimens preserved in the Imperial Museum, Tokio, JORDAN & SNYDER (1901, p. 842), who states: "The single

¹ This supposition is confirmed by a letter dated 24/1 1925 from Dr. E. W. GUDGER, of the American Museum of Natural History, New York, stating that according to Mr. JOHN T. NICHOLS, the Chinese freshwater collection now being studied by him contains a specimen of *Anguilla japonica* from Hainan.

Japanese species differs very slightly, if at all, from the American eel, *Anguilla chrysypa*", and TANAKA (1912, p. 148).

Both the last-mentioned works give Hakodate in Hokkaido (Yezo) as the most northerly find of *Anguilla japonica*, which it may be noted is found throughout the whole of Japan and the Riu Kiu Islands, right to Formosa (Taiwan), cf. p. 342.

The eel fishery of Japan is of much importance, and apart from Europe and North America, Japan is the only place in the world where eel fisheries have assumed considerable dimensions and become an important industry. In illustration of this I give some figures obtained through the Danish Consulate at Yokohama from the Imperial Bureau of Fisheries, Tokyo.

Yield of the Eel Fisheries, Japan.

Year	Weight	Value (Yen)
1914.....	6.391.850	1.294.430
1915.....	7.837.558	1.494.965
1916.....	8.896.166	1.707.464
1917.....	9.141.375	2.326.152
1918.....	8.925.642	3.152.671

The ascent of great hosts of elvers from the sea to the fresh water is a phenomenon quite as well known, apparently, in Japan as in Europe and North America. I have on several occasions received consignments of elvers from Japan, and these were taken at the end of February and in April. In reply to an enquiry, the Imperial Bureau of Fisheries, Tokyo, writes, (¹²/₄ 1924) that the season of ascent of the elvers in Japan is from February to May, especially April and May. The Fishery Bureau forwarded at the same time a sample of 168 elvers taken on the 15th of April 1923 at Ushibari, in the Prefecture of Ibaragi. These were examined for development, length and weight by Mr. A. STRUBBERG, cand. mag., and for number of vertebræ by Mr. VILH. EGE, mag. sc. Of the 168 specimens, 26 were at stage VB-VIA I, 120 at stage VIA I-VIA III, while 22 showed traces of myoseptal pigment (for the significance of this classification see STRUBBERG 1913).

Japanese Elvers (*A. japonica*), Ushibari, ¹⁵/₄ 1923.

Length in mm.	No. of specimens	No. of vertebræ	No. of specimens
63.....	1	119.....	2
62.....	1	118.....	11
61.....	9	117.....	39
60.....	15	116.....	52
59.....	26	115.....	40
58.....	32	114.....	18
57.....	31	113.....	2
56.....	25	112.....	1
55.....	19	Average: 115.885 vertebræ	
54.....	4		
53.....	3		
52.....	2		
Average: 57.47 mm.			

The average length was 57.47 mm., and average weight 152 mg. From this it will be seen that the size of the Japanese elvers coincides very closely with that of the American eel. In the latter, we found an average length of 57.28 mm. in a sample of 443 spec. taken $\frac{5}{8}$ 1913 in Little River, Mass. (SCHMIDT 1916, p. 14).

The number of vertebræ, varying from 112 to 119, with an average of 115.885, answers well to the values I have previously found in samples of *A. japonica* from Japan: 115.772 and 115.980 (SCHMIDT 1913, p. 14).

I give in this connection the result of some countings of vertebræ in Chinese specimens of *Anguilla japonica*, made in 1924 by Mr. VILH. EGE, mag. sc. The majority of the specimens were from Shanghai.

No. of vertebræ in Chinese Eels (*Ang. japonica*).

No. of vertebræ	No. of specimens
119.....	2
118.....	5
117.....	22
116.....	22
115.....	30
114.....	14
113.....	1

Average: 115.760

The range of variation and the average number are, as will be seen, in good accordance with what was found in the Japanese specimens of this species.

Formosa. (Taiwan).

The occurrence of eels is noted by several writers. I will here only mention JORDAN & EVERMANN (1903), who give, p. 325—326, no fewer than 4 species: *Anguilla manillensis* (Bleeker) from Kotosho, *A. mauritiana* Bennett from Kotosho, *A. sinensis* Mc. Clelland from Taihoku and *A. remifera* Jord. & Everm. n. sp. from Hokoto. From the description, I can only consider the two last-named as being *Anguilla japonica* Schleg. I have myself seen both *A. japonica* Schleg. and *A. mauritiana* Bennett from Formosa.

According to information from the Imperial Bureau of Fisheries, Tokyo, the yield of the eel fishery in Formosa in 1920 was 95,427 lbs. As in the case of Korea, it is added that the yield is not proportionate to the plentiful occurrence of the eels, as the fishery is not sufficiently developed.

The Philippines.

The most important work on the eels of the Philippines is that of HERRE (1923) who records the following 4 species from there: *A. mauritiana* Bennett (distributed from Calayan, north of Luzon as far south as Jolo), *A. celebesensis* Kaup., (from Lake Lanao in the north of Mindanao, and Manila), *A. australis* Rich. (from

Lake Bato, Camarines, and Cavite near Manila), and *A. Spengeli* M. Weber from the Cotabato River in Mindanao. *Anguilla mauritiana* is apparently the commonest species, and specimens are known from most of the area. In the north of Luzon, it is found "in mountain streams up to an altitude of more than 1530 m." That it is of some economical importance may be seen from the following: "In the Manila markets one may see living specimens from Laguna de Bay up to a length of 2 m. and a circumference of abt. 460 mm." "This eel is in great favor among the Tagalogs, and commands very high prices, 8, 10, or even 12 pesos being paid for a single fish." The writer gives (p. 131) some interesting information on the eel cult in the Philippines, which I take the liberty of quoting here:

"The Indo-Pacific species of *Anguilla* are the best defined of the genus and attain by far the largest size. These gigantic eels play an important part in the mythology of some of the Polynesians, as the Samoans and Maoris, and among the Malayans, as the people of Celebes and the hill people of Mindanao and northern Luzon. Among the Lepanto Igorots the eel cult is well developed. Near the town of Kágubátan at the foot of the sacred mountain Múgao, are several small lakes or ponds in which are many large sacred eels. The fish are fed every day with rice and sweet potatoes brought by children of the neighborhood, who sing a song which acts as a signal for the eels to come and be fed. In this song they ask the eels to take the food, to bestow good health upon the givers, and to protect them from sickness. The people say "our fathers had these eels" and "it would be death to the person injuring one", while the springs would dry up and there would be no water for the rice terraces. Another aspect of their relations to man is given in the charming little fairy tale "Talia" of northern Benguet, translated by Prof. Otto Scheerer.

Superstitions concerning eels are widespread among the Christian Filipinos. They say the eel contains a magical stone, or mutya, which gives the possessor the power to escape from any knots or fastenings. This is evidently a form of the widespread belief in the bezoar stone, but in this case the slippery agility of the eel is transferred to the owner of the mutya. Such Filipino names as talunasan refer to the slipperiness of the eel. Some people also believe that if eels are eaten when one is recovering from an illness the disease will attack him again with the utmost severity, and death will be almost sure to follow."

I quote in conclusion HERRE'S list of local names, by which *Anguilla* is known in the Philippines (l. c. p. 130); Bagobo, *casili*; Bicol, *casili*, *borirauan*; Bontoc Igorot, *tjalid*; Ibanag, *quiuo-t*, *siging*; Ilocano, *quioet*, *igat*; Ivatan, *tuna*, applied to all kinds of eels; Moro, *casili*; Pampangan, *talunasan*, *palus*; Sambali, *talunasan*, *talunajan*; Tagalog, *igat*, *pabucañginhi*; Tirurei, *berriró*; Visayan, *casili*, *bais*.

Salibabu.

WEBER & BEAUFORT (1916, p. 248) note *A. celebesensis* Kaup from here.

Halmaheira.

STEINDACHNER (1903, p. 456—57) has *A. sidat* Bleek. and *A. mauritiana* Bennett from this island. The latter specimen belongs to *A. celebesensis* Kaup (Mus. Frankfurt!). I have myself seen a specimen of a short-finned, uniformly coloured *Anguilla* from here (Mus. Hamburg!).

New Guinea.

Anguilla is found from the island of Waigiu on the west (specimens in Mus. Paris!, Mus. Amsterdam!) all along the north coast and on the eastern part of the south coast as far as Rigo on the west ($9^{\circ}54' S.$, $147^{\circ}35' E.$, specimens in the British Museum!). For the middle portion of the south coast there are no records, and the collections from there (RAMSAY & OGILBY, 1886, Strickland River, 25 species; REGAN, 1914, Mimika, Setakwa and Utakwa rivers in Dutch New Guinea, north of Frederick Henry Isl., 23 species, do not include *Anguilla*. On the south coast, there is a record of *Anguilla* (1 specimen) from the Lorentz River Dutch New Guinea, estuary abt. $138^{\circ} E.$, (WEBER & BEAUFORT 1916, p. 251). Up to the present, then, *Anguilla* is not known from the middle portion of the south coast of New Guinea.

WEBER & BEAUFORT (1916) also mention the following localities on the north coast of Dutch New Guinea: Mamāpiri river, on the western side of Geelvink Bay, Tawarin and Klipong rivers, Humboldt Bay (*A. mauritiana*), Roon Isl. in Geelvink Bay (*A. celebesensis*, here called "roar"). I have myself seen specimens (Mus. Amsterdam!) from the north coast of Dutch New Guinea from the Mbaai river, Humboldt Bay, (short-finned species) and from the Great Mamberamo River, abt. $137^{\circ}50' E.$, short-finned species. From Eastern New Guinea (formerly German New Guinea) I have seen specimens from Hansa Bay (abt. $145^{\circ} E.$), Potsdam Hafen (abt. $145^{\circ} E.$), Irisspitze, Kelana Hafen (abt. $6^{\circ} S.$, $147^{\circ}30' E.$) and Langemak Bay (abt. $6^{\circ}40' S.$, $147^{\circ}50' E.$) (Mus. Hamburg!) as also from Huon Gulf (Brit. Mus.); further, from Dinawa, Owen Stanley Range, British New Guinea (Brit. Mus.). From the north-western part of the island I have seen specimens from Doreh (Mus. Paris!); the British Museum has also a specimen from the Arfak mountains.

That eels occur in great numbers on the north coast of New Guinea is apparent from the following interesting report which I received with some specimens sent me for examination by Dr. L. F. de BEAUFORT, Director of the Zoological Museum at Amsterdam. The locality was the large Mamberamo River ($2^{\circ} S.$, $137^{\circ}50' E.$) which flows out close to Cape d'Urville: the observations were made by the medical officer, Dr. H. de ROOK in the course of the Mamberamo Expedition in 1922, at Pionier Bivak which lies up country, some considerable distance from the coast. The account runs as follows:

"On the 25th of February 1922, between 8 and 9 in the morning, the entire surface of the Mamberamo River in front of Pionier Bivak was literally covered with eels making their way upstream. They were easily caught by thousands with an improvised net made from bits of gauze bandage fastened to a couple of sticks. Up to that time, the Expedition had not caught any of these fish. The journal of (then) Captain OPPERMAN records the observation of a similar phenomenon at the Edi Falls, on the same river."

Examination of the twelve specimens sent showed that they were of a short-finned species. They were pigmented, and measured 14—23 cm. in length, *i. e.* they

were not elvers, but young eels, such as have also been observed ascending rivers elsewhere, e. g. at Trollhättan, in Sweden.

As far as I am aware, this is the first recorded observation in the tropics of an ascent of eel young en masse, such as is well known from temperate countries (Europe, America, also New Zealand, MAIR 1880 and Australia, KERSHAW 1911)¹

Bismarck Archipelago.

St. Matthias. — (1°30' S., 149°45' E.). A specimen of *Ang. mauritiana* Benn. (Mus. Hamburg!; Dr. G. DUNCKER leg.).

Neu Pommern. — A specimen of a short-finned species was taken in Rein Bay on the north coast, by Dr. G. DUNCKER (Mus. Hamburg!).

Solomon Islands.

GÜNTHER (1910, p. 389) has *A. mauritiana* Bennett from here. From Treasury Island, he notes *A. otaheitensis* Kaup (p. 391).

Australia (incl. Tasmania).

Two species of *Anguilla* are common in Australia: the short-finned, uniformly coloured *Anguilla australis*, described in 1841 by RICHARDSON from specimens from Tasmania and Auckland Island (Brit. Museum!), and the long-finned, mottled *Anguilla Reinhardti*, described in 1867 by STEINDACHNER from a specimen from Rockhampton, in Queensland (Mus. Vienna!). From the tropical part of the east coast (Burdekin, Queensland) MACLEAY (1884, p. 210) has described a long-finned, uniformly coloured species, *Anguilla marginipinnis*. There are thus at any rate three *Anguilla* species in eastern Australia, but I cannot say what *A. marginipinnis* may be without having seen a specimen.

Eels are found along the whole of the east coast of Australia, but are, as far as I can see from the few samples available to some extent, distributed in species, *A. Reinhardti* inhabiting mainly the tropical portion, while *A. australis* is found in the temperate parts of the east coast and the eastern part of the south coast.²

All the various specimens I have seen from Queensland for instance, belonged to *A. Reinhardti*; a small sample from Sydney contained both species, but *australis* was the more numerous (20 against 2), and a sample from Warrnambool in Victoria consisted exclusively of *A. australis* (see p. 360).

MACLEAY (1882, p. 267) gives for *A. Reinhardti*: Sydney, Hawkesbury, Cape York, Richmond River, and for *A. australis*: Tasmania, Victoria and New South Wales coasts and rivers.

¹ In 1925 the ascent of great hosts of true elvers has been observed at Telok Dalem, Nias Island (w. of Sumatra) by Dr. AGNER MÖLLER (Note added during press).

² The two species meet, however, in an intermediate region, as may be seen from a statement by OGILBY (1898) "... both species are equally abundant in the Liverpool and Camden district..." (in the middle part of New South Wales), and *A. Reinhardti* occurs at least as far south as Melbourne (a specimen in Mus. Stuttgart!, recorded by KLUNZINGER (1880, p. 419) as *A. amboinensis* Peters).

OGILBY (1886, p. 58) says of *A. australis*: "Tasmania, rivers of the eastern watershed and coasts of Victoria and New South Wales", and of *A. Reinhardti*: "North and east coasts of Australia, Port Jackson, Hawkesbury and Richmond Rivers."

