Drawings of Scandinavian Plants 13–14

Eleocharis R. Br.

By Sven-Olov Strandhede and Rolf Dahlgren [1]

Institute of Systematic Botany
University of Lund, Sweden

Eleocharis multicaulis (Sm.) Sm.

[*Scirpus multicaulis* Sm., *S. palustris* L. sensu ampl. p.p.]

The species treated earlier (Fasc. I and II) belong to ser. *Eleocharis* (syn. *Palustriformes* Svens.), subser. *Eleocharis* [syn. *Palustres* (C. B. Clarke) Svens.] and have bifid styles and biconvex achenes. The species treated here, *E. multicaulis*, belongs to ser. *Multicaules* Svens. with trifid styles and trigonous achenes.

Rhizomes stout with extremely short internodes and numerous side shoots giving caespitose plants with the basal parts closely embedded in withered old shoots and adventitious roots. Basal sheaths of the culms pale brownish to yellowish or greenish with minute red spots, rarely reddish, at least near the base; orifice oblique, often with a marked tip.

Culms about 1 mm in diameter, often bowbent, 10—50 cm; collenchyma strands rather stout and numerous, normally 1—3 epidermal cell rows between them; normally two palisade layers and two or more parenchyma layers in the interspaces between the vascular bundles, resulting in dark, non-translucent, commonly ± olive green or ± yellowish-green culms. Cell walls rather thick; stomatal guard cells longer than the subsidiary cells (though not protruding as in *E. mamillata*), resulting in convex short ends of the stomata; stomatal length 55—80 μ.

Spikes of about the same length and shape as in *E. uniglumis*, though less variable (6—14 mm). *Basal glumes of the spike amplexicaul, less*

[1] Strandhede is responsible for the text and Fig. 1, Dahlgren for the drawings.

than half the length of the spike [length (2—) 2.5—3 (—3.5) mm, width (1.5—) 2—2.5 (—3) mm], *with a broad green midrib and a broad hyaline margin commonly split in the rounded tip, 1(—2) sterile.* Fertile glumes 3.8—4.6 mm, rounded and brownish (sometimes blackish) with a ± broad greenish, or later yellowish midrib and ± brownish hyaline margins, sometimes split in the tip as in the case of the sterile basal glume. Total number of flowers frequently 20—30 (—36); receptacle density 25—36 fruits per cm of the rachis.

A shoot, developed from an adventitous bud, often found in the axil of the basal glume of the spike (false vivipary). These adventitous shoots often reaching the water or ground because of the frequently bowbent culms, developing occasionally into spike-producing plants while still in the mother spike (see figure).

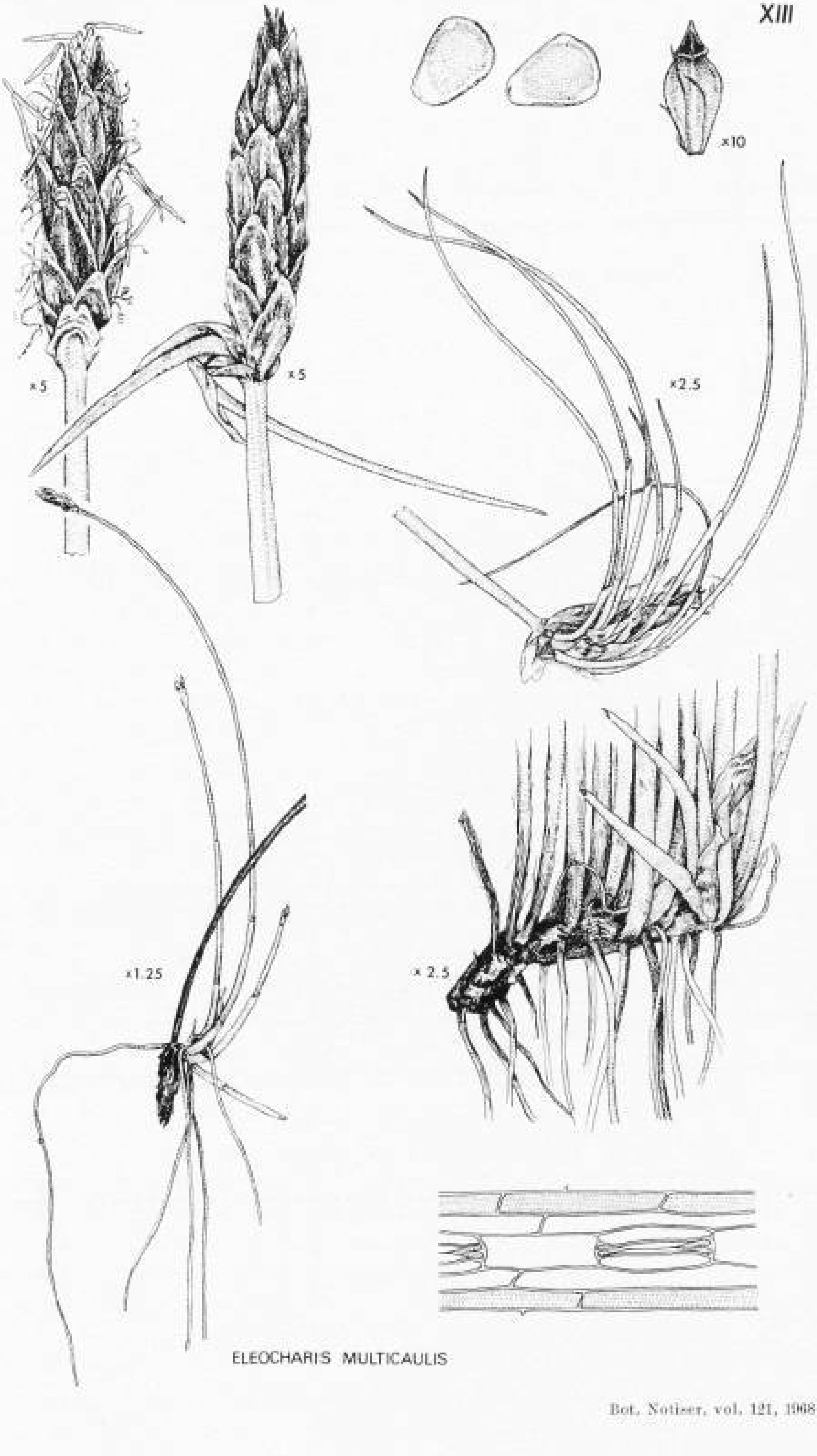
Thecae yellow, 1.8—2.5 (—2.8) mm long. Pollen grains sector- or sac-shaped; length 45—60 μ, width 30—40 μ.

Achene shape angularly trigonous, pyriform to obovate in outline; length (1.3—)1.4—1.8 mm, width 0.7—1.0 mm; colour greenish to blackish-brown; surface rather smooth. *Styles trifid. Style bases prominently developed, somewhat necked or almost sessile; shape angularly trigonous, pyramidal;* length 0.4—0.6 mm, width 0.3—0.4 mm. Bristles 3, well developed and sometimes 1—3 ± rudimentary; barbs short, adpressed.

Chromosome number 2n=20 (Fig. 1) (heteroploid chromosome numbers occur).

E. multicaulis prefers shallow, stagnant, oligotrophic waters with muddy bottoms. Its distribution in Europe is ± atlantic: in Scandinavia it occurs from Bergen in W. Norway south- and eastwards below the mountains and in the southwestern parts of Sweden. Though lacking in eutrophic, calcareous areas, it is collected in pure calcareous mud ("kalkbleke"), poor in nutriment, at Böda, Öland. In Denmark it occupies wet sites in the oligotrophic western parts of Jutland. It is also reported from the Faeroes.

Outside Scandinavia, it occurs in the British Isles and West Europe through the western parts of Germany, France, NW. Spain and Portugal. East of this area, it is known only in small, isolated populations in East Germany, Poland, Trieste, Liguria, Corsica, Sardinia, and Aragon. It is also known in Morocco.



ELEOCHARIS MULTICAULIS

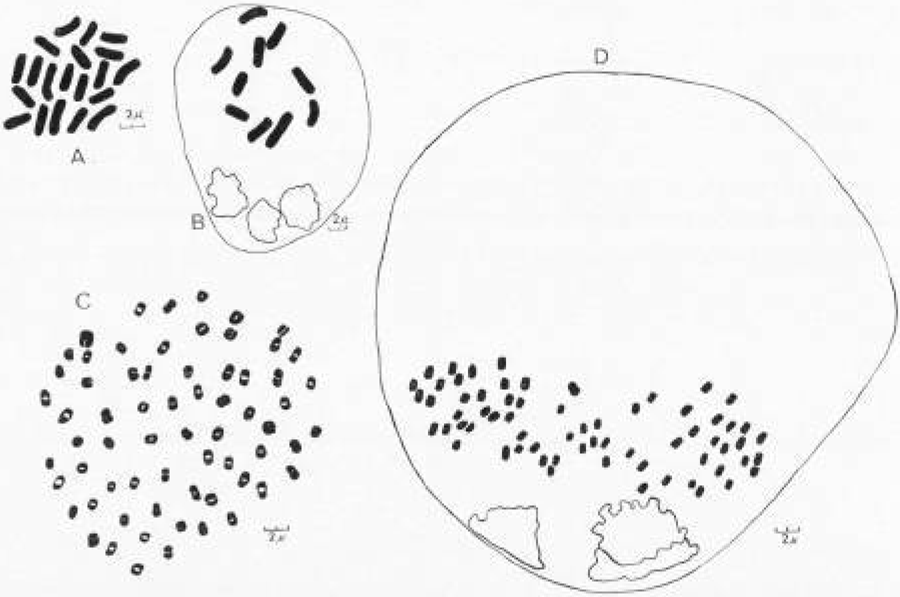


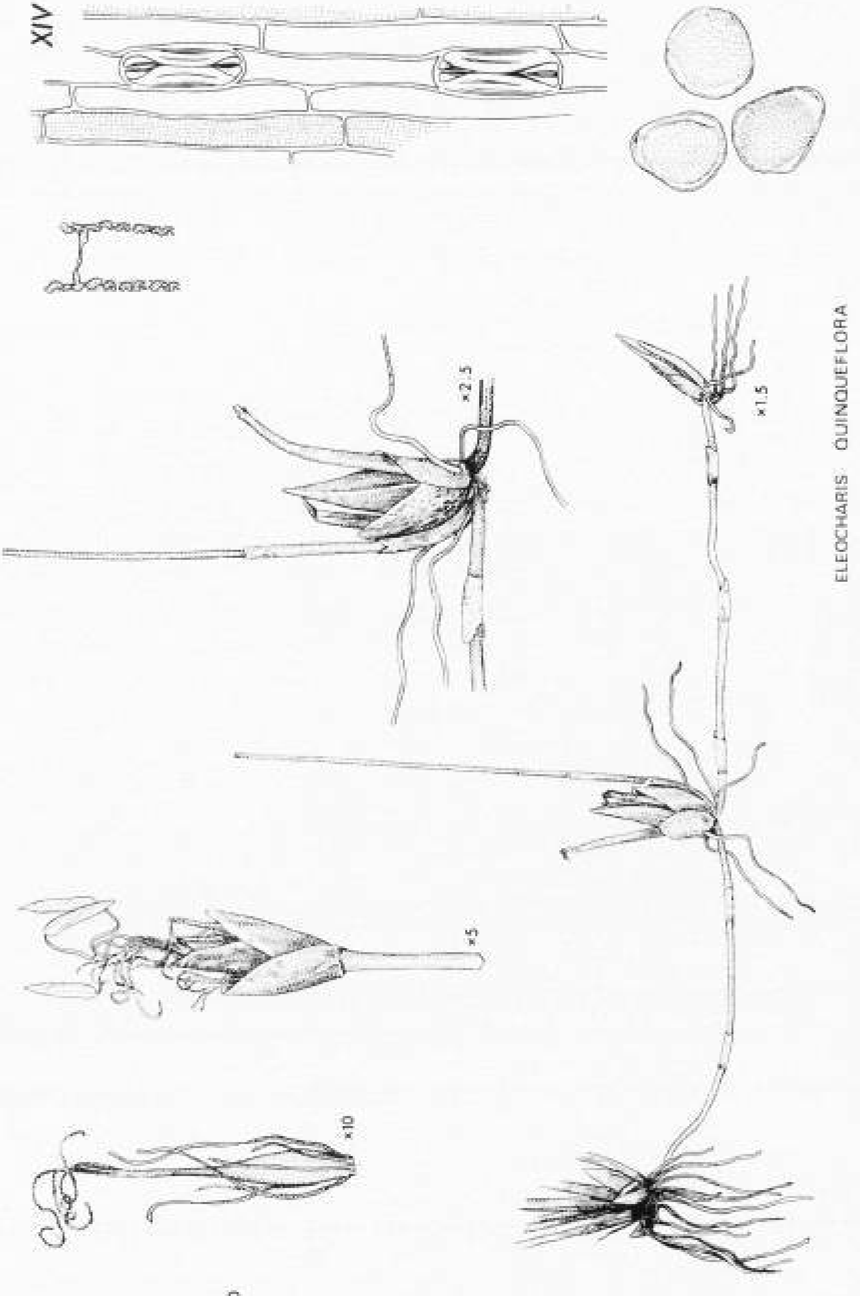
Fig. 1. A—B: *Eleocharis multicaulis.* — A: 2n=20 in a root mitosis (plant no. 058804 from Sweden, Bohuslän, Uddevalla, Kroksjön). — B: 2n=10 in a first pollen mitosis (plant no. 050504 from Sweden, Skåne, Örkened, S. Smesjön). — C—D: *E. quinqueflora* (plant no. 029601 from Skåne, Skanör, Skanörs ljung). — C: 66 bivalents in a first metaphase. — D: n=66 in a first pollen mitosis.

