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CYTOLOGICAL AND
EXPERIMENTAL STUDIES ON THE GENUS
ERODIUM WITH SPECIAL REFERENCES
TO THE COLLECTIVE SPECIES
E. CICUTARIUM (L.) L'HER.

BY

KAI LARSEN



København 1958
i kommission hos Ejnar Munksgaard

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Synopsis.

The paper gives the chromosome number of 34 strains of *Erodium*, all of wild origin, belonging to the species: *E. hirtum* (Forsk.) Willd. subsp. *maroccanum* Maire, $2n = 20$; *E. maritimum* (Brum. f.) L'Her., $2n = 20$; *E. glutinosum* Dumort., $2n = 20$; *E. cicutarium* (L.) L'Her., $2n = 40$, and a new-described species, *E. danicum* K. Larsen, $2n = 60$. This *E. danicum* was found in five localities in Denmark. It is suggested to be an amphidiploid between *E. glutinosum* and *E. cicutarium*. Biological observations and the results of experimental cultivations are communicated.

I. Introduction.

The genus *Erodium* belonging to the Geraniaceae consists of about 60 species, the majority of which have a Mediterranean distribution. Though the taxonomy of this group and particularly *E. cicutarium* (L.) L'Her. and its allies have been treated by various authors from an experimental point of view in recent times, several problems of distribution and cytology still remain.

The present material has been produced by collection of seeds in nature, partly by the author, partly through the kindness of other botanists. The author owes his sincerest thanks to everybody who has contributed to these studies by collecting seeds and placing material at his disposal, and to the Carlsberg Foundation and the Dansk Botanisk Rejsefond, which have provided grants to cover travelling expenses.

The chromosome countings have been carried out on root tips fixed in Navashin-Karpechenko's fluid, where nothing else is stated, embedded in paraffin, and sectioned at about 13 μ . The staining for some few early slides has been done with Gentian Violet, the majority of slides, however, being stained according to Feulgen.

All experimental cultivations have been carried out in the experimental fields of the Botanical Gardens of the University of Copenhagen (HBH). Herbarium studies all refer to the Herbarium of the University of Copenhagen (Herb. C), where also this material will be placed after these studies have been finished.

The writer is indebted to Prof. Dr. T. W. BÖCHER for help and advices during the work, and to Mr. TYGE CHRISTENSEN, M.Sc., for latinizing the diagnosis.

II. Cytotaxonomy.

A. Discussion of previous studies in *E. cicutarium* (L.) L'Her. and its allies.

The basis of taxonomic studies in the family Geraniaceae is the monograph compiled by KNUTH (1912) on orthodox taxonomic lines. It has not been possible to follow this work as far as

TABLE I.
Chromosome counts of previous authors (only species of
known origin mentioned).

Origin	Authors	Obs.
<i>Erodium glutinosum</i> Dum. $2n = 20$		
England:		
Blakeney Point, Norfolk	WARBURG 1938	
Merthyr Mawr, Glam.	—	
Sweden:		
Scania: Kungsmarken near Lund	LÖVE & LÖVE	It is subject to doubt whether this specimen belongs to <i>E. glutinosum</i> (see discussion in the text on p. 23).
Holland:	1942	
Without further statement of the locality	ANDREAS 1946	
<i>Erodium cicutarium</i> (L.) L'Her. $2n = 40$		
England:		
Freckenham, Suffolk	WARBURG 1938	
Borth, Cardigan	—	
Mendip Hills, Somerset (near Wells)	—	
N. Ireland:		
Newcastle, Co. Down	—	
Scotland:		
Aberdeen	—	
Holland:		
Without further statement of the locality	ANDREAS 1946	
Sweden:		
Scania at Åhus	LÖVE & LÖVE	
Germany:	1942	
Schleswig-Holstein	GAUGER 1937	Var. <i>immaculatum</i> KOCH
U. S. A.:		$2n = 36?$; var. <i>pimpinellifolium</i> Sm. $2n = 40$
California	HEISER & WHITAKER 1948	

the *E. cicutarium*-group is concerned since experimental studies have revealed a more natural classification. Thus the diploid West European dune species is here treated as *E. glutinosum* Dum., while KNUTH regards it as a variety under *E. bipinnatum* (Cav.) Willd., viz. var. *sabulicolum* (Jord.) Brumh. The other species belonging to the subsection *Cicutario* Willk. et Lange, *E. cicutarium* (L.) L'Her. is by KNUTH divided into several varieties and forms. It is evident that Knuth was in doubt about

the classification, as three other systems are quoted. In the present treatment I have followed ANDREAS (1946), who divides it into two interfertile subspecies.