In an interesting article: "The distribution of the fresh-water eel in Australia and its means of dispersal" T. S. HALL (1905, p. 80—83) describes the occurrence of the eel. I will quote the following:

"They are common in all the streams of our south coast (*i. e.* s. coast of Victoria), and a correspondent at Mount Gambier, in South Australia, tells me they occur about the Mount, as far west as Lake Bonny." "In reply to a request of mine for information, Mr. A. ZIETZ, the Curator of the Adelaide Museum, says: "Fresh-water eels do not occur in South Australia, except in the Mount Gambier district, between Mount Gambier and Beachport, in waterholes. I have never seen or heard of any eels being caught in the Murray." . . . "Having seen that eels and black fish (*Gadopsis*) were being introduced into Western Australia streams, I wrote to Mr. L. LE SOUËF, Secretary of the Acclimatization Committee of Western Australia, in Perth. He says there are certainly no eels in the southern streams, and inquiries made by him for me resulted in no evidence of their occurrence in the northern rivers of the State."

The result then, seems to be, that *Anguilla* occurs from Cape York (sample in Brit. Mus.!), along the whole of the east coast and on the eastern part of the south coast as far as abt. 140° E. It is lacking on all the remaining parts of the south coast and the southern (temperate) part of the west coast. On the other hand, eels have been found in Dampier Land, on the tropical north-west coast at abt. 18° S. (DAHL, 1898) but as already mentioned (p. 338) these do not belong to the same species as those found on the east coast, but to the Indian *A. bicolor* M. Cl. It is an important task to ascertain now with certainty how far south along the west coast the tropical, Indian *Anguilla*, as found in Dampier Land, extends.

We then come to the north coast of Australia. From here, there are no records of *Anguilla* along the whole long range from Dampier Land (abt. 122° E.) to Cape York (abt. 142° E.). In this connection I may state as follows. The Norwegian zoologist, Dr. KNUT DAHL, who, as mentioned on p. 337 found eels in Dampier Land, also made extensive investigations in Arnhem Land in North Australia. In reply to an enquiry, Dr. DAHL wrote, in a letter dated 8/8 1908: "In North Australia, I do not think eels are common. I have never seen a single one, and it would have been strange if they had been able to escape me among such fish-catching folk as the blacks there." (A large collection of fishes was brought home from Arnhem Land by Dr. DAHL; see RENDAHL 1922).

Mr. T. S. HALL, M. A., University of Melbourne, writes in a letter of 19/5 1913 as follows: "My chief, Professor BALDWIN SPENCER, spent last year at Darwin in the Northern Territory of Australia, mainly on anthropological work, but also doing some general collections as well. He was on the look-out for eels in fresh water. There are fine large rivers, but no fresh-water eels are to be found in this territory, nor do the natives know them."

MACLEAY (1878) and KLUNZINGER (1880) who give records of the fishes at Port Darwin, do not mention *Anguilla*.

According to de CASTELNAU (1879) there are in the Norman River, which flows out into the Gulf of Carpentaria: 25 species of fresh-water fishes known, but no *Anguilla*. In the Palmer River, again, (Gulf of Carpentaria) from which 7 species are recorded, no *Anguilla* have been found (MACLEAY 1883):

It seems, then, that *Anguilla* is lacking along great parts of the north coast of Australia, or occurs there only exceptionally. It is interesting to note, in this connection, that fresh-water eels are apparently unknown along certain parts of the south coast of New Guinea (see p. 344).

As regards the quantity of eels in Australia, it is difficult to form an idea. Most of the accounts I have received from the eastern parts of the country suggest that there are many eels, but that no organised fishery exists. People do not seem to care for eels, and some of the statements even say that they are regarded with loathing, owing to their resemblance to serpents.

I quote here some data communicated from the Fishery Departments of different States and passed on to me in a letter dated 9/3 1921 from the Danish Consulate General at Melbourne:

Victoria: "The following is the quantity in pounds, of eels taken in Victorian waters during the 6 years named."

1915.....	88.643 lbs.
1916.....	115.955 "
1917.....	84.358 "
1918.....	43.079 "
1919.....	76.798 "
1920.....	58.620 "

N. S. Wales: "...no statistics are available, and even a rough estimate of the quantities of eels that could be captured cannot be furnished, as it would be quite unreliable.

Up to the present there is no fresh-water eel fishery in this State, and but few examples are offered in our markets, although all the streams flowing east to the Pacific Ocean are plentifully stocked with these fish, and specimens up to 25 lbs. in weight have been taken.

S. Australia: "...very few of these fish are taken in this State, and therefore no records are taken."

W. Australia: "...there appears to be few, if any, fresh-water eels in this State."

New Zealand.

Eels seem to be very plentiful in most parts of New Zealand. HUTTON (1872, 1890) gives the following 3 species in his catalogue and in his list of New Zealand Fishes: *Anguilla aucklandica* Rich., *A. latirostris* Risso and *A. australis* Rich. HUTTON (1904, p. 52) and WAITE (1907, p. 11) give only two species, viz. *Anguilla aucklandi* Rich. and *A. australis* Rich.

ARCHEY (1924, p. 51) states: "There are two species of fresh-water eel in New Zealand, separated by not very great but apparently constant differences. The first, *Anguilla aucklandi*, which may be called the New Zealand fresh-water eel, is con-

fined, so far as I can discover, to New Zealand and the Auckland Islands. The other, *A. australis* has been taken from Timor, eastern Australia, South Australia, Tasmania and the Auckland and Chatham Islands."

From the Fishery Department of Wellington (per letter dated ⁹/₃ 1921 from the Danish Consulate General at Melbourne) I have the following:

"The fresh-water eel (*Anguilla*) is very plentiful in most of the lakes, rivers and streams in New Zealand. While the eel is a favourite food of the Natives yet only very small quantities is used by Europeans; there is really no demand for this fish, and it is very seldom seen in the retail fish shops. There is no statistical information available regarding the quantity marketed."

Eels from New Zealand were formerly sent to Europe in a frozen state. In 1906, for instance, I bought a sample of frozen New Zealand eels in London, and in 1912, through the kind assistance of Fisheries Director H. LÜBBERT of Hamburg, I obtained abt. 150 large eels from Christchurch, part of a consignment sent to Hamburg. The majority of these eels were *Anguilla australis* Rich.

Eels in New Zealand often grow to an enormous size. DOWNES (1918, p. 300—302) records specimens weighing 38, 46 and 32 lbs. and mentions that on the 2nd May 1917 fourteen eels were taken in the Moumahaki River the smallest of which weighed 12 lbs. and the largest was, according to native measurement, 6 ft. 1 in. in length and 20 in. in circumference.

No statistics being available it is impossible to say anything about the quantity of eels in New Zealand, but to judge from various reports it must certainly be very considerable. MAIR (1903, p. 319) who, in March 1902 visited a native settlement 3 miles up the Piako River found the natives catching large quantities of fish in a tarawa, a funnel-shaped net placed in the opening between two sets of poles 20 ft. to 25 ft. apart. When the tide was favourable it was necessary to take the fish out every quarter of an hour. MAIR lifted the net twice in about three-quarters of an hour and caught 581 eels, from 1 ft. to 4 ft. in length, the largest the size of one's arm. The Piako River being here about 60 yards wide, one can form an idea of the quantity of eels when such a number can be taken out of a bit of water only 5 yards wide. DOWNES (1918, p. 302) says that the baited eel-pots (hinaki) often contain 1 cwt. or even more for one setting. The most he saw taken with baited hinaki was at Kaiwhaiki, Whanganui River in 1907, when something over 3 cwt. was netted from two large hinaki in a single night.

According to DOWNES (1918, p. 303), the Maoris catch the young eel-fry, 2 in. to 6 in. in length, as they go up-stream in summer. They consider them a delicacy and MAIR (1880, p. 316) tells that between 2 cwt. and 3 cwt. were taken in a single night by hanging funnel-shaped bags on the Ohura Falls, up which these little eels were making their way in thousands.

In his interesting paper DOWNES (1918) described the eel-fishing of the Maoris on the west coast of the North Island, their implements and the names given to the various "varieties".

"According to the natives, and they are keen observers of nature — or, rather, they were — there are many varieties of eels, distinguished by different names, but unfortunately, it is impossible to classify them at all thoroughly by Maori nomenclature. One point seems, however, to be established by them to my mind, and that is that some of the species or varieties migrate and others do not. The eels that travel to the ocean annually are classed under the general name tuna-heke, and the migration itself is known as whatuora. It is for these that the pa-tuna are built, and the natives know to within a few days when the eels can be taken. They are never caught with bait, and seldom seen except when they are travelling down the river. The word heke implies to migrate or descend. These eels are subdivided into two or three (possibly more) varieties. The eels that are caught with bait and that remain in one place throughout the year are called tuna-toke — that is, the eel that takes the worm as bait. This eel also embraces several varieties. It is often taken with a baited hinaki, but even in streams where it abounds it is an exception to capture one in a pa-tuna." (l. c. p. 297—98). "As before mentioned, none of the tuna-heke take bait — —, the natives affirming that they live on water and foam (kohuka). The great heke, or migration, seems to take place during March, April, and May, but the natives have no record of the large eels returning. The young fry go up the rivers in the spring in countless numbers. I have taken them in a whitebait-net in October, but am told by the natives that they continue travelling up-stream till well on into the summer," (l. c. p. 302). As to the season of ascent of the eel-fry (elvers), the available observations agree with that of DOWNES. ARCHEY (1924, p. 51) thus says: "In the Canterbury Museum there are elvers of *A. australis* which were caught at the mouth of the River Styx in September 1915, by Messrs. T. Cheston and H. Unwin." In a letter dated 17/1 1925, Professor R. SPEIGHT, Curator, Canterbury Museum, Christchurch, says: "The elvers run in our rivers from September to December, and even a few in January."

To show the importance of eel-fishing to the Maoris I may quote HAMILTON (1908, p. 67—69):

"One of the most important foods in the daily life of the inland Native was the flesh of the fresh-water eels (tuna), which abounded in nearly every river and stream. — — — The Natives recognised at least a hundred varieties or states of growth, and had names for them all. In the evidence taken concerning the use made by the Natives of the Wairarapa Lake about forty names were given. — — — The flesh of the larger eels was prepared by taking out the backbone and smoking or drying the flesh in the sun. A common sight in all villages at certain times of the year was a stage or rows of poles from which hundreds of small eels were hanging drying in the sun, to be stored for future use. For the capture of eels in favourable localities, such as the great swamps on the banks of the Waikato, permanent eel-pa's were built, with carved posts at the principal points, and with watchers always on the spot, to protect the interests of the owners. Johnston, in "Maoria", points out that in the Maori economy the eel played a most important part. — — — For the capture of this much-prized food the Maori erected huge works, only excelled in magnitude by his fortifications. He cut canals leading from the lakes, so that he might have watercourses in which to place his elaborate stake-nets, and on these and the natural outlets to the lakes he built eel-weirs of so gigantic a size and of such durable timber that many of them remain to this day. Huge timbers were drawn into the bed of the river, as close as possible. One that Johnston describes has its right and left wings extending nearly 400 yards into the Rotorua Lake. Towards the end of summer the silver eels, for which the lake is famous, commence to leave the lake, with the autumn floods, for the sea. At the time when the lake is lowest, every preparation for the coming eel-fishing was completed; every worn post was removed, and divers filled the interstices of the sunken beams with the down of the raupo

(punga). As soon as the eels began to move, the chief in charge of the eel-pa had the huge nets put down and the great eel-basket, probably made in that

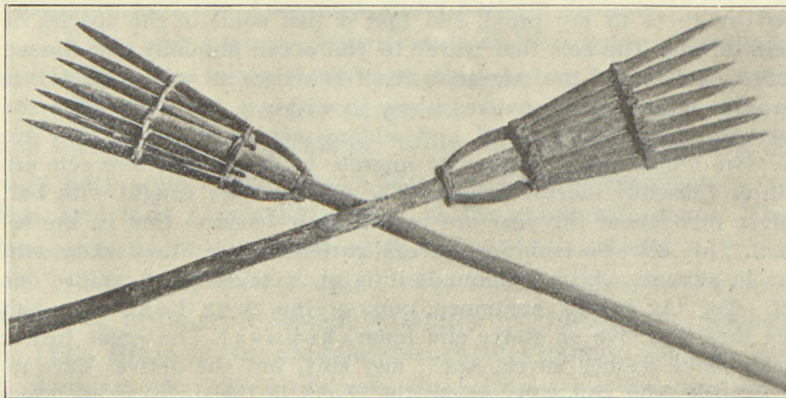


Fig. 1. Eel-spears.
From HAMILTON (1908).

part of the country of the stem of the climbing fern, the mangle (*Lygodium scandens*). This was lifted every hour, and the contents poured into canoes placed ready to receive the catch. The eels which are usually about 18 inches in length, are then cooked and eaten, or sent away as presents. The eels that escaped the net, or forced their way through the crevices in the training-walls, passed on down

the stream to run the gauntlet of other weirs and pole-men further down. — — — About three miles and a half north of the mouth of the Awatere River there is a large mud flat forming the northern portion of Clifford Bay. Mr. C. W. Adams reports that about fourteen miles of canals, about 10 ft. wide, have been made by the Maoris in former times, probably for the purpose of catching eels and other fish. — — — In the Tutaekuri River I have seen the Natives piercing eels and other fish. — — — In the Tutaekuri River I have seen the Natives piercing the muddy banks of the river with a spear tipped with a piece of fencing-wire. When an eel was struck, the spear was kept in its place, and the left hand worked down along the shaft of the spear until the eel was reached. The spears, with the wooden barbs (in fig. 1) have the barbs about 18 in. long, and the total length of the spear is about 7 ft. or 8 ft. — — — Mr. Percy Smith refers to a marau tuna, or eel-rake, as having been used at Te-roto-a-tara, in Hawke's Bay, a swampy lake near Te Aute, long famous for its eels. — — — Sword-shaped wooden clubs are frequently found in the swamps of the North Island, which have been used as eel-clubs to kill the eels taken in the traps and shallow places at the edge of the swamps."

DOWNES (1918) in the interesting work frequently quoted, gives a detailed description of the implements used by the Maoris on the west coast of the North Island for catching eels. For the non-migratory eels they use baited pots or baskets (hinaki) of varying shape and size, often 5 ft. to 6 ft. long (see fig. 2). A very interesting feature is the pa-tuna, as the Natives call their eel-weirs. These are —

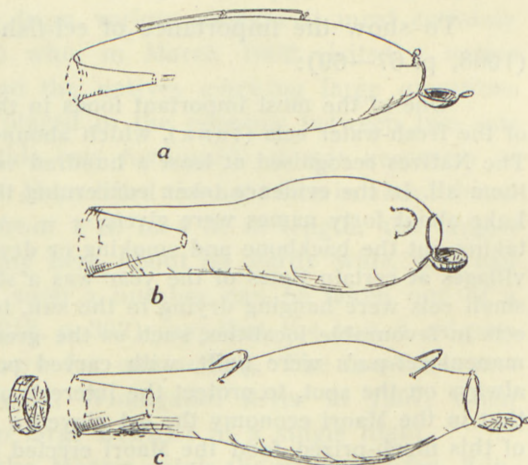


Fig. 2. Types of hinaki (trap-baskets, used with eel-weirs).