E. quinqueflora (F. X. HARTM.) O. SCHWARZ

[*Scirpus quinqueflorus* F. X. HARTM., *S. pauciflorus* LIGHTF., *E. pauciflora* (LIGHTF.) LINK]

This species and *E. parvula*, treated in Bot. Notiser 121 (4), belong to ser. *Pauciflorae* SVENS., characterized by their trifid styles and style bases, which are confluent with the apex of the achenes.

Rhizomes slender and monopodial for about 3—5 nodes with 2—3 cm long internodes, then producing an assimilating culm surrounded by two basal sheaths corresponding to those of the other species. The next shoot generation, developed in the axil of the first basal sheath of the culm, may continue the rhizome, but *more often the following internodes are extremely short, and a cluster of assimilating shoots or, in autumn, a c. 1 cm high and broad bud is produced and serves as a resting organ.* From this bud new generations of assimilating shoots and rhizomes are developed next year. Basal sheaths of the culms


XIV
ELEOCHARIS QUINQUEFLORA
×2.5
×1.5
×5
×10
×10

green to pale reddish-brown, often with reddish bases, orifice straight or somewhat oblique, often with a dark margin.

Culms thin (0.3—0.5 mm in diameter), (3—) 7—20 (—30) cm high; collenchyma strands strong and numerous, usually less than 5 epidermal cell rows between them; commonly one well developed palisade layer and 2—3 ± parenchymatous layers in the interspaces between the vascular bundles, resulting in dark, non-translucent, ± pure to greyish-green culms. *Cell walls thick and markedly undulated, especially along the collenchyma strands.* (Though more markedly in *E. quinqueflora*, as shown in a figure, all taxa have a ± undulated pattern of the cell walls because of the pits between adjacent cells; this pattern is not drawn in the figures of the stomata.) Stomatal guard cells longer than the subsidiary cells, resulting in convex but not protruding short ends of the stomata; stomatal length (50—) 55—70 (—75) μ.

Spikes shorter than 1 cm; *basal glumes amplexicaul, reaching to half the length of the spike or more* (length 2.5—5 mm, width 1.5—3 mm), commonly brown with a marked ± broad, greenish, later brownish midrib, normally with a flower in its axil. Fertile glumes 3.5—4.5 (—6) mm, somewhat obtuse to acute, commonly brown to blackish-red, with a ± keeled midrib and ± brownish hyaline margins during prefloral and floral stages, when older increasingly brownish and membranaceous. *The total number of flowers few, up to eight*; receptacle density 22—37 fruits per cm of the rachis. (The exactness of this value is low as the racheae are shorter than 4 mm.)

Thecae pale yellow and 1.5—2.5 mm. Pollen grains sector- or sac-shaped; pollen length 36—50 μ, width 30—40 μ.

Achene shape angularly trigonous and pyriform to obovate in outline, *with a protruding apex*; length 1.7—2.3 mm, width 1.0—1.3 mm; *colour ± lustrously grey because of a white, epidermal reticulation corresponding to the radial cell walls on the black background of the interior cells; surface smooth. Styles trifid. Style bases at the apex of the achenes black and confluent with the apex.* Bristles (0—) 6 (—8), as long as the achenes or shorter than them (or rudimentary), often unequally developed; barbs rather short, retrorse.

Chromosome number $n=66$ (Fig. 1), $n=67$ in different plants, and $n=66$ and 67 in different first pollen mitoses of the same anther.[2]

[2] The chromosome numbers $2n=132$ and $2n=134$ in H. WEIMARCK: Skånes Flora (1963) and N. HYLANDER: Nordisk Kärlväxtflora II (1966) both refer to my determinations of haploid chromosome numbers in meiotic metaphase I and first pollen mitosis.

E. quinqueflora prefers eutrophic localities. It is most common in wet meadows along the coast, but also occurs in rich fens in the lowlands as well as in the Scandinavian mountains.

It is to be found in large parts of Europe, northwards to Iceland and Kola Peninsula, southwards to the Balkans, and through Asia to the Far East; it also occurs in North America.

A New Species of Lonchostoma (Bruniaceae)

By Arne Strid
Institute of Systematic Botany
University of Lund, Sweden

ABSTRACT

The new species *Lonchostoma esterhuyseniae* STRID is described from Riversonderend Mountains (Caledon Div.), Cape Prov., South Africa. The four previously known species of the genus are all restricted to the SW Cape Province, ranging from the Palmiet River Valley to the Ceres and Clanwilliam Divisions. *L. esterhuyseniae* seems to be most closely related to *L. pentandrum* (THUNB.) DRUCE, which is recorded from a few localities in the Ceres and Clanwilliam Divisions.

Lonchostoma esterhuyseniae STRID sp. nov.

Frutex dense ramosus, foliis imbricatis villosis, capitulis paucifloris terminalibus. Corolla rubra, tubo angusto, segmentis obovatis.

Original collection: Cape Province, Caledon Div.: Riversonderend Mts., large, vertical rocks facing S, ca. 1 mile W top of Pillaarkop, 1440 m s.m. DAHLGREN and STRID no. 4233, 17.11.1965 (holotype NBG; isotypes BOL, K, LD).

Shrub vigorous, much branched, 50—100 cm high, rather dense and wide. Branchlets villous, suberect to ascending, closely leafy towards the tip, lower down defoliated, glabrate, and marked with leaf scars; cortex greyish brown. *Leaves* ascending to appressed, imbricate, 4—7 mm long, 2—3 mm broad, elliptic, acute, with a short black mucro, concave and glabrous beneath, convex and villous above, becoming glabrate when old or retaining hairs at the margins. *Flowers* in the axils of very slightly reduced leaves, sessile, with two bracteoles, in 4—7-flowered terminal heads. Bracteoles 2.5—3.5 mm long, 1—1.5 mm broad, lanceolate, acuminate, with a black mucro, navicular, membranous, villous on the upper half of the dorsal face, ciliate. *Calyx* submembranous, red; calyx-tube obconic, 5—6 mm long, glabrous; calyx-lobes 5, 2—2.5 mm long, lanceolate, acuminate, with black

Fig. 1. *Lonchostoma esterhuyseniae* STRID. A branch from the holotype specimen.

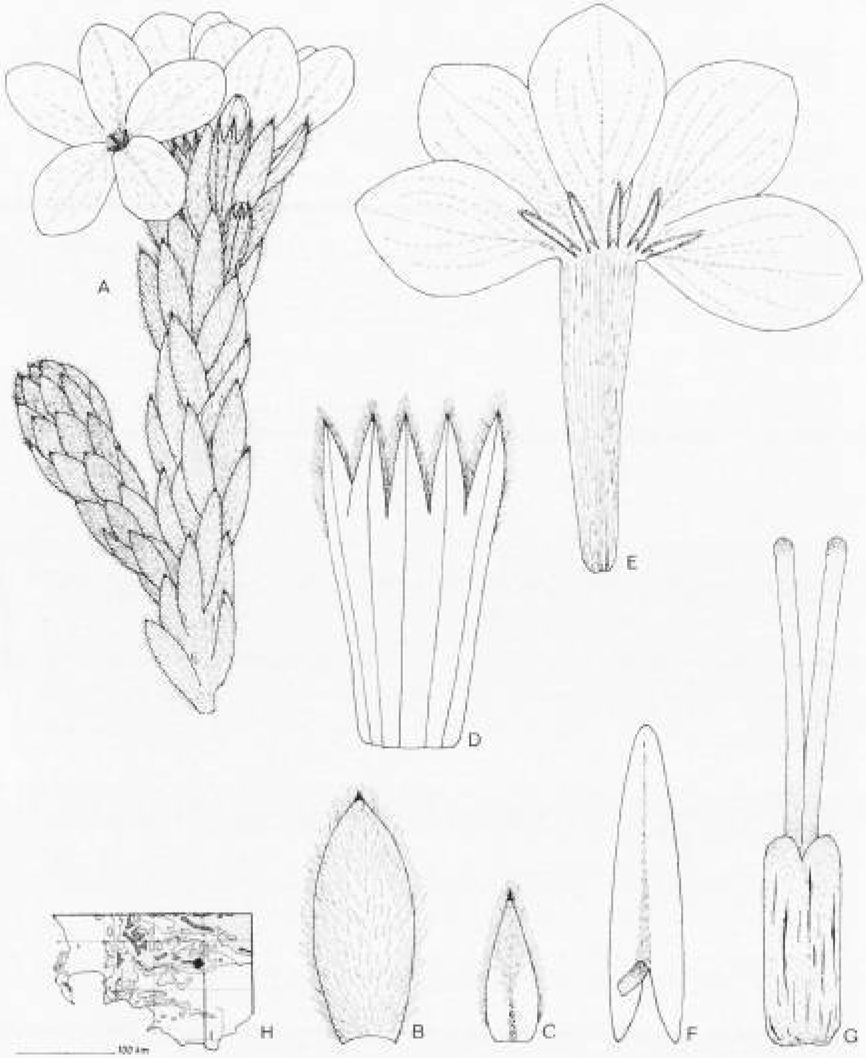


Fig. 2. *Lonchostoma esterhuyseniae*; DAHLGREN & STRID no. 4233. — A: Branchlet. — B: Bract. — C: Bracteole. — D: Calyx opened; seen from inside. — E: Corolla with tube opened; seen from inside. — F: Stamen. — G: Pistil. — H: Map indicating the type locality. — (A ×2.5; B—E ×6; F—G ×18).

mucros, villous on the back, ciliate. *Corolla* glabrous, red; corolla-tube 7—10 mm long, narrow, obconic, free from the ovary, with an external fringe of hyaline hairs at the base; corolla-segments 5, 4.5—6 mm long, 3—4 mm broad, obovate. *Anthers* 5, subsessile, glabrous, inserted in the mouth of the corolla-tube, ca. 2 mm long, lanceolate, sagittate at the base, dehiscent before the flower opens. *Ovary* superior, oblong, 1.5—2 mm long, 0.5—0.7 mm broad, glabrous, with indistinct ribs, imperfectly bilocular, 10—16-ovulate; styles 2, free, slender, 2—2.5 mm long; stigmas minute.

L. esterhuyseniae is only known from a single locality. It was found in crevices on rather wet rocks with temporarily siltering water. When flowering, the subglobose, densely branched shrubs are visible from a long distance by their intensely red colour. Only a few individuals were found, but the species might well occur on additional localities in the rather inaccessable part of the Riversonderend Mountain range lying west of Pillaarkop.

It is a pleasure to name this handsome species after the eminent collector Miss Elsie Esterhuysen of the Bolus Herbarium, Cape Town, who joined the climb on which it was found.

The genus *Lonchostoma* Wikstr. is a small one, containing five species (including *L. esterhuyseniae*), all confined to the south-western part of the Cape Province like the majority of species in the family *Bruniaceae*. The family, which is endemic in South Africa, was revised by Pillans (1947). According to Phillips (1951) there are twelve genera with about 75 species, which are mainly confined to the south-western districts of the Cape Province. The genus *Lonchostoma* is characterized by having unusually large flowers with the petals connate into a tube. The species are virgate shrubs with closely packed, sessile leaves, and flowers in terminal leafy heads. A drawing and description of *L. monogynum* (Vahl) Pillans was published in The flowering plants of South Africa 3 (1923), plate 118. This species differs from the others in having the styles firmly connate throughout. *L. esterhuyseniae* is a distinct species; it seems to be most closely similar to *L. pentandrum* (Thunb.) Druce, which is recorded from a few localities in the Ceres and Clanwilliam Divisions, and differs from *L. esterhuyseniae*, i.e. in having more dense-flowered heads and globose, villous and partly inferior ovary.

LITERATURE CITED

PHILLIPS, E. P. 1951. The genera of South African flowering plants (ed. 2). — Bot. Surv. S. Afr., 25.

PILLANS, N. S. 1947. A revision of Bruniaceae. — Journ. S. Afr. Bot. 13: 121—203.

POLE EVANS, I. B. (Ed.) 1923. The flowering plants of South Africa, vol. III.

A Note on the Chemical Strains of the Lichen Ramalina subfarinacea

By D. L. Hawksworth

Botanical Laboratories, School of Biology
University of Leicester, England

ABSTRACT

The lichen *Ramalina subfarinacea* (NYL. ex CROMB.) NYL. is distinguished from the *R. farinacea* (L.) ACH. complex by the presence of depsidones of the β-orcinol group with a lactol linkage. The taxonomic treatment of chemical races in lichens is discussed, and, in this instance, it is concluded that the status of varietas is most appropriate for the chemical races of *R. subfarinacea*. Three varieties are recognised within *R. subfarinacea* on the basis of the depsidones present in the medulla: var. *subfarinacea* (norstictic acid) which is restricted to maritime rocks; var. *reagens* (B. DE LESD.) HAWKSW. comb. nova (norstictic and salazinic acids) which occurs on both trees and siliceous rocks; and var. *salazinica* HAWKSW. var. nova (salazinic acid) which has only yet been found on deciduous trees.

A recent revision of the *Ramalina farinacea* complex in Europe (CULBERSON 1966) recognised five species — *R. farinacea* (L.) ACH. with protocetraric acid, *R. hypoprotocetrarica* CULB. with hypoprotocetraric acid, *R. subfarinacea* (NYL. ex CROMB.) NYL. with norstictic acid, *R. reagens* (B. DE LESD.) CULB. with both norstictic and salazinic acids, and *R. pollinaria* (WESTR.) ACH. with evernic acid. With the exception of *R. reagens* and *R. subfarinacea* the species can be distinguished by a combination of morphological characters and spot tests on the medulla using potassium hydroxide (K) and para-phenylenediamine (PD) (CULBERSON op. cit.; WADE 1961; LAUNDON 1965).