E. glutinosum Dum. — The chromosome number $2n = 20$ has been stated by the following authors in *E. cicutarium* coll., viz. WARBURG (1938), LÖVE & LÖVE (1944), and ANDREAS (1946). The last-mentioned author was the first to treat the problem concerning the morphology and distribution of the diploid cytotype in a serious way. From a study of Dutch material of *E. cicutarium* coll. ANDREAS reached the conclusion that two chromosome races exist in Holland, one diploid with $2n = 20$, and one tetraploid with $2n = 40$. ANDREAS concluded that the proper botanical terminology of these two types, worthy of specific rank, is *E. glutinosum* Dum. (Fig. 13) and *E. cicutarium* (L.) L'Her.

The two species differ in a number of quantitative characters, but the best distinguishing character is found in the morphology of the fruits. *E. cicutarium* has fruits with a conspicuous pit surrounded by a furrow at the apex. The fruits of *E. glutinosum* has a small pit without a furrow and the beak is usually shorter than 24 mm (15—24) while *E. cicutarium* has a beak of 22—40 mm.

E. cicutarium (L.) L'Her. — According to TISCHLER (1950) the following authors have found the chromosome number $2n = 40$ in *E. cicutarium* coll., viz. GAUGER (1937), WARBURG (1938), LÖVE & LÖVE (1942), ANDREAS (1946), STEBBINS (in HEISER & WHITAKER 1948), MATTICK (in TISCHLER *loc. cit.*), and ROTTGARDT (*ibid.*). Furthermore $2n = 36$ has been reported by HEITZ (1926), GAUGER (1937), NEGODI (1937), and ROTTGARDT (in TISCHLER *loc. cit.*). It is not possible at the present time to decide whether the number $2n = 36$ really does exist in the species or whether it is due to incorrect countings from bad preparations. All cultures studied by me have shown $2n = 40$. Experience has shown that only the vigorous root tips, however, contain mitosis in which the chromosomes lie sufficiently well spaced so that it is possible to count the chromosome number with certainty. On the other hand it is not inconceivable that aneuploid types do exist in Central and South Europe.

According to ANDREAS (*loc. cit.*) *E. cicutarium* (L.) L'Her. can be divided in two subspecies, viz. subsp. *arvale* Andr.,

which is the common weed distributed over the greater part of Europe (and may be regarded as nearly a cosmopolitan), and subsp. *dunense* Andr., which is found in the dunes and on sandy fields near the coast (Figs. 9—10).

WARBURG (1938) studied British material and established that all the inland strains examined and some of the maritime ones were tetraploid, but that two diploids, both maritime, also occurred. These results are not in contradiction with the results of ANDREAS. Much more difficult to explain are the results of LÖVE & LÖVE (1942, 1944), two papers not considered by ANDREAS. These authors found that in Sweden a spring type with $2n = 20$ and an autumn type with $2n = 40$ occur. The diploid plant originated from Lund (Scania) and the tetraploid from Åhus (Scania)., the authors therefore conclude that in Sweden the diploid type is found inland, the tetraploid on the coast, i. e. just contrary to what is the case in England.

These conclusions of LÖVE & LÖVE seem a little premature, as only two strains have been studied, one of "the autumn type" and one of "the spring type". Nor has it been possible for the present author to confirm this on Danish material (cp. p. 23). Furthermore the conclusion that the species react in the opposite way in England and Sweden, is not sufficiently substantiated.

In Table I the author has surveyed the previous counts in which the origin of the material studied could be established. Chromosome counts made on material from botanical gardens are not of much interest any more as far this species is concerned.

B. Present Investigations.

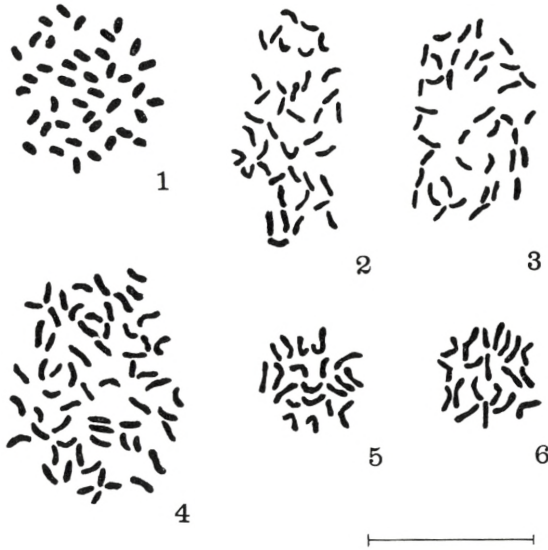
All strains of *Erodium* studied cytologically by the author are surveyed in Table II. The distribution of the European ones is illustrated on the maps Fig. 7 and Fig. 8 together with previously published, localized chromosome counts.