From DOWNES (1918).

or were at any rate formerly — very strong and elaborate, but are now gradually disappearing. In small streams, *e. g.* 30—40 ft. wide, they use the V-shaped form of pa-tuna shown in fig. 3. The fences, which are constructed of rows of stakes, are abt. 30 ft. long. In large rivers, they use the pa-tuna shown in fig. 4 consisting of two parallel fences with cross-returns of a single post facing each other at the foot to hold the trap, the latter consisting of the poha or guiding net and the hinaki or trap-basket (see figs. 2 and 5). The weir is as a rule from 50 ft.

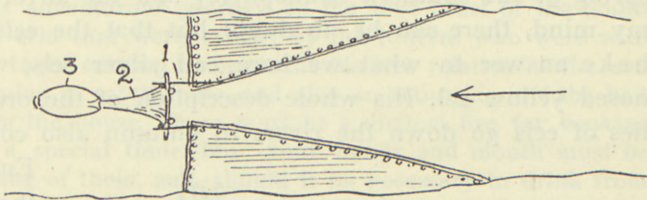


Fig. 3. Pa-tuna (eel-weir) of the V-shaped form used in small streams. 1, braces; 2, poha; 3, hinaki.

From DOWNES (1918).

to 60 ft. long and abt. 20 ft. wide, and it is of great importance that it should have the right direction. If parallel with the current, few fish are intercepted, and if at too great an angle, the eels escape through the fence. The double fence is only for the purpose of intercepting more fish. Further details as to the mode of use will be seen from fig. 5.

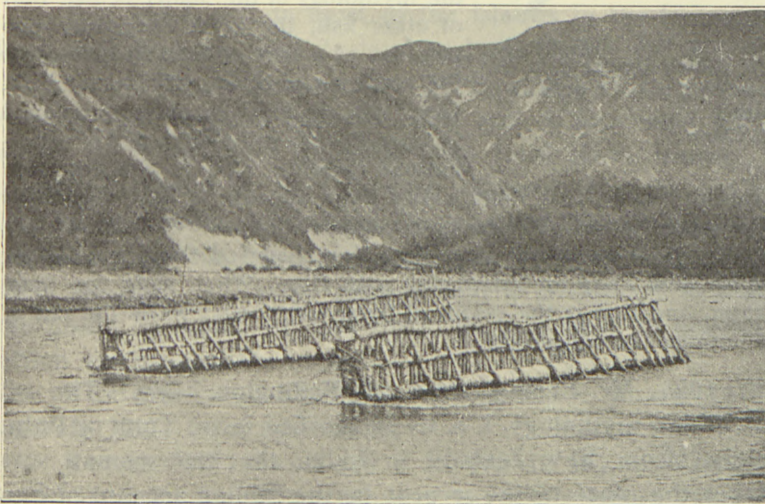


Fig. 4. Pa-tuna, or eel-weir, Whanganui River, New Zealand, looking down-stream.

From DOWNES (1918).

water: hooks, spears and baited pots for sedentary eels, and weirs for capturing the migratory eels. These weirs in particular are — or were — in structure, extent and position, sometimes in connection with artificial canals, calculated to arouse the admiration of any fisheries expert.

From the foregoing, it will be apparent, not only that the eel was of great importance to the original inhabitants of New Zealand, but also that their methods of capture had attained a high degree of technique. Actually, the Maoris were, on the arrival of the Europeans, using precisely the same implements which had been developed in Europe for the capture of eels in fresh

It is also most interesting to note, especially from the data carefully compiled by DOWNES (1918), that these eels of the Antipodes must be as regular in their habits of life as the eels of the northern hemisphere; the eels ascend in spring (the spring of the southern hemisphere) and the silver eels descend in autumn. For to my mind, there can be no doubt but that the eels described by DOWNES as tuna-heke answer to what we here call silver eels, while his tuna-toke is a broad-nosed yellow eel. His whole description of the order in which the different "varieties of eels go down the rivers in autumn also corresponds to what we know from

Europe: first the small silvery males, then the medium sizes, and lastly the large females.

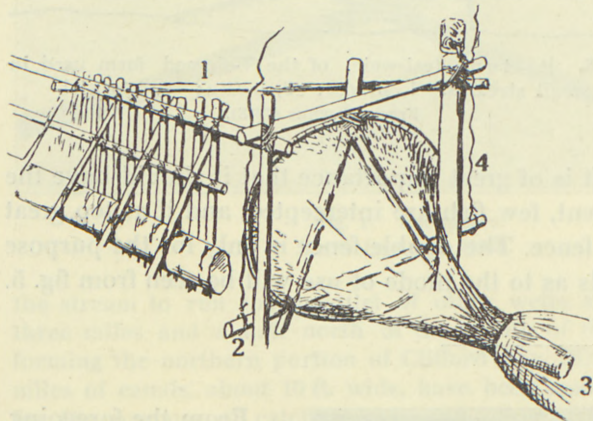


Fig. 5. Pa-tuna, or eel-weir, trap end, showing attachment. 1, angle brace; 2, sliding timber used to raise and lower the poha or guiding net; 3, hinaki or trap-basket.

From DOWNES (1918).

Finally, I must say a few words as to the important part played by fresh-water eels in the mythology of the Maori. I will first of all quote BEST 1903, p. 65:

"The origin of the eel, according to the mythology of the Maori, is, like that of other fish, the great Tangaroa, who presides as a sort of tutelary deity over the denizens of ocean, stream and lake. One Tuna, or Puhi, is often mentioned in legend as the eel-good, a sort of supernatural creature, who is credited with

the performance of some singular deeds. This Puhi, alias Tuna, appears to have flourished far back in the night of time, when heroes and demigods obtained." — — — "In White's "Ancient History of the Maori", vol. II, p. 69, we read that Maui married Hine, a daughter of Tuna and Repo, and that he slew Tuna for interfering with Hine. When slain the head of Tuna fled to the fresh water, and that is the origin of fresh-water eels; while the tail of Tuna fled to the ocean and became the conger-eel".

In a letter dated 14/4 1925, Mr. ELSDON BEST of Wellington says: "The eel appears in Maori and Polynesian mythology, i. e. its personified form, Tuna or Puhi. The phallic eel is prominent from New Zealand to India, the first woman was seduced by Tuna, who takes the place of the serpent in the Biblical account of Eve and the serpent (cf. BEST: "Maori Personifications", in *Journal of the Polynesian Society*, vol. XXXII, No. 2 and 3, and further, BEST: "The Maori", 2 vols., sold by H. Tombs Ltd., Wellington)."

HAMILTON (1908, p. 69) relates of the huge, eel-like monster, the tuna tuoro as follows:

"The tuna tuoro was greatly dreaded by those who waded in the shallow Waikato swamps for eels, for it glided up without being noticed, and if it touched them ever so

slightly they were instantly paralysed and destroyed. It would even pursue its prey over the dry ground, and its progress could only be checked by setting fire to the grass and fern, when the ash adhering to its slimy body rendered it helpless, and incapable of moving any further."

"Brunner, in the course of his adventurous journey on the west coast of the South Island in 1847, relied largely on the eels that were caught by the Natives who were with him. He says, "There is a particular tapu existing amongst the Natives relative to the eel. You must wash your hands before going to catch them, and also on returning, and the bait must be prepared some distance from the house. There must be a distinct fire for cooking the eels, for which you must have a special tinder-box; your hands and mouth must be washed both before and after partaking of them, and, should it be necessary to drink from the same stream from which the eels are caught, you must have two vessels of water — the one to drink from, the other to dip from the stream. Whether this relates to particular places or not I am not able to say, but I found it strictly adhered to at Hokitika and Okarito. At the former place I had to walk half a mile for water, with a stream running within a few yards of our station.'" (HAMILTON, 1908, p. 69).

It is interesting to note that the name "tuna" is the same as used for the eel in Samoa and certain parts of the Philippines (see p. 355 and 343); cf. also the name "tona" used in Madagascar (see Part I, p. 26).

Islands round New Zealand.

Eels are found on most of the islands in the temperate zone round New Zealand, and between New Zealand and Australia.

Lord Howe Island (31° 30' S., 159° 7' E.). — WAITE (1903—1905, p. 189) records both *Anguilla australis* Rich. and *A. Reinhardti* Steind. of which the former seems to be the more common, from Lord Howe Island. That eels occur in great quantity is shown by the following statement from the Australian zoologist, Mr. A. R. McCULLOCH (letter dated Lord Howe Island 25th September 1924): "*Anguilla* occurs plentifully on this island, ascending a watercourse between the hills in an incredible manner . . . I must confess that it is difficult to understand how they reach the places in which we find them, as they have to negotiate smooth basaltic faces which are impassable to us."

Norfolk Island (29° 4' S., 167° 58' E.). — WAITE (1910 p. 381) records *Anguilla australis* Rich. from this island.

Kermadec Island (30° 3' S., 178° 40' W.). — WAITE (1910) does not give any *Anguilla* in his list of the fishes of Kermadec Island. There is, however, little reason to doubt that they are found here, and the writer observes (p. 371) that "our knowledge of the fishes of Norfolk Island and the Kermadec group rests upon meagre records . . ."

Chatham Island (44° 0' S., 176° 35' W.). — I have seen specimens of *Anguilla australis* Rich. and *A. aucklandi* Rich. from this island (Mus. Bremen!).

Auckland Island (50° 45' S., 166° 12' E.). — RICHARDSON (1844—48) has both *Anguilla Aucklandi* Rich. and *A. australis* Rich. from Auckland Island. This locality

is of interest as being the most southerly point in the world where fresh-water eels of the genus *Anguilla* have been found.

D. Tropical Oceanic Islands.

The most important works as regards geography, are GÜNTHER (1910), SEALE (1906) and JORDAN & SEALE (1906).

1. North of the Equator.

Pelew Islands.

GÜNTHER (1910, p. 389) records *A. mauritiana* from these islands, which are situate east of the Philippines. The specimen in the British Museum is not a typical *mauritiana*, but belongs to a closely related form.

Marianne Islands.

PELLEGRIN (1898, p. 228) has *A. mauritiana* from Saypan. Several specimens in the Mus. Paris, including one from Guam, belong to the same form as mentioned under Pelew Islands. HERRE (1923, p. 139) has *A. australis* Rich. from Guam.

Caroline Islands.

I have seen specimens of the same form as mentioned under Pelew Islands in several Museums (Paris, Hamburg, Brit. Mus.) originating especially from Ponapé, but also from Kusaie (Oualan). GÜNTHER (1910, p. 390) gives *A. manillensis* Bleek. from Ponapé, and KENDALL & GOLDSBOROUGH (1911, p. 244) *A. mauritiana* Bennett from Kusaie.

Marshall Islands.

GÜNTHER (1910, p. 389) has *A. mauritiana* Bennett from Bonham or Jaluit Island (6° 5' N., 169° 50' E.).

Gilbert Islands.

I know no records of *Anguilla* having been found here (WAITE 1903, p. 2-3).

Central Polynesian Sporades (Fanning Is. etc.).

I know no records of occurrence of *Anguilla* from here (STREETS 1878).

Sandwich Islands.

Among the Islands of the Pacific there are none whose fish fauna is better known than that of the Sandwich Islands (Hawaii). JORDAN & EVERMANN (1905) note in their great work no fewer than 439 species, but *Anguilla* is not among them. On p. 527, the paucity or lack of fresh-water fishes is referred to, and the writers state "The only native fishes in the streams are species of gobies . . ." It is also stated that various kinds of fresh-water fish have been introduced, but eels are not mentioned among these.

The absence of eels from the Sandwich Islands is a very remarkable fact, which I hope to have occasion to refer to again later.

2. South of the Equator.

New Hebrides.

GÜNTHER (1910, p. 391) has *A. aneitensis* Gthr. from Aneiteum.

New Caledonia.

WEBER & BEAUFORT (1915) who dealt with the collections of SARASIN & ROUX, give the following 4 species: *A. australis* Rich., *A. mauritiana* Bennett, *A. Reinhardti* Steind., *A. celebesensis* Kaup. I have had an opportunity of examining this collection, and find that the only specimen determined as *A. celebesensis* should, from the number of vertebræ, be referred to *A. megastoma* Kaup., or *A. aneitensis* Gthr. The specimens of *A. australis* I refer to *A. obscura* Gthr. with the exception of one, which seems more closely related to *A. bicolor* Mc Cl., from which it differs in certain respects.

Fiji Islands.

GÜNTHER (1910) has from Kandavu, Viti-Levu, Levuka and Nairai, *A. fidjiensis* Gthr., of which he states (p. 390): "kommt der *A. mauritiana* sehr nahe." I see no reason to maintain the species *fidjiensis*. He also records (p. 392) *A. obscura* Gthr. from Kanathea.

BOULENGER (1897, p. 371—74) has from Rotuma, a little island 260 miles N. by W. of Fiji, a list of 108 species, mostly marine, collected by J. Stanley Gardiner. In this collection, of which the collector observes: "I think that the collection of these fish is a fairly complete one", *Anguilla* is not found.

Ellice Islands.

I know no records of the occurrence of *Anguilla* from here (WAITE, 1897, 1899). The same applies to the Phoenix Islands.

Tokelau Islands.

There is a specimen (No. 263) of *Anguilla obscura* Gthr. (labelled *Anguilla australis*) from Duke of York Island in the Australian Museum, Sydney, N. S. Wales!

Samoa Islands.

There are many reports from here of the occurrence of *Anguilla* ("tuna") and I have myself seen several specimens from these islands. It will here suffice to quote JORDAN & SEALE'S work (1906) "The Fishes of Samoa" in which the following 4 species are noted: *Anguilla mauritiana* Bennett, *A. megastoma* Kaup., *A. sidat* Bleeker, and *A. australis* Rich.

A. mauritiana is stated by these writers (p. 192) to be "the commonest eel of

Samoa Islands, abounding in quiet waters in all the streams, and reaching considerable size. We have about 20 specimens, mostly from Vaisigano River. « "The body is always finely mottled or marbled, hence the vernacular name of "*tuna tafa'i-lautalo*" or "eel colored like (boiled) taro." Life colors of one specimen from Apia, dark brown, everywhere reticulate with darker. Another was mottled olive and black; dorsal and anal edged with pale."

Of *A. megastoma* Kaup (called "*tuna mea*" by the natives) these writers state, p. 192, that they have two specimens from the Vaisigano river at Apia. "Life color of a specimen from Apia, yellow brown, belly and dorsal yellow; fine yellow dots on lateral line. Much paler and more yellow than *Anguilla australis*."

Of *A. sidat* Bleeker, it is said: "Life color of a specimen from Apia, plain dark brown, yellow below, dorsal grayish dusky."