R. subfarinacea s. str. and *R. reagens*, however, appear to be morphologically identical and cannot be distinguished conclusively by spot tests (medulla K+yellow turning red and PD+yellow turning orange or red in both cases) or by microcrystalline tests (as usnic acid, or the occurrence of norstictic and salazinic acids together, may interfere) and so must be determined chromatographically. In order to determine a specimen of *R. subfarinacea* s. lat. from the Sidlaw Hills, Perthshire, Scotland, an acetone extract of the washed plant was examined by paper chromatography (using Whatman No. 1 chromatography paper and a solvent system of n-butanol, 4 : ethanol, 1 : water, 5 (upper phase) at 20°C). From the result it appeared to contain only salazinic acid and this was later confirmed by co-chromatography with authentic samples of salazinic (Rf=0.52; PD+orange yellow) and norstictic (Rf=0.63; PD+lemon yellow) acids. It was also found that if specimens of this group containing only salazinic or only norstictic acid were extracted with benzene (to remove most of the usnic acid) and then re-extracted with acetone, both these acids gave characteristic reddish crystals in KK-solution (equal parts of 5 % aqueous KOH and 20 % K_2CO_3; CULBERSON 1967).

Ramalina subfarinacea (NYL. ex CROMB.) NYL. Bull. Soc. Linn. Normand. ser. 2. 7: 258 (1872). — *R. scopulorum* var. *subfarinacea* NYL. ex CROMB. Journ. Bot. (London) 10: 74 (1872).

var. **subfarinacea.** — Lectotype: Scotland, coast of Kincardineshire. Leg. CROMBIE (H). Designated by CULBERSON (1966 p. 849). Contains only norstictic acid in the medulla.

var. **reagens** (B. DE LESD.) HAWKSW. **comb. nov.** — *R. farinacea* var. *reagens* B. DE LESD. Bull. Soc. Bot. France 67: 217 (1920). — Holotype: probably destroyed in World War II (CULBERSON 1966 p. 847). Contains both norstictic and salazinic acid in the medulla.

var. **salazinica** HAWKSW. **var. nov.** — Planta ut in *R. subfarinacea* (NYL. ex CROMB.) NYL. var. *subfarinacea* sed materia chemica medullae differt; medulla et soralia KOH+flavescens se vertens rubescens et PD+lutescens se vertens aurantiaca; acidum salazinicum (non acidum norsticticum) solum continens. Apothecia et pycnidia ignota.

Holotypus: Scotia, Perthshire, Fingask proxima Rait, Sidlaw Hills, ad corticem *Fraxini excelsioris*, 8.V.1968, Leg. P. B. TOPHAM, s. n. (BM). Contains only salazinic acid in the medulla.

R. subfarinacea, as understood here, is an entity within the *R. farinacea* complex distinguished by depsidones of the β-orcinol group with a lactol linkage. Structurally salazinic and norstictic acids are very similar (Fig. 1), differing in a single hydroxyl group, and so, if the production of lichen depsidones is genotypically controlled, may indicate a difference of only a very limited number of genes or linkage groups between the three varieties recognised above.

Habitat preferences of different chemical races in the *R. siliquosa* complex have been demonstrated by CULBERSON & CULBERSON (1967), and habitat differences are also indicated in the *R. subfarinacea* complex. *R. subfarinacea* var. *subfarinacea* appears to be confined to mari-

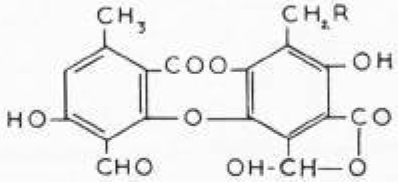


Fig. 1. Chemical structure of norstictic (R=—H) and salazinic (R=—OH) acids.

time rocks, while var. *salazinica* has only yet been found on trees. *R. subfarinacea* var. *reagens* has a wider ecological amplitude than either of the two other varieties, occurring both on trees, to which it was previously thought to be confined (CULBERSON 1966; LAUNDON 1965), and on rocks (e.g. granite: Ronas Hill, Shetland, 22.VII.1966, leg. D. L. HAWKSWORTH no. 542; sandstone: Boarhills, Fife, 12.V.1968, leg. P. B. TOPHAM).

The taxonomic treatment of chemical races in lichens is still a matter of debate (cf. LAMB 1968), but it seems undesirable to recognise these at the specific level when they only differ in a single character. The use of the term "chemical strain" has much recommend to it (LAMB 1951; ALMBORN 1965) but it has not been accepted by the International Code of Botanical Nomenclature (LANJOUW et al. 1966). "Chemovar." was proposed as the solution by TÉTÉNYI (1958) and introduced into lichenology by TARGÉ & LAMBINON (1965). LANJOUW (1958) considered that such races should be accommodated into the normal taxonomic categories.

R. subfarinacea var. *subfarinacea*, var. *reagens*, and var. *salazinica*, appear to behave in a manner parallel to the ecotypes of angiosperm taxonomists, but, in the absence of any evidence for gene-exchange, the status of "varietas" appears to be the most appropriate. In this case chemical races cannot be treated as subspecies since the geographical ranges are unknown and no intermediates have been found.

R. subfarinacea has previously been reported as containing only salazinic acid by ZOPF (1907) and GALUN & LAVÉE (1966). The specimens studied by GALUN & LAVÉE, from basalt rocks, at Har Admon, Ras el Ahmar, Galilee, Israel, were, however, only examined by microcrystalline tests and not by chromatography, and so may belong to var. *reagens* (under which they were placed by CULBERSON 1966) and not var. *salazinica*.

I am indebted to Dr. S. HUNECK (Tharandt, Dresden, Germany) for the gift of a pure sample of salazinic acid, to Dr. D. M. MOORE (Leicester) for his help in the preparation of the manuscript, and to Professor W. L. CULBERSON (Durham, North Carolina, U.S.A.) for his helpful correspondence on the taxonomic treatment of chemical strains in lichens.

LITERATURE CITED

ALMBORN, O. 1965. The species concept in lichen taxonomy. — Bot. Notiser 118: 454—457.

CULBERSON, W. L. 1966. Chimie et taxonomie des lichens du groupe Ramalina farinacea en Europe. — Rev. Bryol. Lichenol. 34: 841—851.

— 1967. Analysis of chemical and morphological variation in the Ramalina siliquosa species complex. — Brittonia 19: 333—352.

— & CULBERSON, C. F. 1967. Habitat selection by chemically differentiated races of lichens. — Science 158: 1195—1197.

GALUN, M. & LAVÉE, H. 1966. Lichens from Her Meron (Jebel Jermak), Upper Galilee. — Bryologist 69: 324—333.

LAMB, I. M. 1951. Biochemistry and taxonomy of lichens. — Nature 168: 38.

— 1968. Chemotaxonomy in the lichens. — Int. Lichenol. Newsletter 1(3): 1—4.

LANJOUW, J. 1958. On the nomenclature of botanical strains. — Taxon 7: 43—44.

— et al. (Ed.) 1966. The international code of botanical nomenclature. — Utrecht.

LAUNDON, J. R. 1965. Lichens new to the British flora. 3. — Lichenologist 3: 65—71.

TARGÉ, A. & LAMBINON, J. 1965. Étude chimiotaxonomique du groupe de Parmelia borreri (Sm.) Turn. en Europe occidentale. — Bull. Soc. Bot. Belg. 98: 295—306.

TÉTÉNYI, P. 1958. Proposition à propos de la nomenclature des races chimiques. — Taxon 7: 40—41.

WADE, A. E. 1961. The genus Ramalina in the British Isles. — Lichenologist 1: 226—241.

ZOPF, W. 1907. Flechtenstoffe in chemischer, botanischer, pharmacologischer und technischer Beziehung. — Jena.

An Ecological Approach to the Lead Problem

By Åke Rühling and Germund Tyler

Department of Plant Ecology

University of Lund, Sweden

ABSTRACT

A considerable accumulation of lead was measured both in plants and soil within a distance of 50—100 m from large roads. However, the accumulation of lead in this belt was only equal to the quantities spread by the cars on these roads during 7—15 months. Mosses proved to accumulate air-borne lead to an exceptional extent. To get a measure of the regional lead pollution, samples of three common woodland mosses were collected far away from roads in southern and central Scandinavia. A distinct NE—SW gradient was revealed with the decrease towards the NE. The lead concentration of the mosses increased with precipitation and with decreasing distance to large population centres. At least in southwestern Götaland a considerable part of the lead which is brought down by the rain will originate from areas outside Sweden. Analysis were also performed on samples collected in Skåne 1860—1968. From values of c. 20 ppm in the years 1860—1875 the concentration of lead was more than doubled between 1875 and 1900. During the first half of the 20th century no measurable changes were observed, but after about 1950 there was a new strong increase to a present average of c. 80—90 ppm. Very low lead concentrations were measured in samples from northern Scandinavia, indicating that the "natural" amounts of lead in mosses are very small and that the concentrations measured in this regional and historical study, principally reflect an influence of human activity.

INTRODUCTION

Pollution of our environment with lead has become the object of increasing interest during the last few years. The present study was performed to establish how this pollution can be traced in the plant cover as an increased concentration of lead.

Local investigations in The United States and Germany have shown that vegetation in the vicinity of roads contains more lead than vegetation growing at a greater distance from the roads (CANNON & BOWLES 1962; cf. GERHARDSSON 1966). There is little doubt that the source of this local accumulation along the roads is the tetraethyl and tetramethyl lead, added to the petrol. In order to measure what level this accumulation of lead has attained in Sweden the concentration of lead in plants and soil was determined in transects across three large roads. Separate samples of various vascular plants were collected, both along and far away from roads, and analyzed for lead. Two common species, *Trifolium repens* and *Festuca ovina*, were cultivated in a greenhouse in soils, collected at the sides of the highways as well as far from roads. They were also grown in soils supplied with varying amounts of lead as PbO. In this way the uptake of lead by the roots was studied.

Mosses collected in the highway transects proved to contain considerably more lead than vascular plants on the same sampling sites. But even far away from the roads the concentration of lead in the mosses under consideration was substantial. As mosses chiefly collect their minerals from precipitation and through sedimentation of dust, they might serve as good indicators of the local and regional supply of lead from the air. To measure the amounts of lead in mosses before the lead petrol came into use, samples of three common species, collected in Skåne 1860—1968, were analyzed. An investigation was also performed intending to establish whether any actual regional gradient might be traced in southern and central Sweden.

LABORATORY METHODS

SOIL. Samples of top-soil (depth 0—5 cm), taken with a steel tube, were treated in a sieve (meshes 2 mm) and the fine earth collected for the following analyses:

pH, electrometrically after extraction for 5 hours with 0.2 M KCl (weight ratio 1 soil : 2 KCl).

HAc-extractable lead (Pb, ext_{HAc}), after extraction for 5 hours with 1 M acetic acid (weight ratio as above).

Total lead with HF-HCl-technique (PAWLUK 1967) on ignited samples.

PLANTS. Vascular plants as well as mosses from the road transects were washed in distilled water for c. 1 minute. After drying to constant weight at c. 37°C, digestion was performed with HNO_3+HClO_4 (4 : 1). Lead concentrations are expressed as ppm dry weight.

Peat from one sample point was dried and digested as plants.

ANALYSIS OF LEAD. Lead was analyzed on a Perkin-Elmer Atomic Absorption Spectrophotometer Mod. 303, equipped with an air : acetylene Boling burner, at the wavelength 283.3 nm with a slit width of 0.7 nm. A hollow cathode lamp, working with a molten cathode and operated at 30 mA, was used.

The wavelength 217.0 nm has a greater sensitivity, but is also more sensitive to changes in the composition of the flame, caused by slight variations in the ratio air : acetylene and the supply of other elements from the sample solution. Measurable interferences by other metals have not been found at the wavelength 283,3 nm with the concentrations of metal ions present in the sample solutions.

THE ROAD TRANSECTS

During spring and early summer 1968 the concentration of lead was determined in plants and soil in transects across three large roads: road E 4 at Stavsjö between Norrköping and Nyköping, road 15 at Oskarshamn, and road 15 (motor road) at Uppåkra between Malmö and Lund.

Transect 1, Stavsjö, Södermanlands län, 32 km W Nyköping, road E 4. Orientation of the transect NW—SE. Coniferous woodland on coarse moraine. Bottom layer densely closed, composed of mosses, mostly *Pleurozium schreberi*; field layer chiefly *Vaccinium myrtillus* and *V. vitis-idaea*, some grasses and herbs, mostly *Luzula pilosa*. The collected soil samples consisted of mor with variable, mostly small contents of sandy mineral soil. pH 2.9—3.8, close to the roadside, where the sand contents was higher, 4.1—5.2. Owing to the variations in the amounts of mineral soil, a calculation of the lead concentrations on the loss on ignition was considered most adequate. Diurnal traffic flow (1968) c. 5000, in the summer c. 7300. Sampling date 15.IV.1968 (plants), 2.V.1968 (soil).

Transect 2, Oskarshamn, Lilla Mark, Kalmar län, road 15. Orientation of the transect NW—SE, only drawn southeast of the road. Pine-wood with a field layer of *Deschampsia flexuosa* or *Vaccinium vitis-idaea* and *V. myrtillus* in patches. Bottom layer, not continuous, mostly with *Pleurozium schreberi* and *Hylocomium splendens*. Top-soil a thin mor with variable contents of mineral soil. Lead concentration of the soil samples calculated on loss on ignition. pH 2.9—3.6. Diurnal traffic flow (1968) c. 3150, in the summer c. 4600. Sampling date 5.V.1968.

Transect 3, Uppåkra, 4 km SSW Lund, Malmöhus län, road 15 (motor road). Orientation of the transect NW—SE, along the sides of a ditch, crossed by the road and covered with a luxuriant sward of grasses and herbs. The area, otherwise completely cultivated, developed on Baltic moraine clay. The topsoil a clayey grass mull, rather poor in organic matter (loss on ignition 4.6—10.0 %) with large contents of Ca, partly as $CaCO_3$. pH very uniform, 7.1—7.3. Diurnal traffic flow (1968) c. 18500. Sampling date 25.IV.1968.

It is evident from Figs. 1—3 that a considerable accumulation of lead is found both in plants and soil in the vicinity of these large roads. With increasing distance from the roadsides there is a rapid decrease in the concentration of lead and 50—100 m from the roads the concentrations are stabilized on a basic level, characteristic of each type of material.