E. glutinosum Dum. — A single sample of this species originating from the British Isles showed the chromosome number $2n = 20$; this is in accordance with the results of ANDREAS (*loc. cit.*).

E. cicutarium (L.) L'Her. — Several strains of this very polymorphous species have been studied. They include the subsp. *arvale*, the typical inland type and field weed, as well as subsp.

dunense, the dune type. In all collections with the exception of some Danish ones further dealt with below, the chromosome number $2n = 40$ has been counted (cp. Fig. 1—3). The chromosomes are nearly isoshaped with a median constriction.

It is a question whether the strain from Portugal (2451) is to be referred to subsp. *arvale* without taking it in an unusually



Figs. 1—6. Root tip mitosis. Fig. 1: *E. cicutarium* subsp. *dunense*, $2n = 40$ (Cult. No. 3040). The chromosomes are contracted in consequence of a pretreatment with 8-hydroxyquinoline for 4 hours before fixation. — Fig. 2: *E. cicutarium* subsp. *dunense*, $2n = 40$ (4451). — Fig. 3: *E. cicutarium* subsp. *arvale*, $2n = 40$ (4238). — Fig. 4: *E. danicum*, $2n = 60$ (2749). — Fig. 5: *E. maritimum* var. *apetala*, $2n = 20$ (4455). — Fig. 6: *E. hirtum* subsp. *maroccanum*, $2n = 20$ (55—18). — The scale is 10μ .

wide sense. But it is beyond the scope of this work to make a classification for all European forms.

As mentioned in the introduction, the species has got a nearly world-wide distribution. In order to ascertain which type has become the common weed in the new world, two South American strains were studied, one from Chile and one from Argentina. Both showed the chromosome number $2n = 40$ and could without hesitation be referred to subsp. *arvale*.

Besides the tetraploid species to which the majority of the strains seems to belong, a hexaploid chromosome type constituting a new species was found in Denmark (Fig. 4). Now poly-

TABLE
Species, origins and chromosome

Species	Localities of collection
<i>E. cicutarium</i> subsp. <i>dunense</i>	Denmark : Lakolk, Römö
—	— : Southern Römö
—	— : Kandestederne, N. Jutland
—	Wales : St. Davis (No. 2).
—	— : Ibidem (No. 3).
—	— : Ibidem (No. 4).
—	— : Tenby (No. 5).
—	— : Ibidem (No. 6).
—	— : Ibidem (No. 7).
—	— : Dale (No. 8).
—	— : Ibidem (No. 10).
—	— : Morfa Duffryn, (No. 12).
<i>E. cicutarium</i> subsp. <i>arvale</i>	Denmark : N. of Hillerød, N. Zealand
—	— : Hillerød, N. Zealand
—	— : Nødebo, N. Zealand
—	— : Sletten, N. Zealand
—	— : Salling, Voldskrænten, N. Jutland
—	France : Gavarnie, in the Pyrenees
—	— : Formiguere, in the Pyrenees
—	Holland : W. of Hengelo
—	— : Island of Terschelling
—	Scotland : Nairn near Innvernes
—	Austria : Seewinkel, E. of Neusiedlersee
—	Portugal : Coimbra (wild origin)
—	Chile : Huasco, N. of Valparaiso
—	Argentina: Chos Malal (Dept. Neuouen)
<i>E. danicum</i>	Denmark : Frederikshavn, N. Jutland
—	— : Vaalse Vesterskov, Falster
—	— : Vesterø, Sigvej, Læsø
—	— : Vesterø, Læsø
—	— : Vesterø, Kirkevej, Læsø
<i>E. glutinosum</i>	Wales : Morfa Duffryn
<i>E. maritimum</i>	— : St. Davis
<i>E. hirtum</i> subsp. <i>maroccanum</i>	Marocco : Haha distr., S. of Mogador

ploid individuals are occasionally found when a sufficiently large material of a species is studied. Probably in every species such individuals occur sporadically (DARLINGTON 1956). In this case, however, in which five strains from different parts of the country

II.

numbers of the strains studied.