GÜNTHER (1910, p. 392) gives *A. virescens* Peters from Savaii, and specimens are found under this name in several museums, originating from the Museum Godeffroy at Hamburg. They are shortfinned eels, not, however, identical with the African *A. virescens* Peters. The majority of those I have seen belong to *A. obscura* Gthr.

Tonga Islands.

GÜNTHER (1910) gives from here *A. aneitensis* Gthr. p. 391) from Vavao, and *A. sidat* Bleek. p. 392). Both specimens (Brit. Mus.!) belong to *A. obscura* Gthr.

Cook Islands.

I have seen a specimen of *A. obscura* Gthr. from Raratonga (Bishop Museum, Honolulu!) collected by A. SEALE and given by him as *A. megastoma* Kaup (SEALE 1906).

GILL who for 22 years acted as a missionary in this group, relates of a local myth according to which the cocoa-nut tree originated with the eel (tuna); from the spot where the head of an enormous eel (the personification of the eel-god, Tuna) was buried, sprang the first cocoa-nut tree and in proof of its being derived from the head of Tuna, when husked, on each nut is invariably found the two eyes and the mouth of Tuna (GILL 1876, p. 77—79).

GILL mentions to have witnessed the capture of an enormous fresh-water eel, measuring *seven* feet in length which "furnished several families with a good supper" (l. c., p. 80).

Manihiki Islands.

I know of no records from here.

Society Islands.

The occurrence of eels in Tahiti is noted as far back as 1835 by CHARLES DARWIN, who, on his voyage round the world with the "Beagle" visited this island in October of that year. He states that eels occurred in the mountain streams up in the highlands on the northern side of the island, whither he went on one of his excursions.

Judging from the specimens found in various museums, eels must be common in these islands. GÜNTHER (1910) has the two mottled species *A. mauritiana* Bennett and *A. otaheitensis* Kaup (from Raiatea), the uniformly coloured *A. aneitensis* Gthr. and the short-finned *A. virescens* Peters (see my remarks on this last under Samoa). Most of the specimens in the collections are from the main island, Tahiti.

As to myths in connection with *Anguilla* see GILL 1876, p. 80—81.

Tubuai or Austral Islands.

SEALE (1906) has *A. megastoma* Kaup from Tubuai island.

I have seen two of his specimens (Bishop Museum, Honolulu!); they belong to *A. obscura* Gthr.

Rapa Island. (27° 36' S., 144° 20' W.).

According to a letter dated ²¹/₁₀ 1925 from Mr. P. H. JOHNSON of the British "St. George" expedition 1924—1925: "fresh-water eels are very common on Rapa Island whilst I could find no news of them on Easter Island which in fact has no permanent streams."

The specimens collected by the "St. George" expedition which were sent me for identification by the British Museum belonged to *Anguilla obscura* Gth.

Marquesas.

SEALE (1906) has *A. megastoma* Kaup from Nukahiva.

Tuamotu Islands.

Nothing is known as to the northern islands of this group, but as they lie between the Society Islands and the Marquesas, in both of which eels are found it is to be presumed that they will also be found here. KAUP (1856 p. 50) has described his species *A. megastoma* from a specimen brought home by the French "Zelée" expedition from "Megarava", probably a corruption of Mangareva, an island in the south-eastern portion of the group (23° 10' S., 134° 55' W.).

Easter Island.

KENDALL & RADCLIFFE (1912) and REGAN (1913) mention the fish fauna of this island. *Anguilla* is not among the species collected there (see further under Rapa Island).

The result of our investigation of the tropical islands in the Pacific may be summed up as follows:

Anguilla is found throughout the whole of the western portion of the Pacific, but is lacking in the eastern parts.

North of the Equator, the eastern limit lies, as far as is known, at the Marshall Islands (Bonham or Jaluit Island, $6^{\circ} 5' N$, $169^{\circ} 50' E$, is the most easterly find recorded) and it is certain that they are lacking in the Sandwich Islands.

South of the equator, the genus extends much farther to the eastward than is the case north of the line, the most easterly find recorded being $23^{\circ} 10' S$, $134^{\circ} 55' W$. (Mangareva).

IV. BOUNDARY REGION BETWEEN THE INDIAN AND PACIFIC OCEAN.

In the tropical zone, the deep basins of the Indian and Pacific Oceans are separated by a large, shallow region between Farther India, the Malay Archipelago and North Australia with New Guinea (pl. II). In this shallow region, the largest in the world, the depth does not exceed 100 m. It does not, however, form a united whole, but consists really of two parts, an Indo-Malayan and an Australian, separated by a system of deeper straits and small but deep basins, round Celebes, the Moluccas and the eastern Sunda Islands. Owing to the narrowness of parts of these connecting channels, however, and the comparatively slight depth at some places (1000—2000 metres) no complete interchange of the water masses is possible, and we may therefore say that the tropical region between Farther India and Australia forms a boundary between the ocean depths of the Indian Ocean and the Pacific.

We shall now proceed to consider the occurrence of fresh-water eels in this boundary region between the Indian and Pacific Oceans. The most important work in this connection is that of WEBER & BEAUFORT (1916) with its wealth of localities where the different species of *Anguilla* have been found.

We may commence with the continent of Asia.

Malay Peninsula.

Neither on the western nor on the eastern side have *Anguilla* been found, though the fish fauna both at Singapore and elsewhere is extremely well known from many large collections (BLEEKER, 1851—1877, see WEBER & BEAUFORT 1911, SAUVAGE 1884; DUNCKER 1904. etc.).

Farther India.

Round the Gulf of Siam, *Anguilla* is not known (BLEEKER 1860—1864, 1865 etc. see SAUVAGE 1881), nor in French Indochina (Cambodia, Cochin China, Annam and Tongking, SAUVAGE 1880, 1881, 1884; VAILLANT 1884; PELLEGRIN 1905; 1907). In answer to an enquiry, Dr. J. PELLEGRIN, of the Muséum d'Histoire Naturelle, Paris, informs me in a letter dated ¹⁹/₅ 1924, as follows:

“J'ai fait quelques recherches au sujet de la capture de Poissons du genre *Anguilla* en Indo-Chine. Je n'ai rien trouvé jusqu'ici. Il n'en est pas fait mention dans les nombreuses

publications de SAUVAGE sur les Poissons de cette région. Moi-même dans les collections de Poissons indo-chinois que j'ai étudiées, je n'ai pas rencontré jusqu'ici d'anguilles."

Not until we reach Hongkong do we again meet with *Anguilla* though, as mentioned p. 340 it is to be presumed that it really exists farther west along the south coast of China.¹

The Philippines have been mentioned already (p. 342—43). *Anguilla* seems to be found nearly everywhere here.

Dutch East Indies.

WEBER & BEAUFORT (1916) repeat all reliable records of the occurrence of *Anguilla*, including BLEEKER'S. I take the liberty of giving WEBER & BEAUFORT'S lists in full here, adding at the same time that after investigation of various numerical characters, in extensive material, I have found it necessary to subdivide the species more than the two Dutch writers do. For instance, I found that the short-finned *Anguilla australis* WEBER & BEAUFORT, which is so extremely common e. g. in Java, does not belong to the same species as the Pacific *Anguilla australis* Rich. I cannot go further into this question here, but quote by way of example the no. of vertebræ in a couple of small samples of "*A. australis*" from Java and Victoria, Australia, merely to indicate the difference in regard to a single numerical character. The counts were made by Mr. VILH. EGE, mag. sc.

No. of vertebræ in "*A. australis*" (Java, Australia).

No. of vertebræ	Java (Tangerang)	Australia (Warrnambool, Victoria)
	<i>Ang. bicolor</i> M.Cl. No. of specimens	<i>Ang. australis</i> Rich. No. of specimens
115		1
114		6
113		10
112	5	12
111	19	5
110	22	1
109	17	
108	14	
107	3	
106	1	
Average	109.64	112.51

The sample from Java was sent me by Dr. HJALMAR JENSEN, formerly resident there, and the one from Victoria (Warrnambool) by Mr. J. A. KERSHAW, of the National Museum, Melbourne.

I next give the localities noted by WEBER & BEAUFORT (1916) for fresh-water eels in the Dutch East Indies:

¹ See footnote p. 340 where it is mentioned that the American Museum of Natural History, New York, has a specimen of *Anguilla japonica* from Hainan.

1. *Anguilla elphinstonei* Sykes.
Habitat: Sumatra (Serdang!) Java!, Celebes (Menado!).
2. *Anguilla mauritiana* Bennett.
Nom. indig.: Mowa (Malay. Batavia); Lubang (Sundan.); Ikan denong (Laut Tawar).
Habitat: Sumatra (Laut Tawar! Atjeh); Lake of Manindjau! (Padang); Simalur!; Nias! Java (Batavia, Buitenzorg, Tjibulus, Perdana, Tjibiliong, Kowawang, Tjitjurup, Tjitarik, Kuningan, Djember!); Borneo; Bali; Lombok; Sumbawa; Flores!; Timor up to 700 and 900 M.; Wetter; Babber!; Celebes (Makassar, lake of Tempe!; Dongala!, Lake of Posso!, Menado, Tondano, Klabat di Atas); Saleyer!; Togian Islands; Buru!; Ambon!; Ceram!; Nusa Laut!; Batjan; Ternate; Halmahera; Rawak; New Guinea (rivers Mamâpiri!, Kli-pong!, Tawarin!, near Humboldt Bay!).
3. *Anguilla celebesensis* Kp.
Nom. indig.: Mengaling (Bo); Roar (Isl. Roon).
Habitat: Simalur!; Nias!; Borneo (river Bo); Celebes; Ambon; Buru; Ceram; Salibabu; Nusa Laut!; Timor!; Kei-Islands!; Island Roon in Geelvink Bay!; New Guinea! (Brit. Mus.).
4. *Anguilla malgumora* Kaup.
Habitat: Borneo (the single known specimen in the Paris Museum).
5. *Anguilla spengeli* M. Web.
Habitat: Simalur!; Nias!, Java (Batavia, Tjikandi); Borneo (Balik Papan!).
6. *Anguilla australis* Rich.
Nom. indig.: Mowa (Malay. Batavia); Sidat (Javan.); Olling (Sundanese name for young specimens), Lara (Sundanese for fullgrown specimens), Sawali Luntjah (Simalur).
Habitat: Pulu Weh (Sabang!); Sumatra (Siboga, Padang, Priaman, Benkulen, Batu Sangkar, Deli!, Sungi Mahe (Upper Langkat); Kota radja (Oleleh, Atjeh!); Simalur!; Nias!; Java (Batavia, Tjampea, Buitenzorg!, Bekasi!, Tjikandi, Bantam, Pendana, Tjibiliong, Leles, Banjumas, Ambarawa, Palabuan Batu, Dirk de Vries Bay); Bali; Lombok!; Sumbawa; Flores!; Timor!; Aru Islands!; Borneo; Celebes (North Celebes, Menado, South eastern Celebes); Batjan!; Halmahera; South New Guinea (Lorentz river!)”

As a basis for discussion of the occurrence of *Anguilla* in the Dutch Archipelago I will take the interesting work by WEBER (1894): “Die Süßwasser Fische des Indischen Archipels etc.” On p. 457 of this work, the writer gives in tabular form the distribution of the various fresh-water fishes among the different islands. I reproduce here the part dealing with *Anguilla*, supplementing the data with what has been added since the publication of WEBER’s work in 1894.

Occurrence (+) or non-occurrence (÷) of *Anguilla* in the Malay Archipelago,
after WEBER (1894).

Singapore .. ÷	Java	Rotti ³	Ceram
Borneo +	Madura ÷	Timor	Ambon
Banka	Bali	Celebes +	Ternate +
Billiton ÷	Sumbawa ¹ .. +	Saleyer +	Halmahera. +
Sumatra ... +	Flores	Batjan	
Nias	Sumba ² +	Buru	

¹ Specimen of *Ang. mauritiana* (WEBER & BEAUFORT, 1916, p. 247).

² Specimen of *Ang. mauritiana* from Pajeti, Sumba, (Mus. Amsterdam!).

³ Specimens of “*Ang. bengalensis*” (REUVENS 1894) = *Anguilla mauritiana* and *A. celebesensis* (Mus. Leiden!).

As will be seen, *Anguilla* was found on most of the islands viz. 18 out of 22. The places where it is lacking are: Singapore, Banka, Billiton and Madura.

In the case of the smaller islands, these records of locality are sufficient, but in the larger ones, it will be necessary to examine the occurrence a little more closely. The large islands are Celebes, Borneo, Sumatra and Java.

Celebes.

Anguilla is found in all parts of the island: east, west, nord and south (WEBER & BEAUFORT 1916, BOULENGER 1897). *A. mauritiana* Bennett in particular seems to be common. WEBER (1913, p. 201—202) gives some interesting information as to its occurrence in Lake Posso, which has an outflow into Tomini Bay, the ascent of which must be extremely difficult owing to the steep course of the river and the presence of waterfalls. The species is here known as "masapi" (large specimens) and "pantawa" (the small ones). A specimen examined by WEBER was 1620 mm. long and with a girth of 430 mm.

Borneo.

Only two precisely localised finds are on record, both in streams flowing out on to the east coast, viz. Balik Papan (*A. spengeli* WEBER & BEAUFORT 1916, p. 249) and the Bo river (a tributary of the Mahakam, *A. borneensis* Popta, POPTA 1924; called there "mengaling"). The very considerable collections of fresh-water fish from the great rivers flowing out on to the west and south coasts do not include *Anguilla* (letter of ²⁶/₃ 1924 from Miss Dr. C. POPTA, Leyden, who has specially studied the fresh water fishes of Borneo; nor does VAILLANT, 1893, 1902—04, include *Anguilla* among the many species recorded in the lists).

Sumatra.

On looking at the finds for Sumatra (WEBER & BEAUFORT 1916) as a whole, we notice that they lie on the west coast and the northern part of the east coast (the latter being Serdang, near Medan; Deli; Soengi Mahe in the upper Langkat). In the great eastern lowlands, from which there are extensive collections, e. g. those dealt with by WEBER & BEAUFORT (1912), *Anguilla* does not appear to have been found.

Java.

To the finds recorded by WEBER & BEAUFORT 1916 I can add Tjilatjap on the south coast (Mus. Vienna!), Bedadoeng near Djember (P. BOVIEN); Kalipasar in Bengalen on the middle part of the south coast, Tangerang west of Batavia, and Palaboean on the western part of the south coast, (according to large collections which I have received from Dr. HJALMAR JENSEN, residing at Buitenzorg and later at Klaten, Java; the collection from Kalipasar consisted of abt. 500 specimens). BLEEKER (1853) has for his *Ang. elphinstonei*: Tjidani (prov. Batavia), Tjitarum (prov. Krawang), Tjamanok (prov. Preanger).