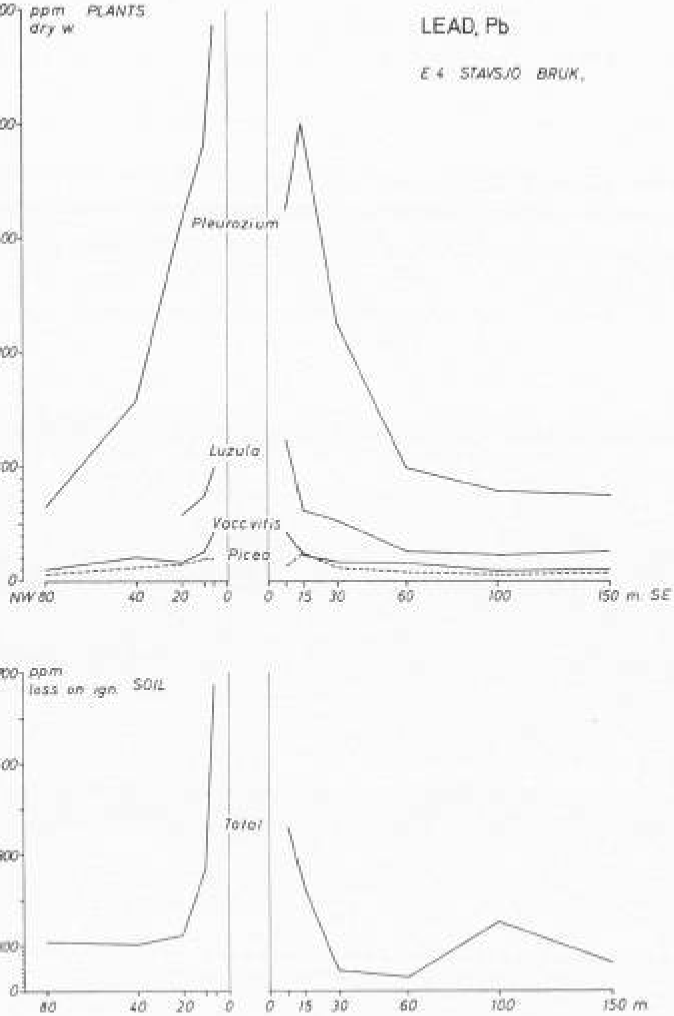


Fig. 1. Lead gradients in the road transect at Stavsjö. Plants: *Pleurozium schreberi*, *Luzula pilosa*, *Vaccinium vitis-idaea*, and *Picea abies* (needles).

The mosses accumulate air-borne lead to an exceptional extent, containing lead concentrations of 300—500 ppm along the sides of these roads. Concentrations amounting even to 700 ppm have been recorded along a motor road in central Sweden (cf. Tab. 1). Vascular plants exhibit considerable differences. The largest uptake of lead by vascular plants in the transects was measured in *Luzula pilosa* with more than

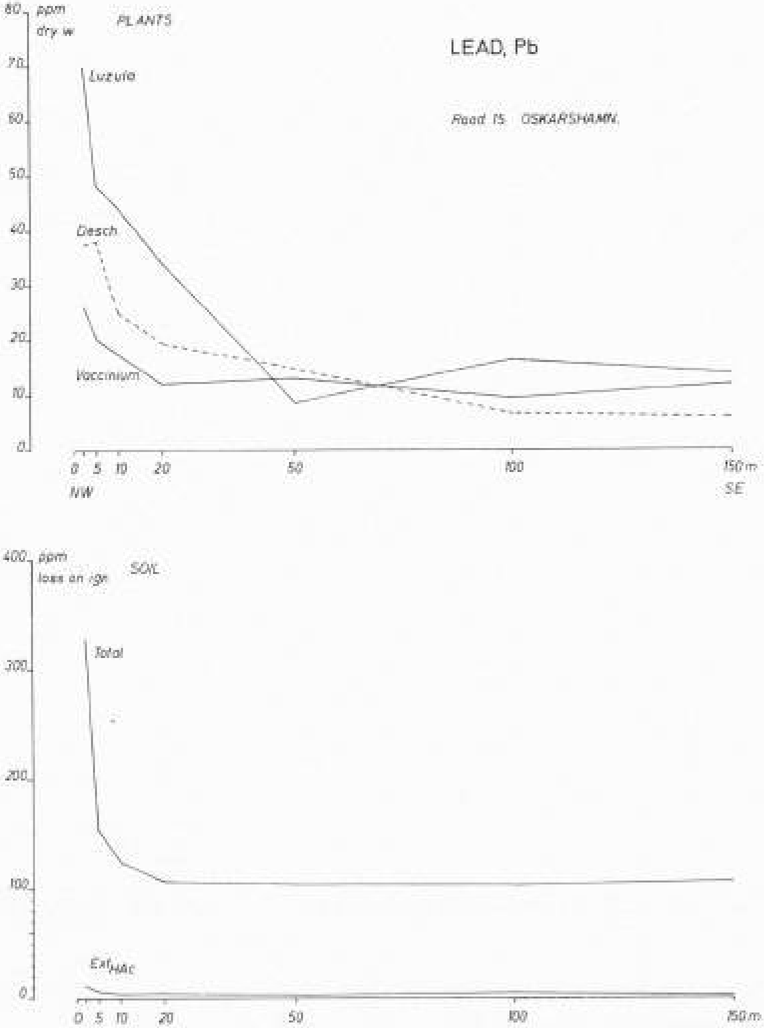


Fig. 2. Lead gradients in the road transect at Oskarshamn. Plants: *Luzula pilosa*, *Deschampsia flexuosa*, and *Vaccinium vitis-idaea*.

100 ppm close to the road at Stavsjö, and the curve of this species attains a horizontal trend on a basic level, higher than those of *Vaccinium vitis-idaea* and spruce needles (Fig. 1). *Luzula pilosa* contains more lead than both *Deschampsia flexuosa* and *Vaccinium vitis-idaea* also in the transect from Oskarshamn (Fig. 2). At Uppåkra, *Alopecurus pratensis* usually is richer in lead than *Anthriscus silvestris*.

That the basic level is rather characteristic of each species is also evident from Tab. 1. Leaves of *Anthriscus silvestris* on non-roadside localities in the Norrköping area had only 5—6 ppm, leaves of *Achillea millefolium* 10—19 ppm. The average concentrations from the roadside localities are for both species about three times these values.

As a preparation for the present study a number of samples of various species were collected and analyzed for lead during early spring 1968 in southwestern Skåne, in the surroundings of Oskarshamn and in northeastern Östergötland. Some remarkably high concentrations were measured. At the heavily frequented intersection of Hornsgatan/Stockholmsvägen in Malmö, 950 ppm was found in young shoots of *Dactylis glomerata* and 510 ppm in leaves of *Achillea millefolium* (cf. Tab. 1). In contrast to these findings it may be stated that flowers of *Tussilago farfara* from Bjälebo, c. 20 km WNW Oskarshamn, contained only 1 ppm lead and several samples of *Vaccinium vitis-idaea* and *Picea abies* (needles) from other non-roadside localities 3—6 ppm.

The amounts of total and HAc-extractable lead in the soil were also determined in the road transects. Also in the soil there is a rapid decrease in the concentration of lead with increasing distance from the roadsides with more or less constant values already beyond c. 50 m. In the two woodland transect on mor (Stavsjö, Oskarshamn) the concentration is stabilized at about the same level. Calculated on volume, the following basic levels are obtained (mg Pb/dm^3):

	Stavsjö	Oskarshamn	Uppåkra
Pb total	8	10	35
ext_{HAc}	0.3	0.5	3

The figures are rather rough approximations. A corresponding conversion to mg/dm^3 of the largest values in each transect gives the following figures:

	Stavsjö	Oskarshamn	Uppåkra
Diurnal traffic flow (1968)	5000	3150	18500
Pb total	65	35	185
ext_{HAc}	4	1	25

As could be expected a clear correlation seems to exist between traffic flow and the amount of lead in the soil close to the roads.

The ratio total : ext_{HAc} is considerably larger in the mor transects (25—35) than in the transect on clayey mull at Uppåkra (c. 9). The

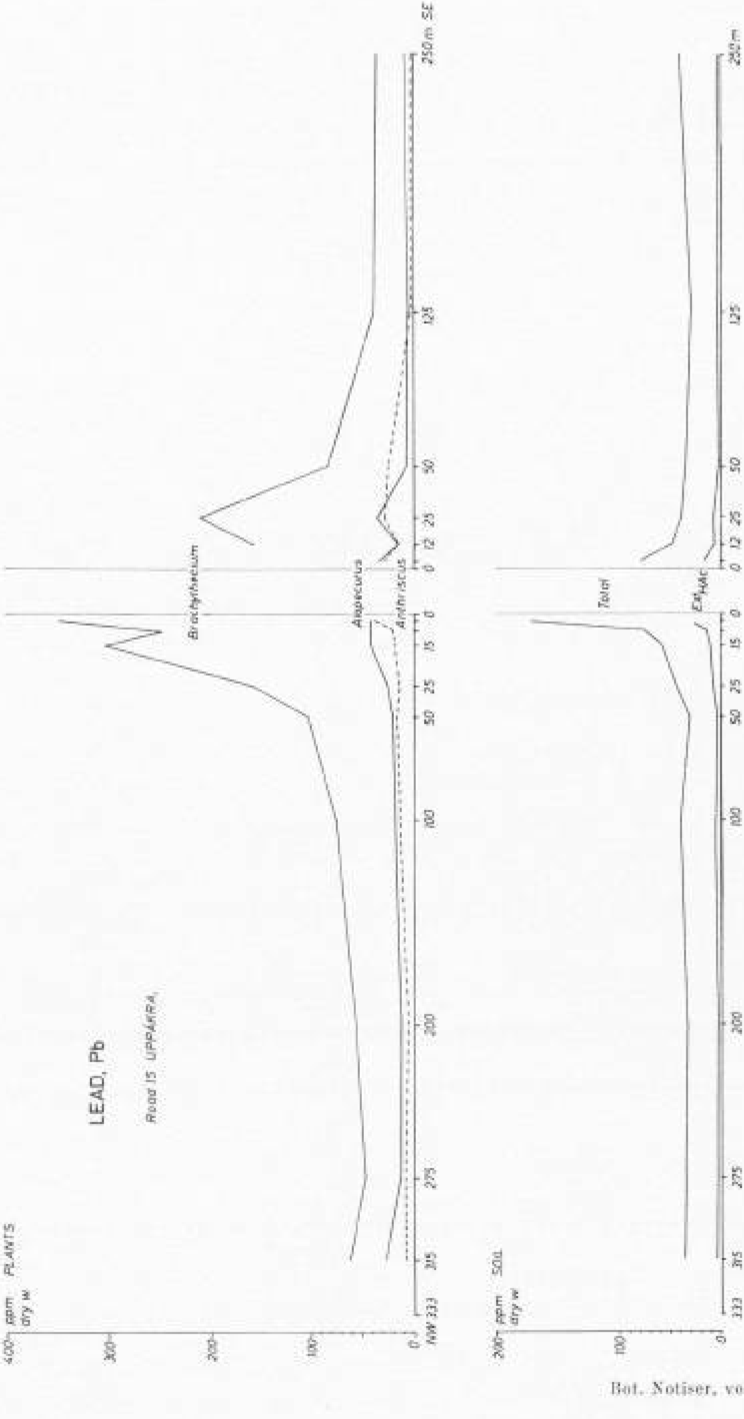


Fig. 3. Lead gradients in the road transect at Uppåkra. Plants: *Brachythecium* sp., *Alopecurus pratensis*, and *Anthriscus silvestris*.

Table 1. The concentration of lead (ppm) in samples of various plants, collected in April 1968. Figures in brackets refer to samples of roots.

	Distance from roadside, metres	Average diurnal traffic flow	
		year	summer
Non-roadside localities			
Östergötlands län:			
A 1 S:t Anna, Yxnö	—	—	—
A 2 Kvillinge, Getsjö	—	—	—
A 3 Rönö	—	—	—
A 4 Häradshammar, Dammen	—	—	—
A 5 Krokek, Marmorbruket	—	—	—
A 6 Kvillinge, Malmölandet	—	—	—
Kalmar län:			
A 7 Oskarshamn, Kolberga	—	—	—
A 8 Döderhult, Fredriksfors	—	—	—
A 9 Kristdala, Bjälebo	—	—	—
A 10 Döderhult, Lagmanskvarn	—	—	—
Roadside localities			
Östergötlands län:			
B 1 Norrköping, Saltängen	2	—	—
B 2 Krokek, Oskarshäll	3—8	750	—
B 3 Ö Husby	1—2	850	1300
B 4 Kvillinge, Norrviken	3	1000	—
B 5 Kvillinge, Åby	6—10	9900	13200
B 6 Norrköping, Himmelstalund	5	19000	—
Södermanlands län:			
B 7 Kila, Stavsjö	3—8	5000	7300
Kalmar län:			
B 8 Oskarshamn, Nynäs	2	9100	11900
B 9 Oskarshamn, Hällarna	2	3150	4600
Malmöhus län:			
B 10 Lund, Dalbykarusellen	3—5	> 20000	—
B 11 Lund, Staffanstorpskarusellen	3—5	> 20000	—
B 12 Malmö, Hornsgatan/Stockholmsvägen	2	> 30000	—

	Locality	ppm	Locality	ppm
Achillea millefolium, leaves	A 1	10	B 2	33
	A 3	19	B 3	24
	A 4	18	B 4	106
	A 5	10	B 5	59
	A 6	13	B 7	47
	A 7	19	B 10	180 (130)
	A 8	11	B 11	230 (250)
			B 12	510

	Locality	ppm	Locality	ppm
Anthriscus silvestris, leaves	A 1	8	B 1	6
	A 3	6	B 2	15
	A 4	6	B 4	13
	A 5	5	B 5	20
	A 6	6	B 6	28
			B 7	18
			B 8	73
			B 9	31
Bellis perennis, leaves	A 7	18	B 12	260
Dactylis glomerata, young shoots	A 6	6	B 5	25
	A 7	10	B 8	42
			B 10	68
			B 11	91
			B 12	950
Festuca rubra, young shoots, ...	A 10	5	B 8	67
			B 10	130
Luzula pilosa, young shoots	A 2	18	B 2	32
	A 6	9		
Matricaria inodora, leaves	A 3	5	B 1	30
			B 6	24
			B 10	160 (93)
			B 11	160 (29)
Picea abies, needles	A 2	3	B 2	7
	A 5	6		
Pleurozium schreberi	A 1	57	B 2	220
	A 2	64	B 5	700
	A 5	41		
	A 6	38		
Rhytidiadelphus squarrosus	A 1	24	B 2	70
	A 3	26	B 5	680
	A 4	22		
	A 5	32		
	A 6	25		
Trifolium spp., leaves	A 1	8	B 1	27
	A 3	11	B 2	37
	A 4	17	B 3	32
	A 5	8	B 5	31
	A 6	8	B 6	17
	A 7	11	B 7	47
	A 8	15	B 8	87
Tussilago farfara, flowers	A 4	6	B 3	11
	A 6	4	B 5	29
	A 9	1	B 7	30
			B 9	28
Vaccinium myrtillus, shoots	A 2	6	B 2	13
			B 7	63
Vaccinium vitis-idaea, shoots	A 2	5	B 2	13
	A 9	6	B 7	43
	A 10	3		

relatively smaller amounts of HAc-extractable lead in the mor may be due to the low pH of these soils. The least stable fractions of lead may already have been removed from the system.