Habitat	Collector	Cult. No.	2n
sandy dune path	Author	3039	40
dunes influenced by sheep	—	3040	40
sandy dune path	—	4543	40
	TH. SØRENSEN	4446	40
	—	4447	40
	—	4448	40
dunes	—	4449	40
dunes	—	4540	40
dunes	—	4451	40
	—	4452	40
	—	4454	40
dunes	—	4456	40
sandy field	Author	2206	40
field	—	2212	40
dry slope	—	55—40	40
roadside	—	2298	40
	P. KAAD	4238	40
weed in field, alt. 1400 m.	Author	1533	40
weed in field, alt. 1600 m.	—	1667	40
roadside	—	1202	40
dune road	—	2432	40
roadside	TH. SØRENSEN	4457	40
dry field	T. W. BÖCHER	4098	40
	Bot. Gard.	2451	40
desert	T. W. BÖCHER		
	& K. RAHN	A 513	40
rocks outside the town	—	A 1591	40
sandy hills	Author	2749	60
	K. HØJGAARD	2753	60
	P. KAAD	4239	60
sandy roadside	—	4240	60
	—	4243	60
dunes	TH. SØRENSEN	4455	20
dunes	—	4445	20
	Inst. Sci. Cherif.	55—18	20

show hexaploidy, the hexaploid is in my opinion to be interpreted as a separate genetic species which till now has been found in Denmark only.

It is possible of course that a closer study on West European

Erodium will reveal that this hexaploid species also occurs outside Denmark. The finding of 5 Danish localities among 13 Danish samples collected at random points in the direction of the species having a northern distribution (for taxonomic treatment see p. 11).

E. maritimum (Burm. fil.) L'Her. — This species belongs to



Fig. 7. Map showing all European localities with known chromosome number of *Erodium cicutarium* (solid dots), $2n = 40$; and *E. glutinosum* (rings), $2n = 20$. The Danish finds are excluded and illustrated on Fig. 8. For extra-European finds see Table I and II.

the subsection *Chamaedryoidea* Brumh. It has two separate distribution areas, one Liguric-Tyrrhenic, and one in Atlantic Western Europe. The sample studied is referred to var. *maritimum* f. *apetala* Rouy (pro. subvar.) characterized by the absence of petals. The chromosome number $2n = 20$ was found (Fig. 5). This is the same number as observed in the two other species belonging to this group, viz. *E. corsicum* Leman, and *E. chamaedryides* (Cav.) L'Her. (Warburg 1938).

E. hirtum (Forsk.) Willd. — A perennial species distributed in the North African steppe region from South West Morocco to Syria. It belongs to the section *Plumosa* Boiss.

$2n = 20$ was found in material from Morocco: Haha district, South of Mogador (Fig. 6). This is the same number as that found by WARBURG (1938) in *E. glaucophyllum* (L.) L'Her., which belongs to the same section.

The material studied was received as seeds from the Institut Scientifique Chérifien, Rabat, through the kindness of Professor CH. SAUVAGE. The strain belonged to var. *maroccanum* Maire (1923), which is a glabrous variety found in Western Morocco.

III. Taxonomical Treatment of the Hexaploid Danish Erodium.

The hexaploid plants of *E. cicutarium* (L.) L'Her. differ from the tetraploid ones in a number of minor characteristics, most of which, however, are quantitative and biological.

The three strains from Læsø Nos. 4239, (Fig. 16), 4240 (Fig. 16) typus, and 4243, were almost identical in their behaviour when grown in the experimental field, as well as in the her-

TABLE III.
Diameters of pollen.

E. danicum 4239—4243, *E. cicutarium* subsp. *arvale* 1202—1591 A, *E. cicutarium* subsp. *dunense* 4452. Further explanation of the Cult. Nos.; see Table II.

Cult. No. 1		Pollen diam. in μ							Average pollen diam. in μ	
		35	40	45	50	55	60	65		70
4239	Denmark				7	32	48	10	3	59
4240	—				6	32	54	8		58
4243	—				7	29	49	10	5	59
1202	Holland			7	59	28	5	1		52
2206	Denmark		1	5	65	24	4			51
2212	—		1	4	54	35	6			52
2298	—	1	13	21	47	16	2			49
2451	Portugal			25	56	14	4	1		50
4098	Austria			4	59	29	8			52
4457	Scotland			9	58	28	5			51
1591A	Argentina			1	19	55	21	4		55
4452	Wales			6	53	30	9	2		52

barium material preserved. The two previously cultivated strains, Nos. 2749 from N. Jutland and 2753 from Falster, behaved in nearly the same way under experimental conditions.