Altogether, I have been able to localise abt. 25 records of occurrence of *Anguilla*

in Java. The majority are from the south coast, the western part of the west coast and the north coast (west of 108° E.). There are, however, also some farther east along the north coast, as for instance Kuningan at abt. $108^{\circ} 30'$ E., and Ambarawa (between Semarang and Magelang). I would point out that in this connection it is of course not the position of the find which is of interest, but the point of the coast at which the river the eel must have ascended flows out into the sea. As a matter of fact, it is often difficult to determine, from the maps at my disposal, what rivers drain the localities noted. Some of the places far up in the interior might, to judge from my map, equally well be drained to the north or south.¹

Summing up, then, the conditions as regards the larger islands are as follows:

Celebes: *Anguilla* is found on all the coasts; Borneo; found on the east coast, but not on the west and south coasts; Sumatra: found on the west coast, but not on the east coast except for its northern portion; Java: found on the south coast, west coast and western part of the north coast, but seems to be rarer in the middle and eastern parts of the north coast.

We have now succeeded in ascertaining in what parts of the archipelago *Anguilla* is found, and where it is lacking, both for the larger and smaller islands. In order to facilitate a general view, I would refer to the chart Pl. II, with the above-mentioned shallow region between the Indian and Pacific Oceans.

A glance at this chart shows that the eels are found everywhere in the vicinity of deep water (the eastern islands, coasts of the Indian Oceans. They are lacking, however, or at any rate rarer, on coasts facing the great shallow water region between Farther India-Sumatra-Borneo-Java.

As regards the other part of the shallow water region — that situate between Australia and New Guinea — the occurrence or non-occurrence of eels would seem to be explained in the same way; it must be borne in mind, however, that the data at our disposal here are far scantier than for the region between Farther India and the Dutch colonies (see p. 347).

We must indeed be careful altogether in asserting that a species of fish is rare or lacking in any of these distant tropical parts. And I therefore wished to

¹ From information communicated by Dr. HJALMAR JENSEN, formerly resident in Java, it would seem that care should be taken in drawing conclusions as to the actual site of finds of *Anguilla* in Java, as native eel merchants travel this way and that across the country selling live eels and "Gurami" (*Osphronemus goramy* Lac.) in all parts. The same would appear from BLEEKER's remarks on the habits of the eels in Java (1864 p. 8): "C'est cette espèce, bien connue des Sundanais sous le nom de Lubang (i. e. *Ang. mauritiana*), qui aime surtout les fleuves de l'intérieur et qui souvent se rend par terre et y fait des marches volontaires assez considérables pour se transporter d'un fleuve ou d'un marais dans un autre. C'est aussi cette espèce que bien des indigènes croient être un serpent, et qu'ils disent attaquer les petites chèvres et même les petits enfants." I take this opportunity of suggesting that zoologists resident in Java might interest themselves in the question as to the "density" of eels in the different parts of the island. A comparison between the middle portion of the north coast, for instance, and the corresponding section of the south, would be of considerable value.

subject the question to further test at one particular place within this "negative" area. I have chosen Singapore for the purpose, as it is one of the best investigated localities, and also because it lies more or less in the centre of the great shallow region.

BLEEKER has already, in numerous works from 1851 to 1877, dealt with the fish fauna of the southern end of the Malay Peninsula and adjacent islands (Singapore, Bintang etc.) (see WEBER & BEAUFORT 1911, p. 44) without recording *Anguilla* from here. As for instance BLEEKER (1861 a) Singapore: 540 species, and BLEEKER (1861 b) Penang: 290 species.

As early as 1906 I addressed an enquiry regarding the occurrence of eels to the Danish Consul at Singapore, Hr. S. GAD. In a letter of $\frac{3}{4}$ 1906 the Consul writes as follows: "During all the years I have been here, I have often seen the natives fishing, and have also frequently noticed the kinds of fish offered for sale in the fish markets, but have never seen an eel, and can definitely assert that eels are not fished for here."

DUNCKER (1904) in "Die Fische der malayischen Halbinsel" gives a very big list, of 480 species, among which *Anguilla* is not found. The collections were made between $1^{\circ} 15' N.$ and $6^{\circ} 5' N.$, and between $100^{\circ} 40' E.$ and $104^{\circ} 0' E.$

As the point is one of interest in this connection, I ventured to apply to Dr. DUNCKER for further information, which he very kindly furnished in letters of $\frac{18}{3}$ and $\frac{22}{4}$ 1924, as follows:

"Ich habe *Anguilla* weder auf Singapore noch auf der Malayischen Halbinsel erhalten, obwohl ich dort 1900—1902 fast 2 Jahre lang hauptsächlich Fische gesammelt habe. Auch Weber und de Beaufort führen diese Findorte für keine einzige ihrer *Anguilla* sp. an. Diese Lücke in der Verbreitung der Gattung ist recht auffällig. Ich bemerke noch, dass ich nicht nur an zahlreichen Punkten der Westküste der Malayischen Halbinsel sammelte, sondern auch der an der Ostküste mündenden Pahang- und den an der Südküste mündenden Johore-Fluss fast ihrer ganzen Länge nach bereist und befischt habe."

"An der Westküste der malayischen Halbinsel habe ich als Curator des Selangor State Museums in Kuala Lumpur über ein Jahr lang von Kuala Selangor (Norden) bis Bandar Maharani (Süden) an der Küste, ausserdem in mehrwöchentlichen Aufenthalten in Singapore hauptsächlich auf dem dortigen Fischmarkt gesammelt, mit der Absicht die Fischfauna jener Gegend möglichst vollständig zusammenbringen. An der Westküste wird die Fischerei von Malayan sehr eingehend betrieben. Der Fischmarkt meines damaligen Wohnorts Kuala Lumpur, wurde von dem Hafenplatz Kuala Klang (jetzt Port Swettenham) aus versorgt, und von mir bezw. von meinen Angestellten fast täglich besucht. Weder auf den Fischmärkten in Kuala Selangor, Kuala Klang, Kuala Lumpur, Port Dickson, Malacca, Bandar Maharani und Singapore noch auf meinen eigenen Sammelreisen in jener Gegend habe ich jemals auch nur ein einziges Exemplar von *Anguilla* gesehen und erhalten, im Gegensatz zu Ceylon und Neu-Guinea."

And finally, I enquired of the Director of the Raffles Museum at Singapore, Mr. C. BODEN KLOSS, whether any specimens of *Anguilla* were preserved there from local or adjacent sources. Mr. BODEN KLOSS replies, under date $\frac{9}{4}$ 1924, as follows: "I regret to say that there are no specimens of *Anguilla* in our collections. No

example of *Anguilla* was recorded from the Malay Peninsula by DUNCKER in 1904, and none seem to have been taken since."

From the foregoing, we can, I think, quite safely assume that *Anguilla* is lacking, or must at any rate be extremely rare, in Singapore, and altogether on either shore of the southern end of the Malay Peninsula.

This negative result then evidently answers to a certain reality, and it may be added that the likelihood of its being correct is strongly supported by the lack or rarity of *Anguilla* in the other parts of this shallow water region, where the southern extremity of the Malay Peninsula is, as it were, in the centre.

And I can further state, that Dr. TH. MORTENSEN, of the Zoological Museum at Copenhagen, who in 1899—1900 made extensive zoological collections in Siam from the inner part of the Siamese Gulf, informs me verbally that he found no *Anguilla* there. The same applies to Dr. HUGH M. SMITH's collections from the Gulf of Siam in 1924 (according to letters from Dr. HUGH M. SMITH of Bangkok, adviser to the Siamese Government on Fishery Questions).

In a letter dated ²²/₁ 1925 Dr. HUGH M. SMITH further says: "Continued search for *Anguilla* in the Gulf of Siam and its tributary rivers and in the markets of Siam, has given only negative results, and it is my opinion that if *Anguilla* occurs at all in these waters it is only as a rare stray."

I must then conclude that the large shallow boundary region between the two Oceans, the Indian and the Pacific, contains no eels, or at any rate very few as compared with the adjoining regions.

V. CONCLUDING REMARKS

A. Survey of Distribution.

We have now, in Parts I and II of this work, considered the occurrence of fresh-water eels throughout the whole of the globe. I will here briefly sum up the results.

Anguilla is found in all three oceans: the Atlantic, the Indian and the Pacific; in the Atlantic, however, only north of the equator, whereas in the other two, it occurs both north and south of the line.

1. Distribution from north to south.

The most northerly find of the genus *Anguilla* is abt. 70° N. (northern Norway); the most southerly, Auckland Island, south of New Zealand abt. 50° S. In the Pacific, the northern limit lies considerably farther south than in the Atlantic, viz. between 40° and 50° N. (as against abt. 70° N. in the Atlantic).

Save for a small range of coast from the northernmost part of Norway to Archangel (abt. 50° E.) on the east, and another insignificant occurrence in Greenland, fresh-water eels are lacking in the arctic and antarctic regions.

Most of the species, indeed, have their habitat in the tropics. Some species, however, are decidedly of a temperate habit, i. e. their main area of occurrence lies outside the tropics, and these include both northern temperate and southern temperate species (fig. 6).

The temperate species are as follows:

Temperate *Anguilla* species.

A. Northern Hemisphere:

1. Pacific: *Anguilla japonica* Schleg. (China, Japan).
2. Atlantic: *Anguilla vulgaris* (Europe, N. Africa, Asia minor),
Anguilla rostrata Les. (America).

B. Southern Hemisphere:

1. Pacific: *Anguilla Aucklandi* Rich. (New Zealand), *Anguilla australis* Rich. nec Boulenger, nec Weber & Beaufort (New Zealand, Australia and Tasmania). The latter species must probably be subdivided.
2. Atlantic: None.

The remaining species have, as mentioned, their main area of distribution in the tropics. The Indian Ocean has no markedly temperate species, but several tropical ones. Among these, however, *Anguilla mossambica* Peters also occurs in great numbers outside the tropics, viz. in South Africa.

Of the tropical species of the Pacific there are two whose occurrence also extends beyond the tropics, viz. in the northern hemisphere *Anguilla mauritiana* Bennett, and in the southern *Anguilla Reinhardti* Steindachner. The other tropical species of the Pacific have not been met with outside the tropics.

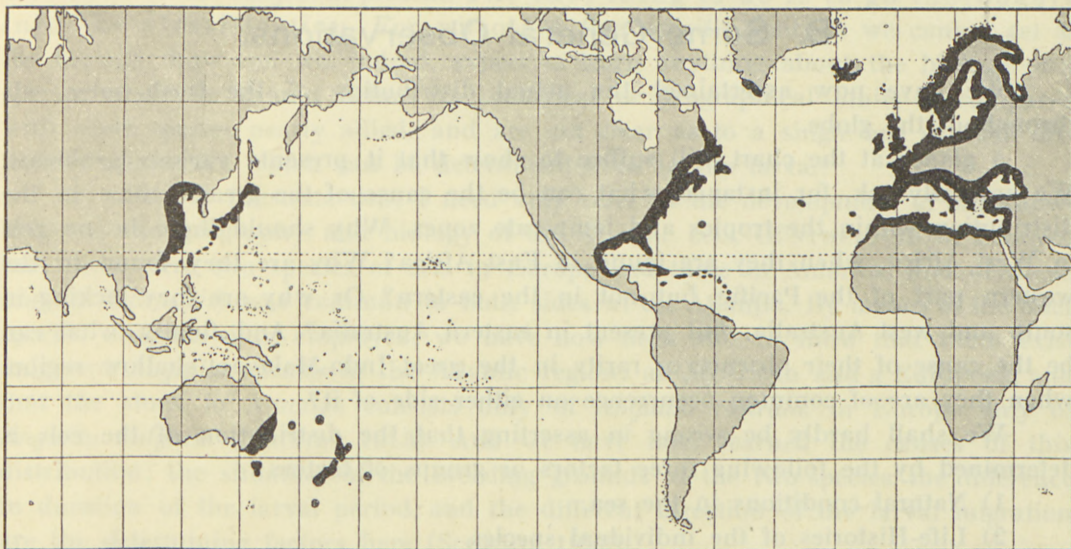


Fig. 6. Showing the distribution of the five temperate species of *Anguilla*.

2. Distribution from east to west.

Within the tropical and temperate zones where the eels are found, we notice some remarkable gaps in their distribution. They are lacking, for instance in West Africa and on the Atlantic coast of South America, on the whole west coast of America, in the Sandwich Islands and on the south coast and southern part of the west coast of Australia. And finally, we have just seen that eels are lacking or scarce in the shallow Indo-Malayan region (see charts Pl. I and II).

In the Atlantic, eels are found on both sides of the ocean, both on the North American and the European side.

In the Indian Ocean, they are also found on both sides; on the east coast of Africa and on the western side of the Malay Archipelago, as also in north-western Australia. They are apparently lacking only in the north-western corner of the Indian Ocean (including probably the Red Sea) and in the greater part of western and southern Australia.

In the Pacific, they are found everywhere throughout the western part, but are lacking in the eastern part. North of the equator, the eastern limit lies at the Marshall Islands, the most easterly find being Bonham or Jaluit Island, at 169°50' E., 6°5' N. South of the equator, they extend considerably farther east, viz. to the Tuamotu Islands, where the easternmost find is Mangareva, at 134°55' W., 23°10' S.

B. Some General Observations.

We have now ascertained the actual distribution of the fresh-water eels throughout the globe.

A glance at the chart will suffice to show that it presents various problems. We naturally ask, for instance, what can be the cause of the great lacunæ in the distribution within the tropics and temperate zones. Why should there be no eels in West Africa, when they are found in East Africa? Why are they found in the western part of the Pacific, but not in the eastern? Or why are they lacking in south and west Australia, but present in eastern Australia? And finally, what can be the cause of their absence or rarity in the great Indo-Malayan shallow region, when they are of common occurrence on either side of it?

We shall hardly be wrong in asserting that the distribution of the eels is determined by the following three factors or groups of factors:

- 1) Natural conditions in the sea.
- 2) Life-Histories of the individual species.
- 3) Historical factors.

We are still insufficiently informed as to these factors.

As regards the natural conditions of the oceans, we know, it is true, some of them in rough outline, as for instance, the depth, temperature and salinity of the water. In regard to the other factors, our knowledge is evidently not sufficient for a thorough understanding of the subject.

In regard to history, we can with a certain degree of probability reckon that the genus *Anguilla* must have its origin somewhere in the equatorial Pacific. For all the species seem to be grouped about this region as their centre. Various other features also, which I am unable to discuss until I have had an opportunity of describing our work on the classification of the Indo-Pacific species, seem to point in the same direction.

And finally, as regards the biological conditions, we are here absolutely in the dark, as no investigations have yet been made outside the Atlantic. We have therefore hardly anything to go upon in considering the great Indo-Pacific region with its numerous species of *Anguilla*. True, we know now — since the finding and identification of the larva of *Anguilla mauritiana* (SCHMIDT 1925) that the Indo-

Pacific eels breed in the sea, that the larvæ undergo a metamorphosis, and that the elvers from the sea move up into fresh water. In this respect, they resemble the two Atlantic species. But we also know that it is quite impossible to draw conclusions as to the biology of one species from that of another, and that we have therefore to study the life-history of each species separately; modern biology affords sufficient instances of this.