The maximum concentrations of lead in the complete transects (Stavsjö and Uppåkra) were measured on the northwestern side of the roads. This is in accordance with the probable distribution of local, air-borne lead with the prevailing winds.

A calculation of total lead in soil and plant biomass, to a distance of 50 m from the roads, shows that the accumulation of lead in this belt by no means corresponds to the quantities of lead which are liberated on the combustion of lead petrol. Total lead in the top-soil (0—5 cm) within 50 m on both sides of the motor road Malmö—Lund is only equal to the quantities of lead which are spread by the cars during 7—8 months with the present traffic flow and average lead concentration of the petrol. If 30 ppm is subtracted as an approximate basic value, not referable to local pollution, the corresponding figure is about 4 months. In comparison with the lead of the soil, the amounts of the plant biomass are almost negligible in this treeless area.

Total lead in the top-soil (5 cm mor) along road E 4 at Stavsjö and road 15 at Oskarshamn, both running through coniferous woodland, is equivalent to the quantities of lead which are liberated by the cars on these roads during 13—15 months. The plant biomass as well as the lead of the plant cover is also more considerable; mosses and dwarf-shrubs in the transect at Stavsjö contribute to about 1 month. In addition there is the lead of the tree layer that cannot be estimated for the present.

Even though the woodland ecosystems will accumulate larger quantities of lead, originating from the combustion of petrol, than open agricultural areas, the following conclusion must be drawn: *only a minor part of the lead, which is liberated by the cars on the combustion of lead petrol, will settle and accumulate in the vicinity of the roads.*

A GREENHOUSE EXPERIMENT

The way of uptake and accumulation of lead by vascular plants is of primary interest to the discussion of the lead problem. In a greenhouse experiment *Trifolium repens* and *Festuca ovina* were cultivated from seeds in soils with different contents of lead, collected on roadsides as well as far from roads (cf. Tab. 2). The shoots were cut 5

Table 2. The concentration of lead in *Trifolium repens* and *Festuca ovina*, cultivated in different soils from Malmöhus län under equal conditions, as well as total and HAc-extractable lead of these soils. All figures calculated as ppm dry weight. Soil 1—4 non-roadside, 5—7 roadside localities. Left figure (plants) = 1st harvest, right figure = 2nd harvest.

	Soil		Species	
	Total	Ext_{HAc}	*Trifolium repens*	*Festuca ovina*
1. Häckeberga SE Skoggård	15	0.1	8.5/ 7.5	1.8/ 5.7
2. Nygård, 4 km SW Genarp	34	0.4	3.7/ 7.0	2.8/ 6.4
3. 2 km E Holmeja	51	0.8	9.1/11.7	4.6/ 4.3
4. Lund, Bot. Garden	62	0.9	5.4/ 7.8	5.0/ 9.0
5. Lund, Staffanstorpskarusellen	124	15	5.5/10.4	4.9/ 7.3
6. Lund, Dalbykarusellen	145	7.6	6.8/ 9.3	10.2/11.4
7. Malmö, Hornsg./Stockholmsv.	450	97	7.2/ 9.0	9.8/ 5.2
Lead, added as PbO to soil nr 4.	0	—	5.4/ 7.8	5.0/ 9.0
	$2 \cdot 10^3$	—	11.1/16.4	19.5/13.0
	$2 \cdot 10^4$	—	490/145	59/92
	10^5	—	290/1140	230/205

weeks after the sowing and a second time after another 5 weeks. The concentration of lead proved to be small in all samples, usually amounting to 5—10 ppm. Any clear difference between the soils could hardly be measured; even the plants grown in soils from the sides of heavily frequented roads usually contained less than 10 ppm. This will be compared with the much larger concentrations (68—950 ppm) in leaves and young shoots of different weeds, actually growing on the same roadsides. (loc. B 10—12, Tab. 1).

On the basis of this experiment it seems most probable that even vascular plants, growing on roadsides, collect air-borne lead chiefly with their shoots and that uptake by the roots is of minor importance. The very large concentration of lead, measured in young, developing parts of perennial weeds, growing on roadsides, might be due to a retransport of lead stored in the roots or other subterranean parts during the winter but collected during previous growing seasons. However, a slow but continuous uptake by the roots may also be of importance. Further studies are necessary to explain the problem. That the concentration of lead in the second harvest, when the plants were about 10 weeks of age, with only few exceptions was larger than in the first harvest after 5 weeks, may be explained on the basis of a slow but continuous uptake with increasing age. That root uptake of substantial amounts of lead, supplied as PbO to a garden soil, actually is possible, is demonstrated by a simultaneous experiment, also recorded in Tab. 2 (lower part).

Table 3. The concentration of lead (ppm dry weight) in samples of *Hylocomium splendens*, *Pleurozium schreberi* and *Hypnum cupressiforme*, collected in May and June 1968. Distance to roads always at least 300 metres.

	Hylocomium splendens	*Hylocomium splendens* segm. I	*Pleurozium schreberi*	*Hypnum cupressiforme*
Södermanlands län				
Strandstuviken, 7 km SE Nyköping	29	24	62	—
Östergötlands län				
3 km W Kvarsebo ch.	54	58	45	30
Ysjön, 11 km NW Åby	57	14	53	56
Torsklint, 9 km NW Norrk.	56	50	51	74
Gettorp, 10 km W Skärblacka	56	57	67	66
8 km NNW Motala	55	47	47	40
Malmö, 8 km NE Norrköping	35	33	38	50
Ö. Stenby, 20 km E Norrk.	28	32	24	44
Varsten, 9 km SE Söderk.	45	41	48	42
Torön, 2 km NE S:t Anna	41	35	43	28
Yxnö, 10 km NE S:t Anna	30	26	57	32
5 km NW Valdemarsvik	48	54	59	19
5 km NW Brokind	33	26	28	24
4 km E Mjölby	53	34	47	57
Stava, 13 km SSW Ödeshög	50	34	32	48
10 km S Kisa	30	29	39	60
Jönköpings län				
Lidhult, 6 km SE Jönköping	41	39	25	38
4 km ESE Bottnaryd	91	69	60	86
8 km NNW Hok	66	47	56	—
7 km NW Ramkvilla ch.	66	47	70	57
Hörje, 9 km N Värnamo	87	63	65	52
6 km E Smålandsstenar	113	54	79	69
3 km SE Landeryd	80	83	92	164
Kronobergs län				
Sävsjöström	57	55	52	43
2 km N Lammhult	52	45	43	67
2 km S Grimslöv	60	52	37	94
2 km SE Målaskog	113	77	75	85
1 km S Traryd	94	46	56	79
Kalmar län				
Blekhem, 8 km S Gamleby	41	44	47	40
N. Kvill, 19 km NW Vimmerby	61	41	49	43
4 km E Vimmerby	58	49	59	34
1 km N Bockara	56	58	44	60
3 km W Oskarshamn	61	52	48	67
3 km N Böda ch.	33	29	51	—
1 km SW Högsrum ch.	45	42	39	—
Gotlands län				
Ar, 7 km NNE Fleringe ch.	43	37	43	—
2 km E Barlingbo ch.	54	49	55	—
3 km NW Kräklingbo ch.	41	36	51	—

	Hylocomium splendens	*Hylocomium splendens* segm. 1	*Pleurozium schreberi*	*Hypnum cupressiforme*
Torsburgen, 4 km S Kräklingbo ch.	68	68	66	—
3 km W Buttle ch.	61	58	59	—
5 km S Hejde ch.	44	51	53	—
2 km E Lojsta ch.	—	—	—	71
3 km NW Eksta ch.	73	74	65	70
Kristianstads län				
3 km NE Osby	90	80	74	78
2 km N Vittsjö	60	55	59	47
3 km SW Örkelljunga	99	82	96	104
6 km W Grevie ch.	—	—	54	110
Skäralid, 5 km NW Röstånga	104	71	100	92
Bjära, 2 km SSE Linderöd	111	110	130	105
1 km NW Vitemölla	48	39	41	77
4 km W S:t Olof	62	54	65	61
Malmöhus län				
S. Rörum, 6 km N Hörby	75	66	91	200
Bönhult, 5 km N Långaröd	101	90	84	99
Tollstorp, 6 km ENE Östraby	74	54	79	81
Mossen, 2 km E Veberöd	66	47	48	—
1 km WNW Everlöv ch.	94	89	77	77
Billebjär, 8 km E Lund	118	116	93	67
Häckeberga, 4 km S Genarp	—	—	50	96
2 km E Holmeja	92	68	76	188
S Yddingen, 3 km SW Holmeja	71	69	—	83
Torup, 4 km S Bara ch.	—	—	—	128
3 km N Lomma	—	—	43	73
3 km E Barsebäcks hamn	96	81	131	147
Hallands län				
1 km S Torup ch.	108	99	84	242
1 km W Rydöbruk	125	115	105	115
7 km NW Falkenberg	72	61	74	95
Haverdal, 6 km WSW Harplinge	68	53	84	133
Tönnersa, 8 km NW Laholm	54	45	66	57
Älvsborgs län				
1 km SW Håverud	79	71	79	118
Halleberg, Lilleskog	112	88	96	—
2 km SSW Rångedala ch.	60	53	53	70
2 km NNW Öxnevalla ch.	63	66	60	60
Skaraborgs län				
Häggeboda, 5 km N Tived ch.	50	24	79	41
2 km WSW Råbäck stn.	51	40	32	—
Kinnekulle, 3 km SSW Hällekis	74	55	86	160
Gorsan, Valstad	24	18	29	—
Ålleberg	—	—	45	116
Nolgården, Vartofta	62	50	—	—

	Hylocomium splendens	*Hylocomium splendens* segm. 1	*Pleurozium schreberi*	*Hypnum cupressiforme*
Värmlands län				
6 km NNW Mangskog ch.	57	48	49	29
Berg, 2 km S Jössefors	79	79	92	85
Ingesund,, 3 km S Arvika	47	44	44	77
Sörmon, 3 km N Karlstad	—	—	68	—
1 km SW Stömne	55	38	49	20
Glahöjden, 7 km ESE Vännacka stn.	62	47	63	31
Gränsen, 3 km S Värmlands-Säby stn.	105	97	—	117
Örebro län				
3 km SW Garphyttan	49	24	97	79
Villingsberg, 10 km ESE Karlskoga	76	61	106	36
3 km SSE Degerfors	90	77	150	100
Kvarntorp	—	—	27	36
Markebäck, 6 km Askersund	41	38	35	52
3 km S Hjortkvarn	36	28	30	23
DENMARK, Själland (Zealand)				
Tisvilde Hegn, 9 km N Frederiksværk	54	54	82	116
Valby, 14 km NNW Hilleröd	—	—	—	46
Grib Skov, 10 km N Hilleröd	88	76	56	187
St. Dyrehave, 6 km SE Hilleröd	—	—	119	189
S Füresö, c. 12 km NW Copenhagen, centre	—	—	—	156
NORWAY				
Valldal, Nordalsfj.	12	—	11	—
Stryn, Innviksfj.	7	—	11	—
Förde, Sunnfjord	30	—	24	—
Balestrand, Sognefjord	34	—	21	—
C. 10 km S Atna, Hedmark	29	—	28	—
Knapstad, c. 35 km SSE Oslo	72	—	89	—

MEASUREMENTS OF A REGIONAL LEAD GRADIENT

The rather large concentrations of lead measured in mosses growing far away from roads and the stabilization of the curves of *Pleurozium* and *Brachythecium* in the road transects on a basic level far above those of vascular plants gave rise to the following regional study.

Three common woodland mosses, *Hylocomium splendens, Pleurozum schreberi* and *Hypnum cupressiforme*, were collected during May and June 1968 in different parts of southern and central Sweden, but also from Denmark and Norway a limited number of samples were obtained. The vicinity of roads was avoided to exclude the possibility of local pollution; no sample was collected less than 300 m from a road.