It is evident that the hexaploid is closely related with the tetraploid dune *Erodiums*, and might be referred to the *E. cicutarium* ssp. *dunense*. A measurement of the diameter of the pollen grains revealed small but significant differences; these measures

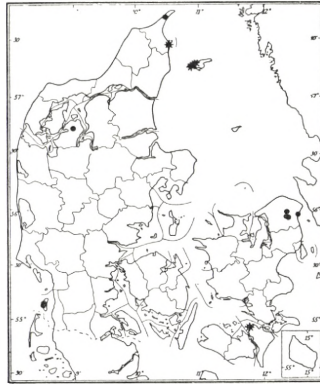


Fig. 8. Map showing Danish localities of *Erodium cicutarium* studied cytologically. Solid dots for tetraploids (subsp. *dunense* and subsp. *arvale*); * indicates hexaploids, *E. danicum*.

are summarized in Table III. From this it is seen that *E. danicum* has slightly larger pollen, with an average diameter of 58–59 μ , than *E. cicutarium*, in which average diameters from 49 to 56 μ were found.

The measurements of other structures of the hexaploid *E. danicum* are all in close accordance with those of the tetraploid *E. cicutarium* given by ANDREAS (1946), as far as can be judged. Unfortunately too little fruiting material was available to give a clear picture. The measurements are: seeds about 3 mm in length beak 25–30 mm, fruit \div beak 4–6 mm. The furrow around the pit, however, is little accentuated. There are most frequently 5 flowers in the inflorescences. This is more than is generally met with in subsp. *dunense*. It seems, furthermore, to be a larger

Figs. 9–10. Danish *E. cicutarium* subsp. *dunense* collected at Kandestederne, N. Jutland, in Aug. 1955. The specimens Fig. 9 may be seedlings from the same summer, while Fig. 10 may be a hibernated specimen.



Fig. 9



Fig. 10

plant than subsp. *dunense*, with decumbent stems and very fine dissected leaves. The stems and in a still higher degree the petioles are densely covered with glandular hairs, in a degree seldom met with in such large forms. Thus the robust habit of subsp. *arvale* is combined with a glandular indumentum and fine dissected leaves. A characteristic biological feature seems to be that the leaves are falling off early in the autumn and new rosettes are formed in the leaf axils. This increased degree of vegetative reproduction is a feature often seen in polyploids.

This hexaploid type should be established as a new species.

Diagnosis.

Erodium danicum nov. sp.

Sectio *Barbata* Boiss., subsectio *Cicutaria* Willk. et Lange.

E. cicutaria satis affine, his notis ab eo diversum: Folia minora, magis dissecta, basalia mox marcescentia. Caules petiolique pilis et glandulis dense obsessi. Inflorescentia 5—6 flora. Plica concentrica foveae ad basim styli in fructum impressae circumjecta minus manifesta. Rosulae vegetativae axillares autumnoprofuse formatae. Numerus chromosomatum $2n = 60$. Pollen majus quam in *E. cicutario*, 58—59 μ diam.

Hab. in arenosis Daniae.

Typus juxta viam prope Vesterø insulae danicae Læsø lectus, in Horto Botanico Hauniensi cultus, postea siccus in Museo Botanico Hauniensi depositus.

Going through the Danish collections from Herb. C it was found that such large forms with proliferating shoots have been found elsewhere in Denmark. It is interesting that the oldest find of this species is just from Læsø (1870, coll. J. P. JACOBSEN). *E. danicum* seems to prefer sandy localities near the coast. It is possible that a form without glutinous hairs (but with large inflorescences, fine dissected leaves and autumnal proliferation) exists within *E. danicum*.

The author is aware that the characters distinguishing *E. danicum* from some *E. cicutarium* (L.) L'Her. types are subtle, on the other hand *E. danicum* is a genetically distinct unit separated from *E. cicutarium* by a sterility barrier and may thus be regarded as a specific evolutionary unit quite different from subsp. *arvale* and subsp. *dunense*, between which gene exchange is possible. In such a case the only consistent solution is, in spite

of the slight morphological deviations from the tetraploid plant, to regard it as a separate species.