We cannot therefore treat the Indo-Pacific eels as one, when considering the causes of their distribution, and we have thus no adequate basis for a thorough discussion of the subject at present. The first thing to do is to go thoroughly into the classification. For without a fine specific analysis we cannot get at the biology; how can we, indeed, expect to learn anything about the biology of a species when we cannot define its zoological or geographical limits as compared with other species nearly allied, and are not clear as to a single one of such distinctive characters which can be determined even in the larvæ?

In order to illustrate this, I need only refer to the development of our knowledge of the geography and biology of the Atlantic eels. GÜNTHER (1870) believed that there were two species of eels in Europe and three in America, and of these, one (*A. latirostris*) was common to both sides of the Atlantic. By means of the finer specific analysis since employed, we have now been able to show that there exist only two *Anguilla* species in the Atlantic region: an American and a European, and that the stock in America consists only of *Anguilla rostrata*, in Europe only of *Anguilla vulgaris* (SCHMIDT 1913). And we have later learned the causes of this distribution; the situation of the breeding grounds of the two species, the difference in duration of the larval period, and the different direction of the larval migration are the determining factors here (SCHMIDT 1922).

So also in the Indo-Pacific region, there is doubtless no other way than that we had to follow in the Atlantic, viz. sound classification of the species by finer specific analysis, and subsequent study of the biology of the different species separately. This, however, means first of all procuring not hundreds but thousands of specimens, and statistical examination of them all. Thanks to the willing assistance I have met with on almost every side when applying for material, a considerable part of the groundwork of this classification has already been done, and several species, both in the Indian and Pacific Oceans, have already been defined, both zoologically and geographically, while a preliminary survey has also been arrived at through the study of museum specimens, including nearly all the extant type specimens.

It is out of the question here to give any account of this work of classification, as it would demand too much detail, and I must therefore refrain from any general discussion of the reasons for the geographical distribution of the eels.

I will, however, here point out that our work on the classification and geography of the Indo-Pacific eels has already brought to light various features suggesting the existence in this region of a greater number of different biological types than in

the Atlantic, some of them more primitive, or we might also say, less specialised, than those which we have met with among the Atlantic eels. The latter seems to apply more particularly to the tropical forms.

The Atlantic region is poor in number of species; the Indo-Pacific is rich. In the Atlantic, there are only 2, whereas in the Indo-Pacific, as I can already discern, there are at least 16 species. Another point should also be mentioned here. We have in the whole of the continent of Europe only a single species of *Anguilla* — and the same is the case with America. In the Indo-Pacific region, on the other hand, the rule is that two or more species occur together. Several of the South Sea Islands, despite their inconsiderable size, are quite remarkably rich in species. Take for instance Tahiti, a mountainous island almost devoid of lowlands, the whole area of which is only twice that of the Isle of Man. On this little rock in the ocean — it is over 7000 ft. high — there are, as we have been able to ascertain, no fewer than 4 or 5 different species of fresh-water eels. This is indeed a contrast to what we have been used to in the Atlantic, with its enormous pure stocks, i. e. consisting of but a single species. There can hardly be any doubt that the cause of this contrast lies primarily in historical conditions; we are here apparently nearer to the spot where the genus *Anguilla* originated, but we have also, in all probability, other biological types to deal with here than in the Atlantic.

As regards the breeding grounds of the Indo-Pacific *Anguilla* species, everything seems to suggest that these eels, like those of the Atlantic, do not breed in places where the sea is shallow. This is already indicated by the finding of the *Anguilla mauriliana* larva at Celebes above great depths (SCHMIDT 1925). Other features also point in the same direction, one of which I will mention here, as it is illustrated by facts which have been dealt with at some length in the present work. I refer to the absence or scarcity of eels in the Indo-Malayan shallow region.

From the fact that eels are not found, or are at any rate extremely rare, in this region, we can, in my opinion, draw various biological conclusions of interest.

Firstly, that the Indo-Malayan fresh-water eels must, like those of the Atlantic, breed in deep water. For if they bred in shallow water, as I have found that some other murænoids (*Muraena*, *Ophichthys*) do (SCHMIDT 1912), they would undoubtedly be common throughout the greater part of this shallow region. As shown at length in the preceding section, however, this is not the case. They are lacking here, or at any rate scarce, despite the fact that they are common enough immediately to the west and immediately to the east of the shallow region (cf. chart Pl. II).

We have here a biological similarity between the Indo-Malayan and the Atlantic fresh-water eels. Another conclusion to be drawn from our observations however, shows that biological differences are also discernible.

To illustrate this, we will compare the Indo-Malayan shallow region with another of the great shallow regions of the globe which has the advantage of being particularly well known. In the Indo-Malayan region eels are few or none — the North Sea region on the other hand, abounds with eels throughout its whole extent.

What can be the reason of this remarkable difference? Evidently, it must be that the eel fry immigrating from the depths of the ocean are, in the case of the Indo-Malayan species, inferior in migratory power to those of the Atlantic species.

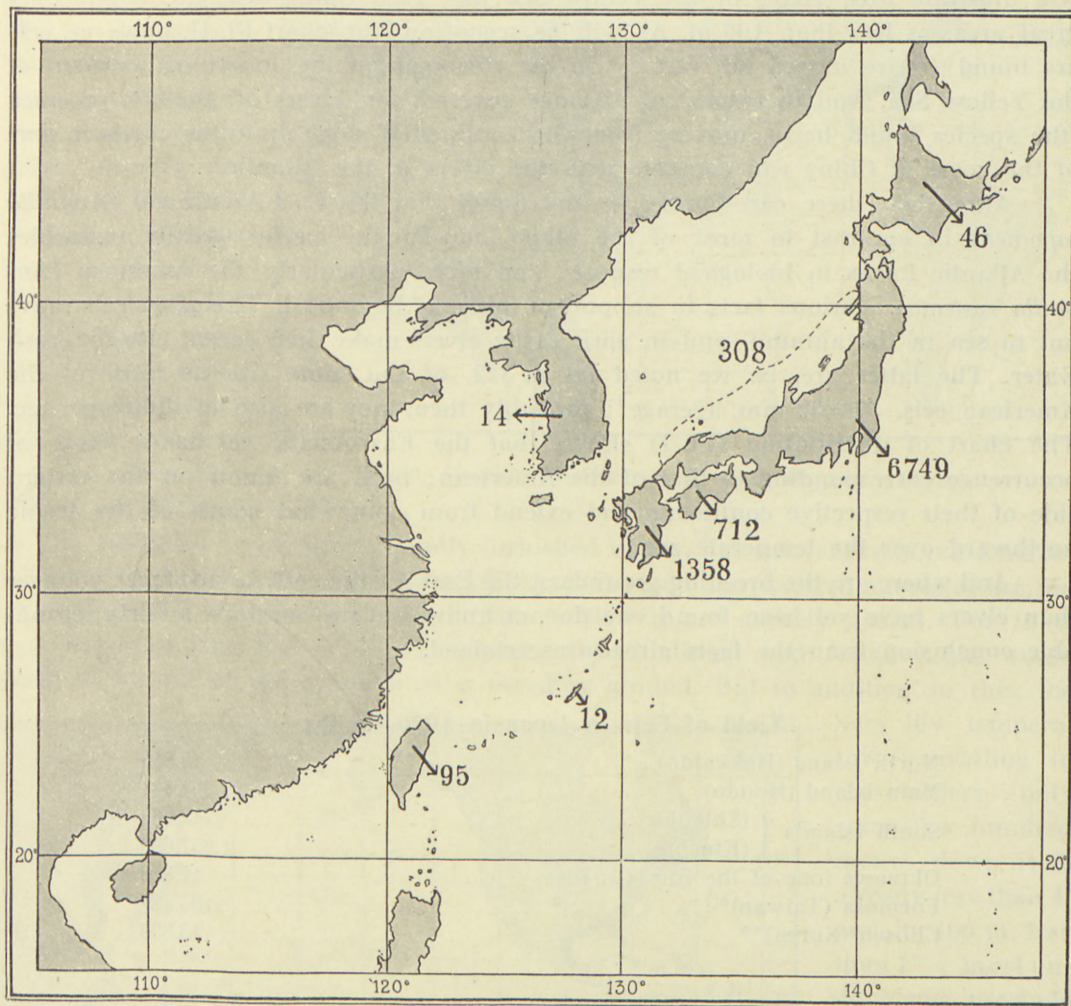


Fig. 7. Yield of Eels in Japan, in 1920, in 1000 lbs.

For if these elvers were able to migrate through shallow water to the same extent as those of the North Sea region, then eels would have been common over great parts of the Indo-Malayan shallow region¹; and also, in the shallow region of North Australia.

¹ Not until the elver stage is reached do eels migrate through shallow sea areas; never in the larval stage. When the latter, coming in from the ocean depths, arrive on the coastal banks (the 200 m. line) they stop there, and do not continue their journey through the shallow water until later, when they have turned into elvers.

It must not be supposed, however, that the migratory power of the elvers in all Indo-Pacific species of eel is so comparatively slight as in these tropical Indo-Malayan species.¹ Investigation of another great shallow area, the sea east of China, will illustrate this. Here, in the Yellow Sea and East China Sea, the depth over great areas is less than 100 m. As will be seen from the chart Pl. II, however, eels are found — are indeed not rare — in the rivers up in the innermost corners of the Yellow Sea, And in respect of distance covered, the elvers of *Anguilla japonica* (the species found here), moving from the continental slope up to the northern part of the coast of China can compete with the elvers of the Atlantic.

Altogether, there can hardly be any doubt that the East-Asiatic eel (*Anguilla japonica*) in contrast to most of the other Indo-Pacific species, greatly resembles the Atlantic forms in biological respects, and more particularly the American (*Anguilla rostrata*). Various facts in support of this may be quoted. The silver eels move out to sea in the autumn, and in spring, the elvers make their ascent into the fresh water. The latter are, as we noted on p. 342, of the same size as those of the American eels, 57—58 mm. average²; probably then, they are also of the same age. The chart of distribution (Pl. I) shows that the East-Asiatic eel has a range of occurrence corresponding to that of the American; both are found on the eastern side of their respective continents and extend from somewhat south of the tropic northward over the temperate zone.

And where are the breeding grounds of the East-Asiatic eel? As no stages younger than elvers have yet been found, we do not know, but we can draw a fairly reasonable conclusion from the facts already ascertained.

Yield of Eels in Japan in 1920, in lbs.

North Island (Hokkaido)	45.859
Main Island (Hondo)	7.304.431
South Islands { (Shikoku)	712.083
{ (Kiushiu)	1.357.699
Okinawa (one of the Riu Kiu Ids)	11.858
Formosa (Taiwan)*	95.427
Chosen (Korea)**	13.896

Hondo*** { Pacific provinces	6.749.098
{ Western (Sea of Japan) provinces	307.700

* and ** "Though eels are found comparatively abundantly in Chosen and Formosa, the fishing has not been much developed there until now, owing to economical reasons, so that the yield is relatively small" (Mr. Riu Kichi Murakami, Director, Imperial Bureau of Fisheries, Tokyo, in letter, dated April 12, 1924).

*** Prefectures Aomori (North end), Yamaguchi (South or rather West end), Nagano and Gumma (central), yielding a total of 247.633 lbs. excluded. The yield of Yamaguchi alone amounted to 148.167 lbs.

The following prefectures have been taken as western (bordering on the Sea of Japan): Akita, Yamagata, Niigata, Fukui, Ishikawa, Toyama, Tottori, Shimane.

¹ The two most common species are *Anguilla bicolor* M. Cl. and *A. mauritiana* Bennett.

² Other samples investigated showed average lengths of 55—56 and 58—59 mm.

The distribution of eels in Japan, as it appears from the official catch statistics for the various prefectures, shows very distinctly that the largest quantities of eels are found on the Pacific shores, whereas there are fewer on the coasts facing the Sea of Japan; more than twenty times as many, indeed, on the Pacific side than on the other (see Fig. 7 and Table

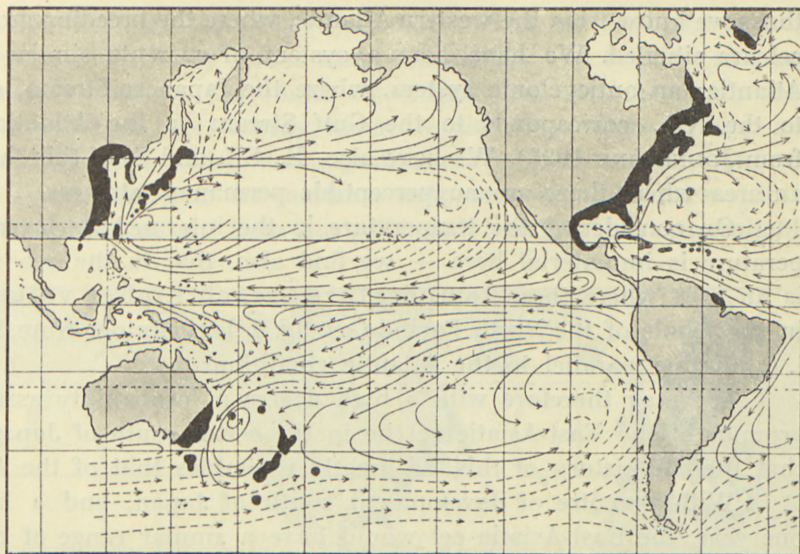


Fig. 8. Currents. Distribution of temperate *Anguilla*-species.

p. 372, compiled from figures kindly furnished by Mr. RIU KICHI MURAKAMI, Director of the Imperial Bureau of Fisheries, Tokyo). And on the western shores of the Sea of Japan, about Vladivostok, and farther north eels are entirely absent. For these reasons alone, the Sea of Japan, between the Continent and Japan itself, would seem to be out of the question as a breeding ground. But in addition to this, the

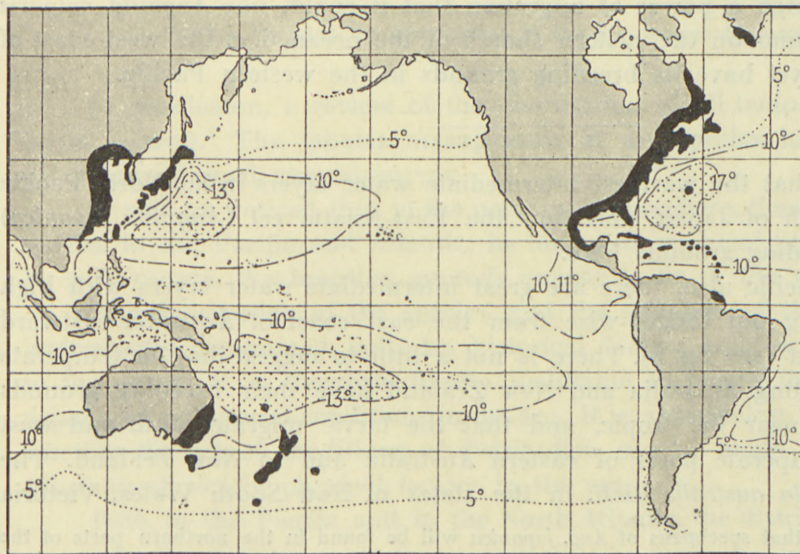


Fig. 9. Temperature in 400 m. Distribution of temperate *Anguilla*-species.

very low temperature prevailing in these waters — only some few hundred metres down it is already less than 4° and in 400 m. less than 1° — must undoubtedly preclude the breeding of eels in this sea.