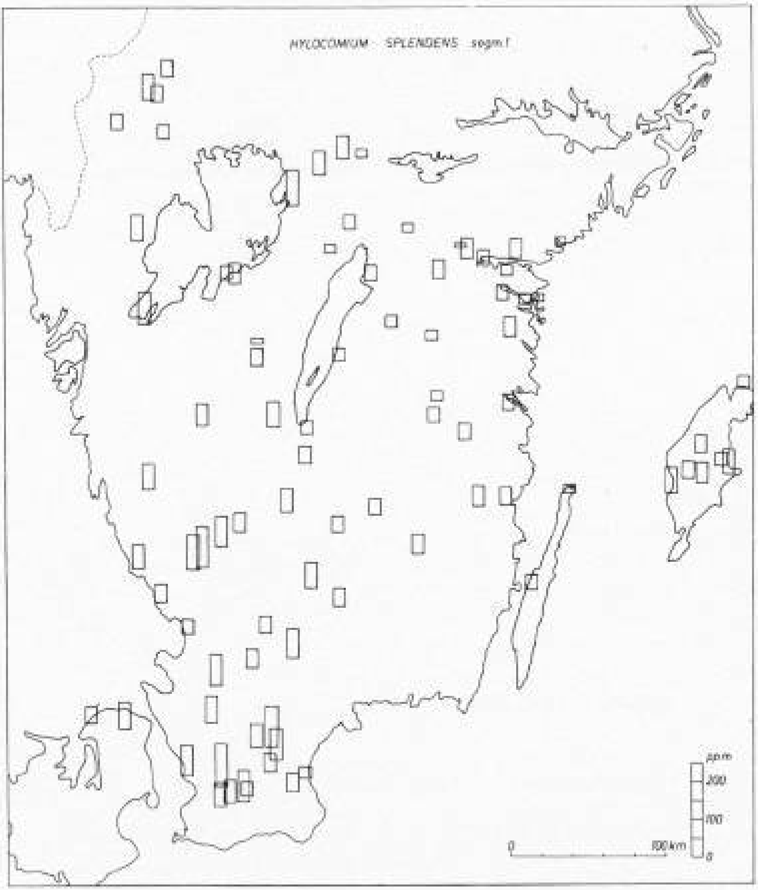


Fig. 4. Lead concentration of *Hylocomium splendens* (segment 1).

The samples were treated as in the road transects but were not washed before drying. To reduce the possible influence of differences in the rate of decomposition and general turnover between different localities, segment 1 (the youngest fully developed segment and the new developing segment) of *Hylocomium splendens* was also treated and analyzed separately (cf. TAMM 1953).

The results have been compiled in Tab. 3 and Figs. 4—6. A distinct NE—SW gradient is revealed with all three species. As an average the samples from Malmöhus län are about twice as rich in lead as the samples from Östergötlands län, with intermediate figures for Jönköpings and Kronobergs län. A comparison between the concentration

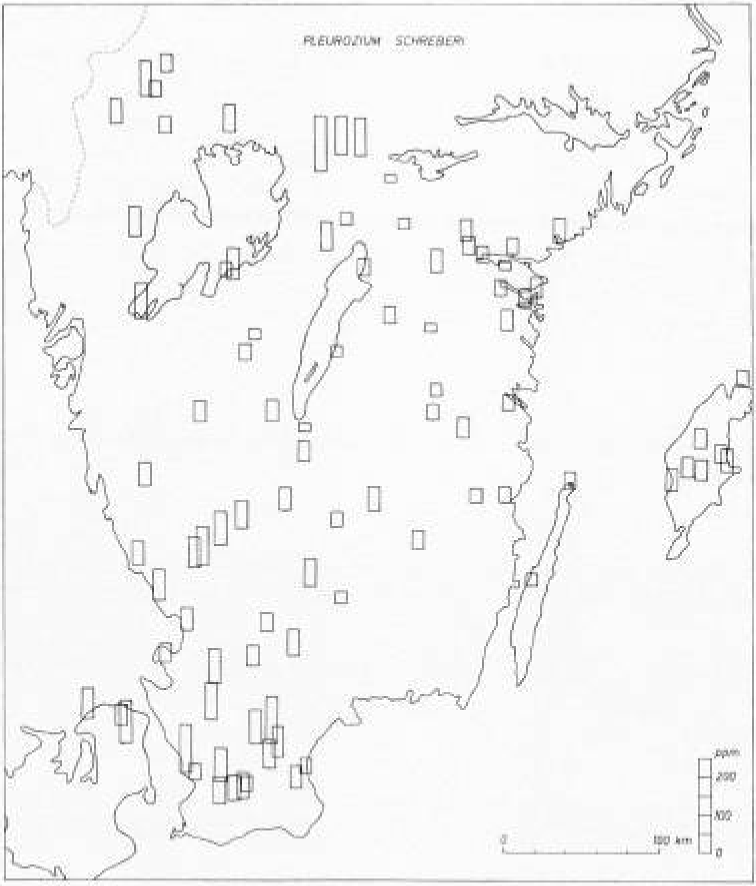


Fig. 5. Lead concentration of *Pleurozium schreberi.*

of lead and the mean annual precipitation (Atlas över Sverige, Bl. 32) shows a rather close relationship. The largest lead concentrations have been measured in samples from Linderödsåsen and Söderåsen in Skåne and from the very humid Torup—Landeryd area on the southwestern slopes of Sydsvenska Höglandet. In central Sweden the samples from Kilsbergen and its slopes towards Lake Vänern diverge through considerable contents of lead, at least partly coinciding with a rather large mean annual precipitation. In northeastern Götaland, where the mean annual precipitation never exceeds 600 mm, the lead concentration of the samples is never large.

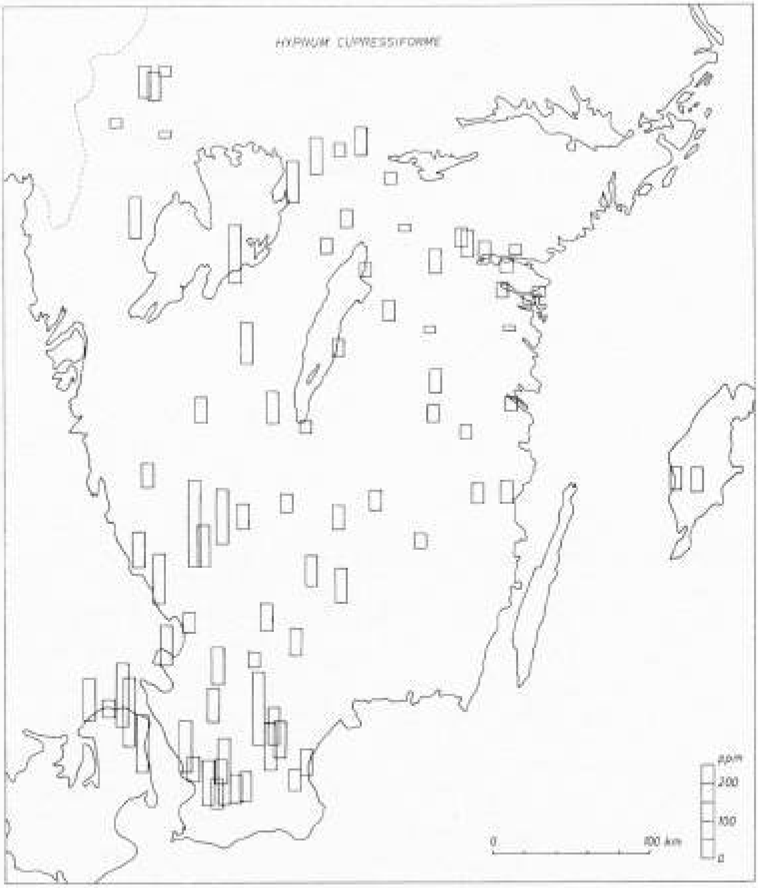


Fig. 6. Lead concentration of *Hypnum cupressiforme*.

There is little doubt that a real correlation exists between precipitation and lead concentration of mosses. But the NE—SW gradient in lead concentration is considerably stronger than the corresponding gradient in precipitation. Consequently, a calculation of the lead concentration as ppm/100 mm mean annual precipitation (Fig. 7) still exhibits a clear NE—SW gradient. The densely populated Öresund area is outstanding, but as a whole the mosses in the southwestern half of Götaland contain significantly more lead than mosses of the same species in the northeastern half, even on this particular basis of calculation.

Two distinct aberrations, difficult to explain, are found in the maps. On Gotland and particularly in the area east of Lake Vänern the lead

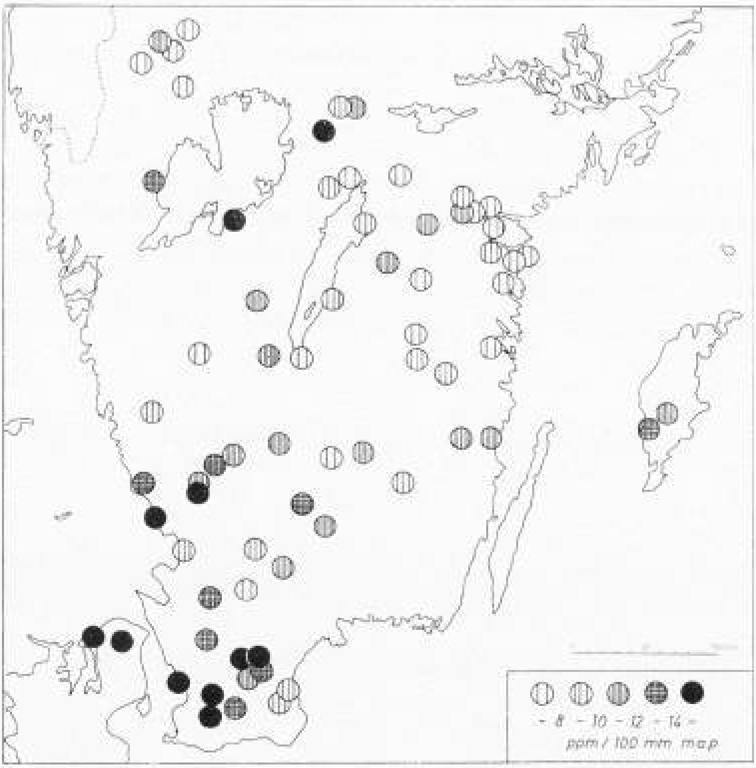


Fig. 7. Lead concentration (averages of *Hylocomium splendens, Pleurozium schreberi* and *Hypnum cupressiforme*), calculated as ppm per 100 mm mean annual precipitation (m.a.p.).

concentrations are greater than could be expected. The explanations for these aberrations from the otherwise distinct trend are at present unknown to the authors.

The measured NE—SW gradient in ppm/100 mm precipitation can hardly be explained by some climatical gradient. The ratio convective : cyclonal precipitation is usually somewhat larger in the interior of the country than along the coasts. Even as to the precipitation of snow in percent of total annual precipitation (cf. Atlas över Sverige, Bl. 31) there is chiefly a coast—inland gradient with the maximum in the interior of Sydsvenska Höglandet.

On the basis of available information, recorded in Tab. 3 and Figs. 4—7, the following conclusions are drawn: *The lead concentration of the mosses increases with precipitation and with decreasing distance to* *large population centres.* The considerable difference in ppm/100 mm precipitation between Östergötlands län and southwestern Småland/Halland is not connected with any corresponding difference in the number of people inhabiting these areas. It seems most probable that a considerable part of the lead, which is brought down by the rain, at least in southwestern Götaland *originates from areas outside Sweden,* especially the large population centres of Western Europe. But in the high figures, particularly for *Hypnum cupressiforme*, in the densely inhabited Öresund area a large component of local lead can hardly be excluded. A study of the distribution of lead in the mosses of the more isolated Stockholm area would be of great interest, as well as, for example, of western and interior Jylland in Denmark, to a more accurate understanding of this problem.

MEASUREMENT OF A HISTORICAL LEAD GRADIENT

To measure the development during the last century of the lead concentration in mosses, analyses were performed on samples of the same species (*Hylocomium splendens, Pleurozium schreberi,* and *Hypnum cupressiforme*) as in the regional study, collected in Skåne and preserved in the Botanical Museum of Lund. The result, illustrated in Fig. 8, shows an interesting and unexpected trend. From values of c. 20 ppm in the years 1860—1875 the concentration of lead is more than doubled between 1875 and 1900. During the first half of the 20th century there are little or no changes; though the range is rather large the averages are between 40 and 50 ppm. But after 1950 there is a new strong increase to the present average of 80—90 ppm in 1968.

The first rise in the lead concentration will be explained by some industrial factor of pollution, possibly the increased use of coal (cf. GERHARDSSON 1967 p. 21). The second rise coincides well with the rapid increase in the combustion of lead petrol in Western and Northern Europe.

The conclusions must be that the *increase in the lead concentration* of the mosses from Skåne *is restricted to two distinct periods: a first increase towards the end of the nineteenth century, a second increase during the last two decades.* Whether the factor of pollution causing the first increase is still of any greater importance is uncertain. That the recent increase is caused by the combustion of lead petrol is more than probable.

The historical aspects of the lead problem have also been studied as the vertical lead gradient in a column of weakly humified peat (H 1—2, according to the scale of v. POST & GRANLUND (1926)) from Nöbbele Mosse at Värnamo in western Småland, sampled in May 1968. Down to a depth of about 25 cm the concentration of lead was almost uniform, amounting to c. 45 ppm both in the living *Sphagnum magellanicum* on the surface and in the peat beneath. Below 25 cm there was a rapid decrease to 26 ppm at 35 cm, 12 ppm at 45 cm, 8 ppm at 55 cm and 6 ppm at 65 cm sampling depth. But the interpretation of this gradient is difficult. A time-scale cannot be drawn in this newly deposited peat and a certain release and diffusion of lead ions cannot be precluded in these very acid environments. Fresh moss samples, extracted for 9 hours in 0.001 M HCl (pH after extraction 3.21) lost practically no lead, whereas with 0.01 M HCl (pH 2.03) c. 40 % and with 0.1 M HCl c. 90 % of their original contents of lead (c. 60 ppm) was released during 9 hours.

THE USE OF MOSSES AS INDICATORS OF LEAD POLLUTION

How reliable are mosses as indicators of lead pollution by human activity? Or more precisely what is the basic, "natural" lead concentration of the mosses included in this study?