Another question which arises in this connection is: how has



Figs. 11. British *E. cicutarium* subsp. *dunense*. Collected in nature July 24, 1954.

the hexaploid species developed? Unfortunately meiosis has not been studied, but the pollen seems to be quite normal and dwarf pollen is completely absent. Furthermore, the fruit-setting is also normal. Both indicate a regular meiosis. A polyploid plant with normal meiosis might have developed through amphidi-

ploidy. Here it is obvious to think of a diploid and tetraploid parent, and as a working hypothesis, until further experimental studies have been procured, it may be natural to think of *E.*



Fig. 12. British *E. cicutarium* subsp. *dunense*, No. 4448 grown in the experimental field, coll. in the middle of Sept. 1955.

glutinatum Dum. and *E. cicutarium* (L.) L'Her. as the two parents:

$$\begin{array}{rcc}
 E. \textit{glutinatum} \times E. \textit{cicutarium} \textit{ ssp. arvale} \rightarrow E. \textit{danicum} \\
 2n = 20 \qquad \qquad 2n = 40 \qquad \qquad 2n = 60
 \end{array}$$

Therefore it cannot be taken for granted that *E. glutinosum* is to be found in Denmark. It is possible that *E. danicum* is much more widely distributed than known at present and may have invaded Denmark from the South. Further studies of the West European dune forms of *Erodium* therefore are highly needed. Also a synthetisation of the amphidiploid should be tried.

IV. Experimental Cultivations.

WARBURG (1938) tried to grow strains of *E. cicutarium* coll. from different habitats but without great success. More intensive



Fig. 13. *E. glutinosum* from nature, No. 4455.

cultivations were carried out by ANDREAS (1946). These show that subsp. *dunense* was rather difficult to grow on ordinary soil; the plants started flowering very late and some did not flower at all in the first summer, but hibernated in mild winters and flowered the following summer, while in severe winters (e.g. 1941/42) no strains were able to hibernate.

In the present experiments the greatest trouble has been the low germination percentage of the seeds, and the author is aware

of the insufficiency of the number of plants in the experiments; nevertheless some of the data have been put in tabular form.

The species have been grown in the experimental field of



Fig. 14. *E. cicutarium* subsp. *arvale* No. 2298 grown in the experimental field and showing typical appearance of the field weed.

the Botanical Gardens of the University of Copenhagen. The soil there is heavy clay, very dry in summer.

E. cicutarium (L.) L'Her. In the summer of 1956 a number of strains from the British Isles and Denmark were grown in this experimental field. In Table IV these plants have been arranged according to their ability to produce flowers. It is evident, in spite of the regrettably low number of individuals in the batches,

TABLE IV.
Cultivations 1956.

Material of *E. cicutarium* subsp. *dunense* (4459—4452), *E. cicutarium* subsp. *arvale* (4457—4238), *E. danicum* (4239—4243) and *E. glutinosum* (4455). The Cult. Nos. are explained in Table II.

Cult. No.	5. 8. 56			25. 9. 56		
	Rosette	Flowers + rosette	Flowers - rosette	Rosette	Flowers + rosette	Flowers - rosette
4459	1	—	—	1	—	—
4451	9	—	—	8 ¹	—	—
4454	12	—	—	6	4	—
4450	10	—	—	4	6	—
4446	8	—	—	—	7	—
4447	13	—	—	—	11	—
4456	2	—	—	—	2	—
4448	4	2	—	—	5	—
4452	—	2	—	—	—	2 ²
Total	59	4	—	19	35	2
4457	—	13	—	—	—	11
4098	—	2	1	—	—	3
4238	—	—	1	—	—	1
Total	—	15	2	—	—	15
4239	—	—	2	—	—	1
4240	—	—	2	—	—	2
4243	—	—	1	—	—	1
Total	—	—	5	—	—	4
4455	2	—	—	—	—	2

¹ When, as in this case, there are fewer plants on the 25. 9. than the 5. 8., this is due to some specimens preserved for the herbarium.