In the Pacific south of Japan, the hydrographical conditions are altogether different, and remind us in several respects of

those we know from the western Atlantic, where the breeding grounds of the American eel are situated. We have here a system of currents similar to that of the North Atlantic; an anticyclonic system, where the Japanese Stream, or Kuro Siwo, flowing to the NE., corresponds to the Gulf Stream in the Atlantic (see fig. 8, currents from JOHNSTONE 1923). We have also, E., SE. and S. of this the Pacific Gulf Stream, an area where there are no perceptible permanent streams.

On considering the temperature in the intermediate layers, — the surface temperature is immaterial here — we find also, that in the sea south of Japan there is an area where these temperatures reach higher values than anywhere else in the whole of the North Pacific (see fig. 9, temperature from SCHOTT & SCHU 1910), i. e. another parallel to the Atlantic conditions.

We may therefore with a high degree of probability assume that the breeding grounds of the East-Asiatic eel lie in the ocean south of Japan near the tropic, and that the life history of this eel greatly resembles that of the American form.

With a centre of development south of Japan, and a larval period of about one year, the East-Asiatic eel would have a similar range of distribution to that of the American species. And this is also actually the case, inasmuch as it is found from the south of China and Formosa to northern Japan (see fig. 6).¹

There are thus evident points of similarity between the North Pacific and the North Atlantic, as far as the eels are concerned. But in the North Pacific, there is only one temperate species, *Anguilla japonica*, whereas in the North Atlantic there are two, *Anguilla rostrata* and *Anguilla vulgaris*, both with their breeding grounds in the western part of the Atlantic ocean.

We thus lack in the North Pacific a species answering to the European form, i. e. a form with so high a power of migration that it could, like *Anguilla vulgaris* in the Atlantic, be found on the eastern shores of the ocean, i. e. the west coast of North America, and yet have its breeding grounds in the western Pacific.

We have seen that the warmest intermediate water layers in the North Pacific are to be found south of Japan, and that the East-Asiatic eel (*Anguilla japonica*) probably has its breeding grounds here.

In the South Pacific also, there are great intermediate water layers with high temperature, stretching out tongue-wise from the east coast of Australia eastward north of New Zealand (see fig. 9). There is not a little to suggest that the temperate species of eels inhabiting Australia and New Zealand have their breeding grounds in the warmer area near the tropic, and that the larvæ migrate south and west from here to the temperate parts of eastern Australia and to New Zealand. The distribution of *Anguilla australis* Rich. in the states of New South Wales, Victoria

¹ It is quite likely that specimens of *Ang. japonica* will be found in the northern parts of the Philippines, and I should also be surprised if the species is not found, albeit only as stray specimens, still farther north than at Hakodate, in Japan, its northernmost limit of occurrence on record up to now.

and South Australia for instance, seems best explained when we have one or more centres of production situated in the ocean east of Australia. The decrease in quantity of eels from the east coast to the south coast, and their total or nearly total disappearance before we reach the Murray River, would seem characteristic, and suggestive of the direction from which the migrating eel fry must arrive. But I will refrain from further consideration of the southern temperate eels until the results of the investigation of samples sent me from Australia and New Zealand are available.

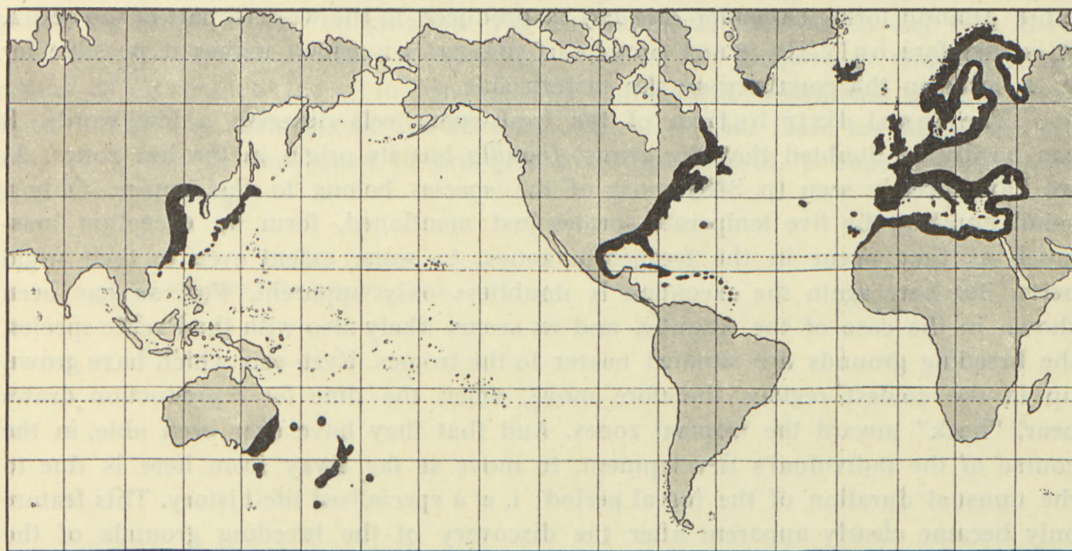


Fig. 10. Showing the distribution of the five temperate species of *Anguilla*.

In conclusion, a review of the distribution of all temperate species of eel will be of interest.¹ The tabular arrangement of the species in question, p. 366, and fig. 10 give a good general survey.

It will be noticed that in the northern hemisphere, there are temperate *Anguilla* species in the Pacific and Atlantic, in the southern hemisphere, only in the Pacific. In both oceans, the breeding grounds appear to lie in the western portion.

The distribution of the species, and the situation of the breeding grounds, are undoubtedly determined both by historical factors and by the natural conditions in the ocean. It is therefore hardly justifiable to regard the distribution as solely dependent on natural conditions in the sea. It is nevertheless interesting to investigate whether the actual conditions of distribution can be made to agree with the distribution of certain physical factors in the sea.

Both in the Pacific and in the North Atlantic, the distribution of the eels seems

¹ The tropical species owing to biological differences, and inadequate specific delimitation, cannot be treated under one head with the temperate forms.

to coincide with the distribution of temperatures in the intermediate water layers where the earliest stages occur. In both cases, we find the warmest intermediate layers on the western side of the ocean. And in both oceans the eels are found in the countries bordering on the western sides: Eastern Asia, Eastern Australia, Eastern America, whereas they are lacking in those on the eastern sides: Western North America, Western South America. The occurrence of the European Eel on the eastern shores of the north Atlantic seems to be the only exception to this rule, and even this exception is only apparent. For we know that this species, like the other Atlantic form, (*Anguilla rostrata*) is produced in the western part of the ocean. It is therefore only its great power of migration which makes it possible for it to occur in the countries on the eastern side.

The zonal distribution of the fresh-water eels deserves a few words. It can hardly be doubted that the genus *Anguilla* has its origin in the hot zones. As we have already seen (p. 366) most of the species belong to the tropics. Only a small number, the five temperate species just mentioned, form an exception inasmuch as they occur in the temperate zones, to some extent even in their frigid parts. But here again the exception is doubtless only apparent. For, as has been shown in the case of the Atlantic, and as seems likely also with the Pacific species, the breeding grounds are situated nearer to the tropics. Even eels which have grown up in the coldest regions therefore move, when the time for reproduction draws near, "back" toward the tropical zones. And that they have ever been able, in the course of the individual's development, to move so far away from here is due to the unusual duration of the larval period; i. e. a specialised life-history. This feature only became clearly apparent after the discovery of the breeding grounds of the Atlantic eels.

In addition to these migrations in the course of the individual's life, (ontogenetic migrations), we have also to consider those which the genus has made since the first *Anguilla* made their appearance somewhere in the equatorial Pacific (phylogenetic migrations). That such have taken place is plainly apparent when we consider the three species which we know best in zoological and geographical respects: the European (*Ang. vulgaris*), the East-Asiatic (*Ang. japonica*) and the American eel (*Ang. rostrata*). That these are so nearly related zoologically as is actually the case, and nevertheless so far removed in geographical respects, is distinct evidence of the extent of such phylogenetic migrations. From the breeding grounds of the Atlantic eels in the western Atlantic to the presumed breeding grounds of the East-Asiatic species south of Japan, is a distance approaching half the circumference of the globe. By what roads *Anguilla vulgaris* and *rostrata* (or their common ancestor as the case may be) made their way from the Pacific — where *Anguilla japonica* remained behind — to the western Atlantic, we may perhaps never be able to determine with certainty. They have probably followed a westerly route; but, if the Pacific were once linked up with the Atlantic via what is now Central America, the migration may have taken place by a more direct easterly route.

There has been some discussion of late years as to how the present European and American eels can have differentiated out from a common Atlantic ancestral form. Probably this is what happened, but we can hardly disregard the possibility that the differentiation may have been effected earlier, and that the two species may have reached the western Atlantic by different routes. In other words, that the western Atlantic would only be a meeting place for the two species, and not the site where their differentiation took place.

Phylogenetic speculations of this sort may be interesting, and leave of course pretty fair scope for the imagination. For the moment, however, at any rate, they have little to do with science. It would be more to the purpose to endeavour, by means of investigations, to ascertain the ontogenetic migrations of the Indo-Pacific eels, and their actual life-histories generally. That there are numerous interesting problems here open to practical investigation will, I hope, be apparent from the foregoing.

Copenhagen, 20. January 1925.

VI. LITERATURE

- ARCHEY (1924). Gilbert Archey: Fresh-Water Eels and their Life-History (The New Zealand Journal of Science and Technology, vol. VII, No. 1, p. 49—51, Wellington 1924).
- BARNARD (1925) K. H. Barnard: A Monograph of the Marine Fishes of South Africa (Annals of the South African Museum, vol. XXI, June 1925).
- BASILEWSKY (1855) St. Basilewsky: Ichthyographia Chinae borealis (Nouveaux mémoires de la Soc. Impériale des Naturalistes à Moscva, Tome X, Moscva 1855, p. 215—263).
- BERG (1917) L. S. Berg: Sur la distribution de l'anguille dans les eaux de la Russie (Annuaire du Musée Zool. de l'Acad. Sci. de Petrograd, XXI (1916), p. 343—346, 1917); in Russian.
- BEST (1903) Elsdon Best: Food Product of Tuhoeland (Transactions of the New Zealand Institute 1902, vol. XXXV, Wellington 1903).
- (1924) E. Best: The utu piharu, or lamprey-weir, as constructed on the Whanganui River (The New Zealand Journal of Science and Technology, vol. VII, No. 1, p. 25, Wellington 1924).
- BLEEKER (1853) P. Bleeker: Bijdrage tot de kennis der Muraenoiden en Symbranchoiden van den Indischen Archipel (Verh. Bat. Gen. XXV, 1853, p. 1—76).
- (1861a). P. Bleeker: Mededeling omtrent vischsoorten, nieuw voor de kennis der fauna van Singapoera (Versl. Akad. Amsterdam, XII, 1861, p. 28—63).
- (1861b). P. Bleeker: Iets over de vischfauna van het eiland Pinang (Versl. Akad. Amsterdam, XII, 1861, p. 64—80).
- (1864). P. Bleeker: Atlas Ichthyologique des Indes Orientales Néerlandaises, Tome IV, Amsterdam 1884.
- BOULENGER (1897a). G. A. Boulenger: An account of the Fresh-water Fishes collected in Celebes by Drs. P. & F. Sarasin (Proc. Zool. Soc. London, 1897, p. 426—429).
- (1897b). G. A. Boulenger: A List of the Fishes obtained by Mr. J. Stanley Gardiner at Rotuma, S. Pacific Ocean (Annals Mag. Nat. Hist., 6 Ser., vol. 20, 1897, p. 371—74).
- (1907). G. A. Boulenger: A List of the Fresh-water Fishes, Batrachians and Reptiles obtained by Mr. J. Stanley Gardiner's Expedition to the Indian Ocean. (Transact. Linn. Soc. London, 2 Ser. Zoology, vol. XII, 1907, p. 291).
- (1915). G. A. Boulenger: Catalogue of the Freshwater Fishes of Africa, vol. III, London 1915.
- CASTELNAU (1879). Comte F. L. de Castelnau: Notes on the fishes of the Norman River (Proc. Linn. Society of New South Wales, III, p. 41—51, 1879).
- DAHL (1898). Knut Dahl: Reiser i Nord-Vest-Australien, Kristiania, Cammermeier 1898.
- DOWNES (1918). T. W. Downes: Notes on Eels and Eel-weirs (Tuna and Pa-tuna) (Transactions of the New Zealand Institute 1917, vol. L, Wellington 1918).
- DUNCKER (1904). G. Duncker: Die Fische der malayischen Halbinsel (Mitt. Naturhist. Mus. Hamburg, XXI, 1904, p. 133—207).
- EVERMANN & GOLDSBOROUGH (1907). B. W. Evermann and E. L. Goldsborough: The Fishes of Alaska (Bull. Bureau of Fisheries, vol. XXVI, 1906, Washington 1907, p. 219—360).
- GILCHRIST & THOMPSON (1917). J. D. F. Gilchrist and W. Wardlaw Thompson: The Freshwater Fishes of South Africa (continued) (Annals of the South African Museum, vol. XI, Part VI, 1917).
- GILL (1876). W. W. Gill: Myths and Songs from the South Pacific, London, Henry S. King & Co., 1876.