The historical diagram indicates that c. 20 ppm was an average for Skåne about one hundred years ago. But there is little reason to believe that 20 ppm would be this "natural" concentration. Samples from earlier days are probably unobtainable.

A few determinations were performed on old samples of *Hylocomium splendens* from areas outside Skåne: Töreboda in Västergötland (1909) 17 ppm, Lomseggene in central Norway (1858) 14 ppm, Vassitjokko in Torne Lappmark (1902) 11 ppm, and Iceland (1903) 6 ppm. But two samples from isolated fjord bottoms in western Norway, collected in 1968, contained only 7 and 12 ppm and *Pleurozium* from the same localities 11 ppm (cf. Tab. 3). Five samples of *Sphagnum lindbergii* and three of *Sphagnum robustum* from the Torneträsk area of north-western Lappland, collected in 1965, measured c. 7 (5—12) ppm, whereas the lead concentration of three samples of *Sphagnum magellanicum* and *Sph. papillosum* (uppermost part) from the Åkhult mire in central Småland, collected in 1957, was 19—36 ppm and in *Sphagnum magellanicum* (uppermost part) in three samples from Nöbbele Mosse, western Småland, collected in 1968, 42—49 ppm.

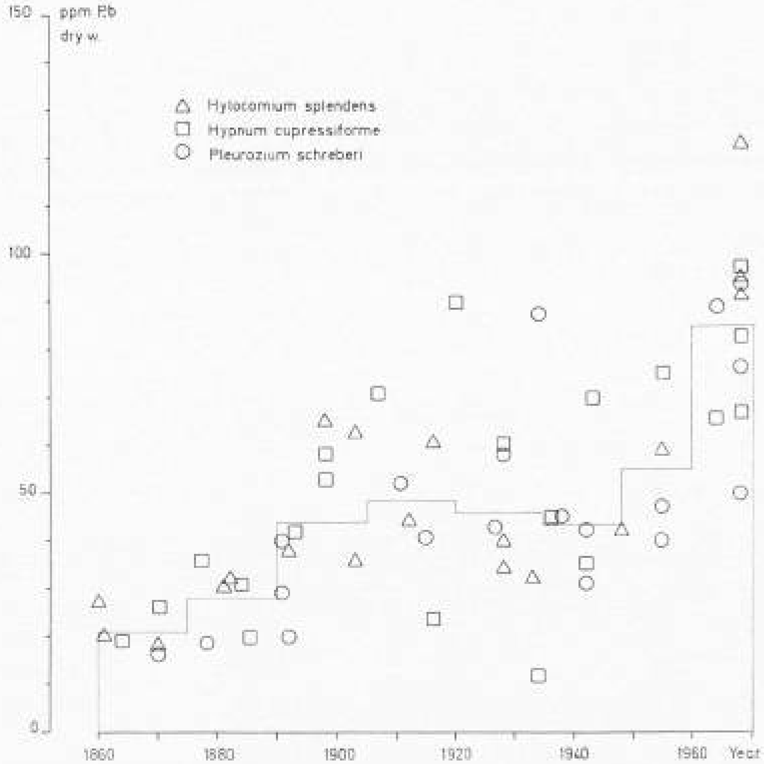


Fig. 8. Lead concentration in samples of *Hylocomium splendens, Pleurozium schreberi* and *Hypnum cupressiforme*, collected in Skåne 1860—1968.

These examples indicate, that *the "natural" amounts of lead in mosses are very small and that the concentrations measured in this regional and historical study principally reflect an influence of human activity.*

ACKNOWLEDGEMENTS

This investigation was performed in the laboratories of the Department of Plant Ecology, University of Lund. The authors are indepted to Laborator NILS MALMER, Head of the department, for putting the facilities of the department ot our disposal. Financial support was obtained from Forskningsnämnden, Statens Naturvårdsverk.

The samples from Gotland were collected by fil. stud. ANDERS LARSSON, from the Åkhult mire and Nöbbele Mosse by Laborator NILS MALMER, some samples from Skåne by fil. lic. TORE MÖRNSJÖ and *Sphagnum* species from the Torneträsk area by fil. lic. MATS SONESSON. Fil. stud. JÖRGEN TYLER collected the samples from Norway.

Information of traffic flow was given by Statens Vägverk.

LITERATURE CITED

Atlas över Sverige. 1953. Bl. 31—32. Stockholm.

Cannon, H. L. & Bowles, J. M. 1962. Contamination of Vegetation by Tetraethyl Lead. — Science 137: 765—766.

Gerhardsson, G. 1966. Bilavgasproblemet i Sverige. — In: Luften Bilen Människan. Statens luftvårdsnämnds konferens i Stockholm 1965. pp. 11—32. Stockholm.

— 1967. Blyanvändningen i Sverige och utlandet. — In: Bly i bensin och avgas. Stockholm.

Pawluk, S. 1967. Soil Analyses by Atomic Absorption Spectrophotometry. — Atomic Absorption Newsletter 6: 53—56.

Post, L. v. & Granlund, E. 1926. Södra Sveriges torvtillgångar. I. — Sveriges Geol. Undersökning. Ser. C. No. 335.

Tamm, C. O. 1953. Growth, Yield and Nutrition in Carpets of a Forest Moss (Hylocomium splendens). — Meddelanden från Statens Skogsforskningsinstitut 43: 1—140.

Stratigraphical and Chemical Studies on Two Peatlands in Scania, South Sweden

By Tore Mörnsjö

Department of Plant Ecology
University of Lund, Sweden

ABSTRACT

In connection with studies on the botanical character of different kinds of peat in profiles from two peatlands determinations of pH, ash content, total contents of Na, K, Mg, Ca, Mn, Fe, Al and insoluble residue (SiO_2) have been carried out on samples through the profiles. The result of the investigation shows that there are significant differences in the content of ash, Ca, Mn, Fe and Al as well as in the molar ratio Ca/Mg between minerotrophic and ombrotrophic mire peat. In the ombrotrophic mire peat some deviations from the general pattern are demonstrated. They may due to secondarily supplied minerals brought about partly by human activities and partly by an elevation of the subsoil water level or dislocations of the peat bed.

INTRODUCTION

The aim of this investigation has been to study relations between peat stratigraphy and changes in the mineral composition in profiles including minerotrophic mire peat and ombrotrophic mire peat. Particularly emphasized are certain deviations found in the mineral composition of ombrotrophic mire peat assignable to secondary influences of various kinds. The investigations have been carried out on two peatlands, Fjällmossen and Skoggårdsängar. Fjällmossen is an intact mire illustrating well the difference in mineral composition between mineral soil water conditioned peat formation (minerotrophic mire peat) and purely rain-water conditioned peat formation (ombrotrophic mire peat, bog peat). Skoggårdsängar has been subjected to intense human influence through peat-cutting and irrigation. The chemical changes in the bog peat brought about by inundation of the ground will be demonstrated. — A comprehensive description of the present vegetation, habitat conditions and development of Skoggårdsängar will be given in a later publication, in the present paper referred to as Mörnsjö (in prep.).

Concerning the terminology of the concept mire and its subdivisions current usage in Swedish plant ecological literature has been followed (see e.g., Du Rietz 1954, Malmer 1965, and Sjörs 1965). The peats are classified after their botanical composition.

The field and laboratory works were carried out during October 1966.

DESCRIPTION OF THE SITES

Fjällmossen

Fjällmossen is a large mire area about 2 sq. km situated on the southwestern part of the ridge Linderödsåsen in the parishes of Långaröd and Huaröd. Linderödsåsen, the largest continuous upland of Scania, has an altitude of 175 to 195 m. The annual precipitation is about 800 mm. The bedrock consisting of gneisses is covered by archaean moraine usually with fine sand as the main component. Heath forests (mainly *Fagus sylvatica*) prevail in the area. *Calluna* heaths occur here and there and among mire types bogs and poor fens are the most common ones. In the vicinity of Fjällmossen there is considerable arable land.

Fjällmossen is a good example of a bog mire, i.e., a mire complex comprising mainly bog areas (Du Rietz 1959). It consists of two large concentrically domed bog areas. Both of these are surrounded by narrow lagg fens. The main part of the latter has been cultivated; nowadays they are used as pasture. Only in the southernmost part of the bog mire does the lagg fen appear in its natural state (Fig. 1). Both of the bogs have a similar appearence. The following description refers to the southern one, from which the investigated profile has been taken. The bog vegetation is differentiated from the margin towards the centre as follows: a marginal stripe of bog vegetation wooded by birch (*Betula pubescens*) which in turn is followed by an open bog plain. The latter is differentiated into a marginal *Calluna vulgaris - Erica tetralix* stagnation complex and a very extensive central part with well differentiated hummock and hollow vegetation. The vegetation of the stagnation complex as well as the vegetation of the field and bottom layers in the wooded bog area consists of the following common species: *Calluna vulgaris, Empetrum nigrum, Erica tetralix, Rubus chamaemorus, Eriophorum vaginatum*, lichenes (mostly *Cladonia rangiferina, C. sylvatica* coll. and *C. pyxidata*) and bryophytes such as *Sphagnum magellanicum, S. rubellum, Leucobryum glaucum* and, but rarely, *Rhacomitrium lanuginosum*. The species mentioned also form

Fig. 1. Fjällmossen. View of the bog plain of the southern bog mire. In the foreground the lagg fen dominated by *Carex rostrata* and *Sphagnum apiculatum*. — T. MÖRNSJÖ photo. Sept. 12, 1966.

the hummock vegetation in the central part. Here *Sphagnum imbricatum* becomes frequent and scattered spots of *S. fuscum* are to be found. Further, *Trichophorum caespitosum* is common. The hollow vegetation is usually composed of *Rhynchospora alba, Drosera longifolia, D. intermedia* and *Sphagnum cuspidatum. Sphagnum tenellum* has been noted, too.

The bog vegetation of Fjällmossen is characteristic of the western type of bog vegetation in Scandinavia, which has been called the Komosse type or Rubellion (DU RIETZ 1949). The predominance of birch in the wooded bog vegetation in Fjällmossen is significant of bogs lying within "the southern deciduous forest region". In some places along the margin of the bog peat-cutting for the farmers home requirements has taken place. Usually only the most superficial part of the peat deposits has been exploited. The peat-cutting and drainage ditches dug in connection with this have obviously not influenced the vegetation cover of the rest of the bog.

As to the stratigraphy and developmental history of the southern bog the reader is referred to NILSSON (1935 p. 411; for the nomenclature of periods used below see NILSSON 1961). He shows that the central part of the bog mire is developed upon sediments of an ancient lake and further that the ultimate overgrowth of the lake basin by *Cladium* and *Carex* swamps in the centre took place at the end of the Boreal time. He also states that birch and pine grew far out on the bog during its earlier developmental stage and that these trees have disappeared later on. The greatest formation of bog peat took place during the Sub-Boreal time.

The profile investigated has been sampled at a point on the southern bog plain about 400 m from the mire margin. It was selected at a place where the peat bed rests directly on moraine ground close to the sediment limit. Thus the profile represents a peat bed which has not been subjected to dislocations. At the surface of the profile the vegetation cover consists of *Calluna vulgaris*, *Erica tetralix*, *Eriophorum vaginatum* and *Sphagnum magellanicum*.

Skoggårdsängar

Skoggårdsängar is situated in the parish of Genarp westward of and quite near the lake Häckebergasjön within the geomorphological region usually called "the South Scanian hill district west of Romeleåsen". The altitude of this region is about 50 to 70 m and the annual precipitation about 550 mm. The soil cover is shale- archaean moraine with clayey moraine sand as the most common type of soil. The indigenous vegetation is dominated by *Fagus sylvatica*. Both heath and meadow forest types are represented. However, today the main part of the region is arable land. Peatlands, usually very small ones, are frequent. Nearly all of them have been exploited chiefly for peat-cutting.

In the present paper the northwestern part of Skoggårdsängar only is taken into consideration, i.e., that part of the peatland to which the stratigraphical section in Fig. 3 refers.

The peatland has been developed in the basin of an ancient lake. The ultimate overgrowth by swamps and fens took place during the middle

Fig. 2. Skoggårdsängar. View of the northwestern part of Skoggårdsängar. The area has been subjected to peat-cutting and artificial elevation of the water level. Nowadays *Carex elata* and *Carex lasiocarpa* swamps cover the bog peat ground. The stratigraphy of the area is shown in Fig. 3. — T. Mörnsjö photo. Aug. 1966.

of the Atlantic time. Then its development in the central part was linked into formation of a bog. Through transformation of those peat kinds visible in the upper half of the stratigraphical section into corresponding peat genous sites the following zonal differentiation was realized. In the centre there was a concentrically domed bog area differentiated into an open bog plain and a marginal bog area wooded by birch. Towards the mineral ground there was a narrow lagg made up of alder carrs. So far this bog mire is quite similar to that actually met with in Fjällmossen.

The surface layer of the bog has been heavily destroyed by peat-cutting, that probably took place before the beginning of this century. Along the stratigraphical section peat-hags cut down to various levels are visible. In the middle part there are low peat ridges, the level of which is the top level of the former bog surface.

For a long time Skoggårdsängar has been used for storing of water in a water-regulation system connected with the lake Häckebergasjön. Since the beginning of the 1950-decade the whole peatland is converted into a shallow pond. On the stratigraphical section the present water level in the area is marked. The present vegetation cover of the former bog is developed under the regime of mineral soil water. In the peat-hags there is a swamp vegetation dominated by *Carex elata*, *C. lasiocarpa* and *Cladium mariscus*. The peat ridges are covered by parvocariceta of rich fen type. Those peats cupping the bog peat bed are formed by this vegetation that has been secondarily introduced. There is no spot left of the former bog vegetation.

The profile is taken on a peat ridge about 20 m eastward of the middle point of the stratigraphical section.