² Perhaps the strain has hybridized with subsp. *arvale*.

that the tetraploid British dune types (Figs. 11—12) practically do not flower under the present conditions while the tetraploid British weed as well as the Danish field weed (cp. Fig. 14) flowered abundantly. From the table it is seen that out of 63 individuals belonging to 9 different samples of *E. cicutarium* subsp. *dunense* from the British dunes only 4 had started flowering on 5. August, while 59 were still vegetative rosettes. The 4 flowering individuals still had large rosettes. One and a half month later, on 25. September, 19 out of 56 individuals alive

at that time were still vegetative, while 35 were flowering, but all the 35 with rosettes, only the two plants of No. 4452 from Wales had lost their rosette leaves. Perhaps this deviating strain had



Fig. 15. *E. danicum* No. 4240 grown in the experimental field, collected Sept. 1955.

suffered hybridization with *E. cicutarium* subsp. *arvale*. The 3 samples of *E. cicutarium* subsp. *arvale* all lost their rosette leaves during the autumn and flowered abundantly. These facts suggest that subsp. *dunense* in nature is a hibernating annual.

In the rather severe winter 1955/56 all strains died, whether they had flowered or not.

Cultivations carried out in previous years are all in close accordance with those of ANDREAS, thus in the mild winter of 1950/51 some few individuals of the strains 1202 from Holland and 2212 from Denmark, N. Zealand, hibernated.

It is evident that the general conditions given in the expe-

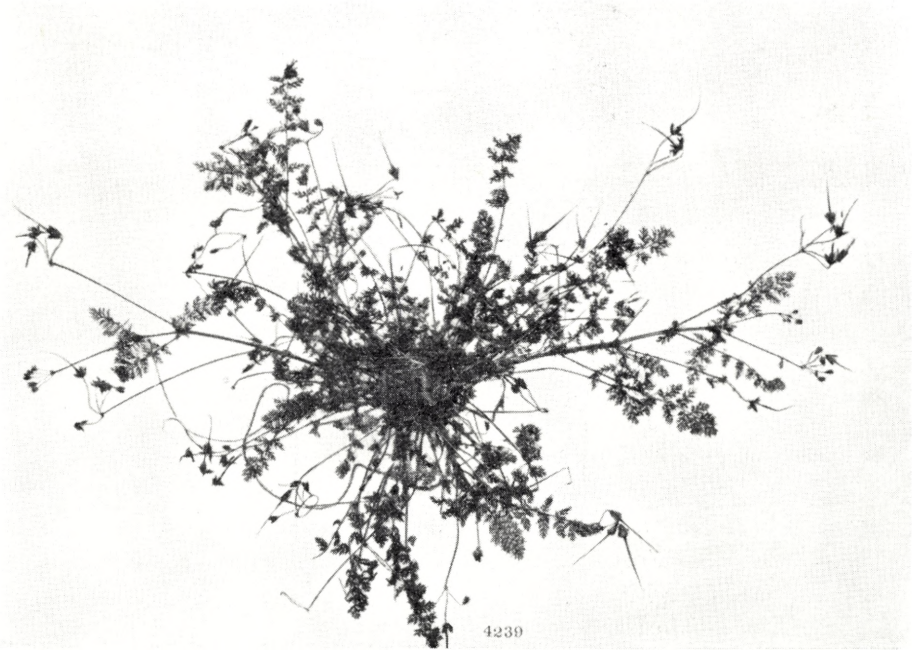


Fig. 16. *E. danicum* No. 4240 the type specimen grown in the experimental field, collected Sept. 1955.

rimental field have promoted the development of the vegetative part of the plants. These large rosettes are much more sensitive to the winter than the small rosettes developed in nature.

E. danicum K. Lars. behaved nearly as subsp. *arvale* (cp. Table IV). It developed a short-lived rosette and got very long branches which in the autumn, as described above, developed new rosettes in the leaf axils.

E. glutinosum Dum. In the vegetative parts this species deviated from the other dune *Erodiums* in so far as the rosette leaves were ascending, while in *E. cicutarium* (L.) L'Her. they were always decumbent. The batch consisted of two plants only. In

the last part of September they ceased flowering and were without rosette leaves, but had many vegetative shoots.

E. maritimum (Burm. fil.) L'Her. The seeds germinated in the last part of April. The plant flowered luxuriantly all the summer from the last part of June until the autumn, when the rosettes had reached a diameter at about 25 cm. In August new seedlings originated from seeds of the fruiting plants. They germinated in a large number in the experimental field; no doubt the species is able to produce two generations a year in climates which allow the seedlings to hibernate.

E. hirtum. The species remained vegetative during the first summer. The plants developed glabrous rosettes and a root system bearing characteristic globular tubers. These vegetative plants all died during the winter, even if they were hibernated in greenhouse at 7° C.