- GÜNTHER (1870). A. Günther: Catalogue of the Fishes in the British Museum, vol. VIII, London 1870.
- (1889). Günther: 3rd Contribution to our Knowledge of Reptiles and Fishes from the Upper Yangtze-Kiang (Ann. Mag. Nat. Hist. (6 Ser.) vol. 4, 1889, p. 218—29).
- (1910). A. Günther: Die Fische der Südsee (Journal des Museum Godeffroy, Heft IX, Hamburg 1910).
- HALL (1905). T. S. Hall: The distribution of the fresh-water Eel in Australia and its Means of Dispersal (Victorian Natural, vol. 22, p. 80—83, 1905).
- HAMILTON (1908). A. Hamilton: Fishing and Sea-Foods of the Ancient Maori (Bull. No. 2, Dominion Museum, Wellington, New Zealand 1908).
- HERRE (1923). Albert W. C. T. Herre: Philippine Eels (The Philippine Journal of Science, vol. 23, No. 2, p. 123—236, Aug. 1923, Manila).
- HUTTON (1872). F. W. Hutton: Catalogue of Fishes of New Zealand (Geol. Dept. New Zealand, 1872).
- (1890). F. W. Hutton: List of the New Zealand Fishes (Trans. & Proc. New Zealand Instit. 1889, vol. 22, (N. S. vol. 5) 1890, p. 275—285).
- (1904). F. W. Hutton: Index Faunæ Zelandiæ, London 1904.
- ISHIKAWA & MATSUURA (1897). C. Ishikawa and K. Matsuura: Preliminary Catalogue of Fishes etc. in the Nat. Hist. Department, Imperial Museum. Tokyo 1897.
- JOHNSTONE (1923). James Johnstone: An Introduction to Oceanography with special reference to Geography and Geophysics, Liverpool 1923.
- JORDAN & EVERMANN (1903). Jordan and Evermann: Notes on a Collection of Fishes from the Island of Formosa (Proc. U. S. Nat. Mus., vol. 25, 1903, p. 315—368).
- (1905). Jordan and Evermann: The aquatic resources of the Hawaiian Islands. Part I, Shore Fishes (Bull. U. S. Fish. Com., XXIII for 1903, Part I, Washington 1905).
- JORDAN & SEALE (1906). David Starr Jordan & Alvin Seale: The Fishes of Samoa. — Description of the species found in the archipelago, with a provisional check-list of the fishes of Oceania. Bulletin of the Bureau of Fisheries, vol. XXV, 1905, Washington, Dec. 15, 1906.
- JORDAN & SNYDER (1901). Jordan and Snyder: A Review of the Apodal Fishes or Eels of Japan, with description of nineteen new species (Proc. U. S. Nat. Mus., vol. 23, No. 1239, p. 837—890, 1901).
- KAUP (1856). Kaup: Catalogue of Apodal Fish in the collection of the British Museum, London 1856.
- KENNDALL & GOLDSBOROUGH (1911). William C. Kenndall & Edmund L. Goldsborough: The Shore Fishes in Rep. Sci. Results Exp. Trop. Pacific, XIII, Memoirs of the Museum of Comparative Zoölogy at Harvard College, vol. XXVI, No. 7, Cambridge, U. S. A., Febr. 1911, p. 241—344.
- KENDALL & RADCLIFFE (1912). W. C. Kendall and L. Radcliffe: The shore fishes of the «Albatross» Expedition, 1904—1905 (Mem. Mus. Comp. Zoöl. Harvard College, XV, p. 75—171, 1912).
- KERSHAW (1911). J. A. Kershaw: Migrations of eels in Victoria (Victorian Naturalist, 27, p. 196—201, 1911).
- KLUNZINGER (1880). C. B. Klunzinger: Die v. Müllersche Sammlung australischer Fische in Stuttgart (Sitzungsberichte der Kais. Ak. d. Wiss., Math.-Naturwiss. Classe, Bd. LXXX, I Abt., Wien 1880, p. 419).
- MACLEAY (1878). W. Macleay: The Fishes of Port Darwin (Proc. Linnean Society of New South Wales, II, p. 344—367, 1878).
- (1883). W. Macleay: The Fishes of the Palmer River (Proc. Linnean Society of New South Wales, VII, p. 69—71, 1883).
- (1884). W. Macleay: Notes on a collection of Fishes from the Burdekin and Mary Rivers (Proc. Linnean Society of New South Wales, VIII, 199—213, 1884).
- MAIR (1880). G. Mair: Notes on Fishes in Whanganui River (Transactions of the New Zealand Institute, vol. XII, Wellington 1880).
- (1903). G. Mair: Notes on Fish found in the Piako River (Transactions of the New Zealand Institute, vol. XXV, Wellington 1903).

- OGILBY (1886). Douglas Ogilby: Catalogue of the Fishes of New South-Wales with their principal synonyms. Sydney 1886.
- PAGET (1925). G. W. Paget: Report on the Fisheries of Egypt for the year 1923, Ministry of Finance, Egypt, Coastguards and Fisheries Service, Cairo 1925, p. 28.
- PALACKY (1891). J. Palacky: Die Verbreitung der Fische, Prag 1891.
- PELLEGRIN (1898). J. Pellegrin: Contribution à l'étude ichthyologique des îles Mariannes (Bull. Mus. Hist. Nat. T. 4, 1898, p. 228—29).
- (1905). J. Pellegrin: Mission permanente Française en Indo-Chine. Poissons de la Baie d'Along (Tonkin). (Bull. Soc. Zool. France, vol. 30, 1905, p. 82—88).
- (1907). J. Pellegrin: Mission permanente Française en Indo-Chine. Poissons du Tonkin. (Bull. Mus. Hist. Nat., Tome 13, 1907, p. 499—503).
- (1922). Jacques Pellegrin: Les poissons des eaux douces de la région madécasse (Assoc. française pour l'Avancement des Sciences, Congrès de Montpellier 1922).
- POPTA (1924). C. Popta: *Anguilla borneensis* n. sp. (Zool. Mededeelingen Museum Leiden, No. VII, p. 73—76, 1924).
- RAMSAY & OGILBY (1886). E. P. Ramsay and J. D. Ogilby: A contribution to the knowledge of the fish-fauna of New Guinea (Proc. Linnean Society of New South-Wales, 2. ser., vol. I, p. 8—20, 1886).
- REGAN (1913). C. Tate Regan: A collection of Fishes made by Professor Francisco Fuentes at Easter Island (Proc. Zool. Soc. London 1913, p. 368—374).
- (1914). C. T. Regan: Report on the Fresh-water Fishes collected by the British Ornithologists' Union Expedition and the Wollaston Expedition in Dutch New Guinea (Trans. Zool. Soc., London, vol. 20, 1914, p. 275—286).
- RENDAHL (1922). Hjalmar Rendahl: A contribution to the Ichthyology of North-West Australia (Meddelelser fra det Zoologiske Museum, Kristiania No. 5).
- RÉUVENS (1894). C. L. Reuvsen: Fresh & Brackish Water Fishes from Sumba, Flores, Groot-Bastaard, Timor, Samae and Rotti (Notes from the Leyden Museum, vol. XVI, 1894).
- RICHARDSON (1844—48). Sir John Richardson: Ichthyology of the voyage of H. M. S. Erebus & Terror. London 1844—48.
- (1845). John Richardson: Report on the Ichthyology of the Seas of China and Japan (Report of the Brit. Assoc. for the Advancement of Science for 1845, p. 187—320).
- SAUVAGE (1880). H. E. Sauvage: Recherches sur la Faune Ichthyologique de l'Asie et description d'espèces nouvelles de l'Indo-Chine (Nouvelles Archives du Muséum d'Hist. Nat., 2 Série, Tome 3, p. 123—193, 1880).
- (1881). H. E. Sauvage: Recherches sur la faune ichthyologique de l'Asie et description d'espèces nouvelles de l'Indo-Chine (Nouv. Archiv. Mus. d'Hist. Nat., 2 Série, Tome 4, 1881, p. 123—194).
- (1884). H. E. Sauvage: Note sur une collection de Poissons recueillie à Pérak, Presqu'île de Malacca. (Bull. Soc. Zool. France, vol. 9, 1884, p. 216—220).
- SCHMIDT (1912). Johs. Schmidt: Danish Researches in the Atlantic and Mediterranean on the Life-History of the Fresh-water Eel (*Anguilla vulgaris*) (Internat. Revue der gesammten Hydrobiologie und Hydrographie, Leipzig 1912).
- (1913). Johs. Schmidt: First Report on Eel Investigations (Rapp. et Procès-Verbaux du Conseil International pour l'Exploration de la Mer, vol. XVIII, Copenhagen 1913).
- (1915). Johs. Schmidt: Second Report on Eel Investigations (Rapp. et Procès-Verbaux du Conseil International pour l'Exploration de la Mer, vol. XXIII, Copenhagen 1915).
- (1916). Johs. Schmidt: On the Early Larval Stages of the Fresh-water Eels (*Anguilla*) and some other North Atlantic Murænoids (Meddelelser fra Kommissionen for Havundersøgelser, Ser. Fiskeri, Bind V, No. 4, Copenhagen 1916).
- (1922). Johs. Schmidt: The Breeding Places of the Eel (Phil. Transact. Royal Society of London, Series B, vol. 211, B. 385, 1922).
- (1925). Johs. Schmidt: The Breeding Places of the Eel, with Postscript (General Appendix to the Smithsonian Report for 1924, Washington 1925).

- SCHOTT & SCHU (1910). G. Schott and F. Schu: Die Wärmeverteilung in den Tiefen des Stillen Ozeans (Annalen der Hydrographie und Maritimen Meteorologie, Berlin 1910).
- SEALE (1906). Alvin Seale: Fishes of the south Pacific (Occasional Papers Bernice Pauahi Bishop Mus., Honolulu, 1906, 4, 1—89, pl.).
- (1917). Alvin Seale: New species of Apodal fishes (Bull. Mus. Comp. Zool., vol. LXI, No. 4, Cambridge, Mass. 1917).
- SNELL & TAMS (1920). H. J. Snell and W. H. T. Tams: The Natural History of the Island of Rodri-ges (Proceed. Cambridge Philosophical Society, XIX, Pt. 6, Cambridge 1920).
- STEINDACHNER (1892). F. Steindachner: Über einige neue und seltene Fischarten aus der ichth. Samm-lung des K. K. Naturh. Hofmuseums (Denkschr. d. K. Akad. Wiss. Wien, mat.-nat. Cl., 59 Bd., p. 357—384, Wien 1892).
- (1903). F. Steindachner: Die Fische, in Ergebn. einer Zoolog. Forschungsreise in den Molukken und Borneo . . . von Dr. Willy Kükenthal (Abh. Senckenberg. Naturf. Ges. 25 Bd., p. 411—464, Frankfurt a. M. 1903).
- STREETS (1878). Thomas Hale Streets: Contributions to the Natural History of the Hawaiian and Fanning Islands and Lower California (Bull. U. S. Nat. Mus., VII, p. 43—102, Washington 1878).
- STRUBBERG (1913). A. Strubberg: The metamorphosis of Elvers as influenced by outward conditions (Meddelelser fra Kommissionen for Havundersøgelser, Serie Fiskeri, Bind IV, No. 3, 1913).
- TANAKA (1912). Shigeo Tanaka: Fishes of Japan, vol. IX, Tokyo Nov. 26, 1912, p. 148—150).
- TEMMINCK & SCHLEGEL (1846). Temminck and Schlegel: Fauna Japonica, Poiss., p. 258, pl. CXIII, fig. 2; 1846.
- VAILLANT (1884). Léon Vaillant: Contribution à la Faune ichthyol. du Tonkin (Bull. Soc. Zool. France, vol. 9, 1884, p. 209—215).
- (1893). Léon Vaillant: Contribution à l'étude de la Faune Ichthyologique de Bornéo (Nouv. Arch. Mus., 3 sér., T. 5, 1893, p. 23—114).
- (1902—04). Léon Vaillant: Résultats Zool. de l'Expedition scient. néerland. au Bornéo Central. Poissons. (Notes Leyden Museum, vol. XXIV, 1902—04, p. 1—166).
- VINCIGUERRA (1890). D. Vinciguerra: Pesci di Birmania (Viaggio di Leonardo Fea in Birmania e regione vicine, Genova 1890).
- WAITE (1897). E. R. Waite: The Mammals, Reptiles, and Fishes of Funafuti (Mem. Australian Mu-seum, III, p. 165—201, 1897).
- (1899). E. R. Waite: The Fishes of Funafuti (Supplement) (Mem. Australian Museum, V, p. 537—546, 1899).
- (1903a). E. R. Waite: Additions to the Fish-Fauna of Lord Howe Island, No. 2. (Rec. Austr. Mus., vol. IV, 1903).
- (1903b). E. R. Waite: Notes on the Zoology of Paanopa or Ocean Island and Nauru or Pleasant Island, Gilbert group. The Fishes. (Record of the Australian Museum, vol. V, p. 2—3, Sydney 1903).
- (1904). E. R. Waite: Catalogue of the Fishes of Lord Howe Island (Records of the Australian Museum, vol. V, p. 187—230, Sydney 1904).
- (1907). E. R. Waite: A Basic List of the Fishes of New Zealand (Records of the Canterbury Mu-seum, vol. I, No. 1, Christchurch 1907).
- (1910). E. R. Waite: A List of the Known Fishes of Kermadec and Norfolk Islands, and a Com-parison with those of Lord Howe Island. (Trans. & Proc. New Zealand Institute 1909, vol. XLII, Issued 1st June 1910, Wellington, p. 370—383).
- WEBER (1894). Max Weber: Die Süßwasser-Fische des Indischen Archipels etc. (in Max Weber: Zool. Ergebnisse einer Reise in Niederländ. Ost-Indien, vol. III, 1894, p. 405—476).
- (1913). Max Weber: Neue Beiträge zur Kenntniss der Süßwasserfische von Celebes (Bijdragen tot de Dierkunde uitgegeven door het Koninklijk zoölogisch Genootschap »Natura Artis Magistra«, Amsterdam 1913).

- WEBER & BEAUFORT (1911). Max Weber and L. F. de Beaufort: The Fishes of the Indo-Australian Archipelago, I, Leiden 1911.
- (1912). Max Weber and L. F. de Beaufort: Die Fische (in A. Maass: Durch Zentral-Sumatra, vol. II, p. 1—20, Leipzig 1912).
- (1915). Max Weber and L. F. de Beaufort: Les Poissons d'eau douce de la Nouvelle-Calédonie (in F. Sarasin & J. Roux, Nova Caledonia, Zoologie, vol. II, L. I, No. 2, Wiesbaden 1915).
- (1916). Max Weber and L. F. de Beaufort: The Fishes of the Indo-Australian Archipelago, III, Leiden 1916.

CONTENTS

	Page
I. Introduction	(3) (329)
II. The Indian Ocean	(8) (334)
A. Western Section (Africa)	(8) (334)
B. Northern Section (Asia)	(10) (336)
C. Eastern Section (Malaya and Western Australia)	(11) (337)
III. The Pacific	(13) (339)
A & B. Eastern and Northern Sections	(13) (339)
C. Western Section	(13) (339)
D. Tropical Oceanic Islands	(28) (354)
1. North of the Equator	(28) (354)
2. South of the Equator	(29) (355)
IV. Boundary Region between the Indian and Pacific Ocean	(33) (359)
V. Concluding Remarks	(40) (366)
A. Survey of Distribution	(40) (366)
1. Distribution from North to South	(40) (366)
2. Distribution from East to West	(41) (367)
B. Some General Observations	(42) (368)
VI. Literature	(52) (378)