V. Observations in Nature.

According to JOHANSEN (1899) *Erodium cicutarium* (L.) L'Her. as a rule is a hibernating annual on Gotland. FRIES (1866) mentions that in dry places in Scania (S. Sweden) an early spring type is to be found which has hibernated with a very short stem ("subacaule"). FRIES regards this type (designated as a species by JORDAN) as a biennial form of the common annual field weed. The biennial form may be identical with var. *crassicaule* in SYLVÉN (1906, p. 179, Fig. 2 c, d, and Fig. 17 in the present paper), a variety to be found to be the commonest type on the limestone pavement ("alvar") on Öland. It seems exclusively to be a hibernating annual. Also summer annuals are reported from Scandinavia by several authors.

In Denmark it is obvious that on dry sandy hills in Northern Zealand *E. cicutarium* (L.) L'Her. behaves as a hibernating annual together with a number of other hapaxanthic species (e. g. *Trifolium arvense*, *Jasione montana*, *Cerastium semidecandrum*, etc.). Small rosettes were observed in the middle of December 1955; at that time rosette diameters of 5—8 cm were measured on the slopes at the southern end of the lake Esrum Sø. The same locality was visited again in the middle of April 1956. The rosettes had all hibernated in contrast to those of the experimental field. They had not increased in diameter, but small buds were

observed among the rosette leaves. Some plants transferred to room temperature (Fig. 17) developed flowers within ten days. These specimens could be referred to the same spring type (var. *crassicaule*) as mentioned by SYLVÉN and FRIES.

Some of the "spring-type plants" were transplanted to the



Fig. 17. Hibernated rosette of *E. cicutarium* collected in the middle of April 1955 (cp. the text on p. 22).

Botanical Gardens. They developed to normal subsp. *arvale* and showed the chromosome number $2n = 40$. Thus the statement of LÖVE & LÖVE (mentioned above, p. 6) could not be confirmed on Danish material.

It is the author's impression that *E. cicutarium* (L.) L'Her. is most frequently a hibernating annual on dry slopes and in dunes (both subsp. *arvale* and subsp. *dunense*), whereas the field weed most frequently is a summer-annual.

Another purpose of the present investigations has been to establish whether the northern limit of *E. glutinosum* does reach Scandinavia. A study of the collections from Denmark in Herb. C

has revealed some small glutinous plants which have not developed mature fruits. In morphological appearance they were close to the description of the hybrid *E. cicutarium* × *glutinosum* (*E. anaristatum* Andreas). *E. glutinosum*, however, was not represented in the Danish collection. On the other hand, few sheets from the West Jutland dune areas were available. On travels in 1951 along the Jutland west coast from the South to the North the dune types of *Erodium* were studied; only subsp. *dunense* (Figs. 9—10) seems to be present there. The sterile forms mentioned above may have developed through poor nutrition or other unfavourable environmental factors.

VI. Summary.

1. The chromosome number of the following species of *Erodium* have been counted in material from natural habitats (see Table II): *E. hirtum* (Forsk.) Willd. subsp. *maroccanum* Maire, $2n = 20$; *E. maritimum* (Brum. f.) L'Her., $2n = 20$; *E. glutinosum* Dumort., $2n = 20$; *E. cicutarium* (L.) L'Her., $2n = 40$ (both subsp. *dunense* Andreas and subsp. *arvale* Andreas); *E. danicum* K. Lars., $2n = 60$.
2. A hexaploid cytotype of *E. cicutarium* coll. found in five localities in Denmark is established as a new species, *E. danicum* sp. nov. It is suggested to be an amphidiploid between *E. glutinosum* and *E. cicutarium* subsp. *arvale*.
3. Experimental cultivations with the two subspecies of *E. cicutarium* and *E. danicum* were carried out and summarized in Table IV. When grown as summer annuals plants of subsp. *dunense* very often do not reach flowering, while subsp. *arvale* and *E. danicum* always developed flowers.
4. Observations on *E. cicutarium* in nature has shown that summer-annuals as well as winter-annuals occur in Denmark. They were both found to be tetraploid. Thus the statement of diploid spring forms from Sweden could not be confirmed.
5. A search for *E. glutinosum* in the dune areas along the Danish North Sea coast gave no results. It is possible that it has its northern limit close south of the Danish frontier and that only the more robust *E. danicum* has been able to migrate further North.

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