METHODS

All samples were collected by means of a Hiller peat borer. At each site two sampling profiles close to each other were bored. In the one of them determination of peat kinds and the degree of humification was performed (10 grade scale of v. POST). Samples for close examination of plant remains were collected. Furthermore, in this sampling profile samples were taken at 10 cm interval for determination of pH and ash content. In the other sampling profile samples were collected for determination of mineral constituents. Each sample was collected within 10 cm of the peat core, according to the ash content of the former profile.

The plant remains were determined by means of microscopic studies. On the basis of lists of plant remains recorded from individual peat kinds the peat genous vegetation was interpreted and classified.

The pH was determined with a glass electrode, together with the reference electrode inserted directly into the peat and gyttja samples.

Ash content was determined by means of heating material dried at 105°C in a muffle furnace at about 550°C.

The analyses of mineral constituents were carried out using the method described by MALMER & SJÖRS (1955 p. 49). After having dried the material to constant weight at 105°C, it was carefully crushed and mixed. Two grams of the material were then digested and evaporated with HNO_3 and $HClO_4$. The residue was dissolved in diluted HCl. The insoluble residue is regarded as SiO_2. In the solutions total amounts of the following ions were determined: Na, K, Mg, Ca, Mn, Fe and Al. The determination was performed by atomic absorption (Perkin—Elmer Atomic Absorption Spectrophotometer Mod. 303). In the determination of Ca lantane was added.

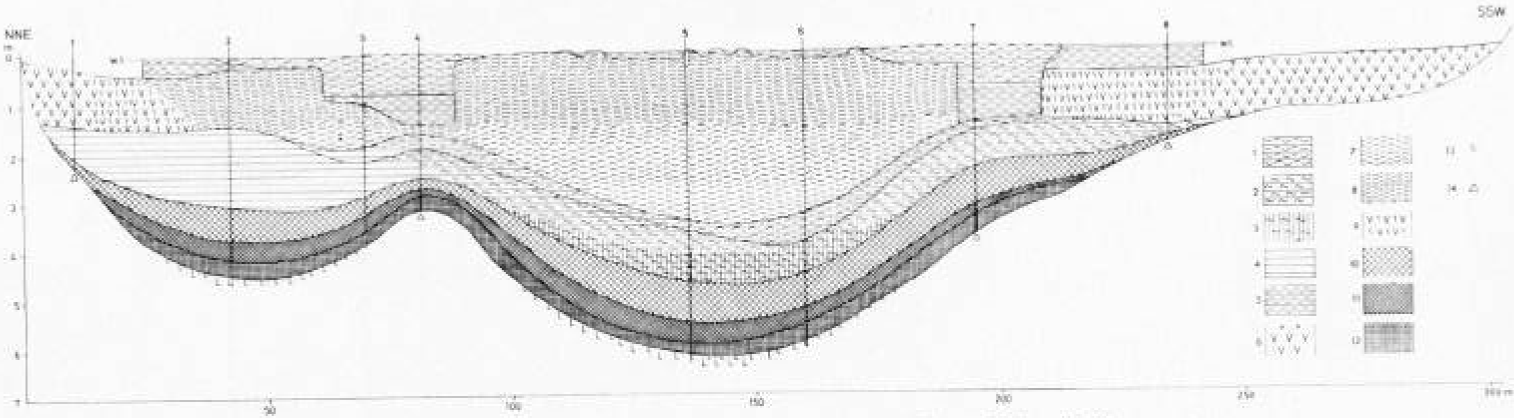


Fig. 3. Stratigraphical section from the northwestern part of Skoggårdsängar. — From MÖRNSJÖ (in prep.).

The investigation of the stratigraphy of the deposit has been carried out by means of an examination of bore-hole profiles, in the Fig. marked with numerals. The peatland is developed in the basin of an ancient lake. A short description of the development is given in the text. The curvature of the contact line gyttja — peat is a consequence of a secondary compression of the sediment layers by the heaviness of the peat bed. The surface layer of the bog has been heavily destroyed by peat-cutting. Peat-hags cut to deep levels are visible at the profiles 3 and 4 and at the profile 7. They are overgrown by *Sphagnum* carpets. In the middle part of the section shallow peat-hags and peat ridges are visible. The profile dealt with in the present paper is taken on a peat ridge about 20 m eastwards the profile 5. The peatland is covered by water for most part of the year; *w.l.*—the water level at high water.

Explanation of stratigraphical symbols. 1—6 minerotrophic mire peats: 1 *Carex-Sphagnum* peat, 2 *Carex-Bryales* peat, 3 *Phragmites-Bryales* peat, 4 magnocarices peat, 5 magnocarices peat (recently formed) and 6 *Alnus* peat (carr peat). — 7—9 ombrotrophic mire peats: 7 *Sphagnum* peat, slightly humified (H 3—4), 8 *Sphagnum* peat, moderately humified (H 5—7) and 9 *Betula-Eriophorum vaginatum* peat. — 10—12 sediments: 10 coarse detritus gyttja, 11 fine detritus gyttja and 12 clay-gyttja. — 13 clayey sand. — 14 moraine.

RESULTS

The profile from Fjällmossen.

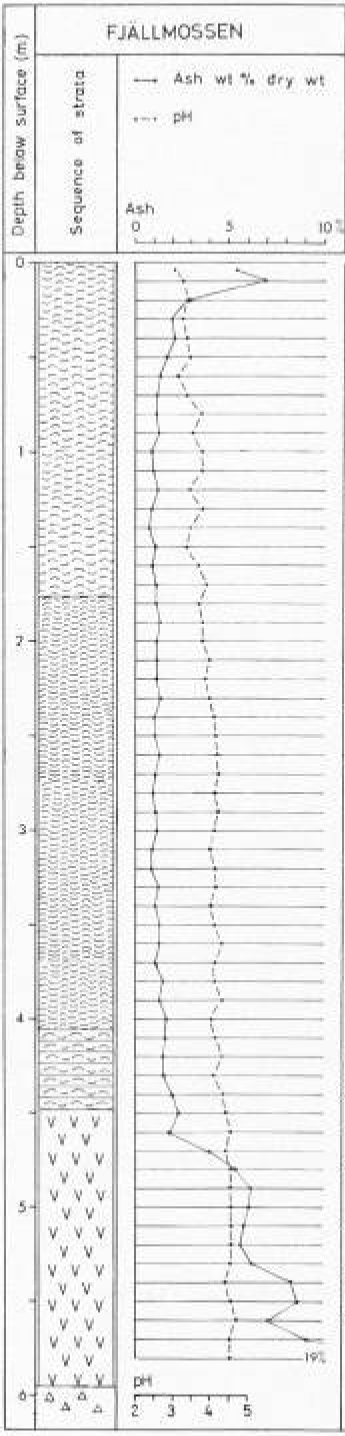
The results are given in Fig. 4. In the *Alnus* peat (H 8—9) resting upon moraine ground remains of alder and scattered graminide radicells are the only plant remains observed. I interpret the peat as having been formed by alder carr. The *Carex-Sphagnum* peat (H 6) contains radicells of carices (mainly *Carex rostrata* type) together with leaves and stems of *Sphagnum apiculatum* and/or *S. angustifolium*. Its peat genous vegetation ought to be classified as poor fen vegetation. The *Sphagnum* peats can be divided into *Sphagnum fuscum/rubellum* peat (H 5—6) occurring between 4.1—1.7 m and *Sphagnum magellanicum* peat (H 4) occurring from 1.7 m up to the surface. There is a large amount of ericoid plant remains and fibres of *Eriophorum vaginatum*. No remains of fen plants have been observed anywhere in these peats. The *Sphagnum* peats can be interpreted as bog peats. Thus the botanical determination of the peat layers clearly indicates a division of the profile into two parts: one basal part formed by minerotrophic mire vegetation (carr and fen peats) and one continuous with the surface formed by ombrotrophic mire vegetation, bog vegetation (bog peats).

The pH is highest in the carr peat, then it falls through the fen peat. The lowest figures are found in the upper half of the bog peat with a rather irregular variation. Since not all aspects of the acid-base conditions have been studied it is difficult to evaluate the significance of pH in relation to geobotanical limits. Important changes may have occurred since the time of the formation of the peat affecting the pH, for example, in the redoxpotential. Concerning acid-base conditions in bog profiles the reader is referred to MATTSON & KOUTLER-ANDERSSON 1954 pp. 344 et seq.

From the ash curve and the distribution of mineral constituents through the profile it is evident that more or less well indicated changes appear in relation to the sequence and kinds of strata.

In the carr peat the ash content is high, except in the upper part where a decrease is noted. There is a strong correlation between the ash curve and the contents of SiO_2 in samples 25—21. The high contents of SiO_2, Ca, Fe as well as the high Ca/Mg ratio reflect a strong influence of mineral soil water during the formation of the carr peat.

Fig. 4. The profile from Fjällmossen. — For explanation of the stratigraphical symbols see Fig. 3.



Total contents of mineral constituents calculated per g dry peat.

Sample No	SiO_2 mg	Na µmol	K µmol	Mg µmol	Ca µmol	Mn µmol	Fe µmol	Al µmol	Ca/Mg
1	18.8	12	5.0	39	40	0.26	13	30	1.0
2	9.1	9.7	2.5	52	39	0.17	9.2	20	0.8
3	8.7	20	1.9	55	30	0.10	6.7	9	0.5
4	3.9	17	1.5	57	25	0.07	5.9	6	0.4
5	5.4	13	1.8	60	21	0.10	5.9	11	0.4
6	5.7	14	1.8	60	18	0.07	10	8	0.3
7	6.0	15	2.2	51	19	<0.05	6.8	6	0.4
8	3.1	19	2.5	60	13	<0.05	5.8	6	0.2
9	3.1	20	3.3	62	17	<0.05	5.7	8	0.3
10	4.0	15	2.9	41	13	<0.05	4.9	9	0.3
11	5.5	19	3.2	57	17	<0.05	5.1	10	0.3
12	4.2	18	3.1	53	21	<0.05	4.6	10	0.4
13	3.6	18	2.7	58	30	<0.05	5.4	10	0.5
14	3.6	19	2.7	53	34	<0.05	5.2	7	0.6
15	2.9	12	2.5	42	51	<0.05	7.6	6	1.2
16	3.4	13	2.4	42	69	<0.05	9.1	6	1.6
17	2.5	12	2.1	40	90	0.14	13	6	2.3
18	2.4	12	2.0	33	120	0.14	17	5	3.6
19	2.1	10	1.5	16	108	0.17	18	5	6.8
20	1.6	8.3	1.3	12	108	0.18	20	5	9.0
21	1.9	5.5	1.1	9	310	0.26	43	8	34
22	8.6	5.5	1.8	12	410	0.59	110	20	34
23	6.9	5.4	1.5	12	410	0.70	79	14	34
24	11.0	8.4	1.6	10	360	0.73	100	11	36
25	26.5	10	3.2	12	320	1.1	130	8	27

Fig. 4.

Mattson, Sandberg & Terning (1944) have discussed the use of the exchangeable ratio Ca/Mg to distinguish peats formed under minerotrophic conditions from peats formed under ombrotrophic conditions. They found that Ca/Mg ratios are > 1 in minerotrophic mire peat and < 1 in ombrotrophic mire peat. Mattson & Koutler-Andersson (1954 p. 334) point out that the Ca/Mg ratio can be altered in ombrotrophic mire peat due to changes in the hydrology in the bog since the time of formation of the bog peat. Records about the exchangeable ratio Ca/Mg in various kinds of mire peats are to be found in, for example, Malmer & Sjörs (1955), Olausson (1957), Sjörs (1961) and Chapman (1964). In the present paper the Ca/Mg ratios are calculated on total amounts. Thus in Figs. 4 and 5 Ca/Mg means the molar ratio of total Ca to total Mg. This obviously does not invalidate the figures as an indicator of the situations mentioned above. As to bog peat (ombrotrophic mire peat) and probably also as to peat formed in poor minerotrophic mire sites the total contents of Ca and Mg occur in the exchangeable state (see Malmer & Sjörs op. cit. p. 67).

In the fen peat the mineral composition is distinctly different. The ash content is around 2 per cent, corresponding to a decrease in SiO_2, Ca, Fe and Al in samples 20 and 19. The Ca/Mg ratios are 9.0 and 6.8 respectively. All these figures indicate that the water of the peat genous site of this fen peat was poorer in minerals than that of the carr peat.

The mineral composition of these peat types displays an unmistakably minerotrophic pattern, which among other things is characterized by Ca/Mg ratios much greater than 1.

In the middle part of the bog peat bed, say from samples 4 to 14, there is an even distribution of the mineral constituents which is very striking. The ash content is very low, only about 1 per cent. The contents of Ca, Mn, Fe and — less significantly — those of SiO_2 and Al are low compared with the amounts in the carr and fen peats. The Ca/Mg ratios are low, often 0.3. All these data together make up a chemical pattern indicative of pure ombrotrophic conditions. Similar conditions have been demonstrated by Malmer (1962) when dealing with surface peat and its importance as plant substrate.

In the basal part of the bog peat bed up to about 3 m below the surface there is a chemical pattern intermediate between that found in the bog peat above and that found in the fen peat below. The geochemical boundary between the minerotrophic and ombrotrophic patterns lies at a level between the samples 15 and 14, where the Ca/Mg ratio changes from 1.2 to 0.6. There is simultaneously also a change in the Ca/Na ratio. However, the botanical boundary between minerotrophic mire peat and ombrotrophic mire peat lies immediately above sample 19. The most probable explanation to this incompatibility is that the peat must have been affected by disturbances of secondary nature. My opinion is that the lowest meter of the bog peat bed has been subject to infiltration of mineral soil water since the time of formation of that peat layer. The path of inflow may have been the layer of *Carex-Sphagnum* peat as this has a rather loose texture. As the disturbance appears over an interval of about 1 m it implies that great changes in the hydrological system of the basin have taken place. Evidence that at least two great changes in the precipitation climate in the area have occurred can be given, both of them probably resulting in an elevation of the subsoil water level. One change took place when the wooded bog became replaced by an unwooded stage during the Atlantic time, the other when strong formation of bog peat was initiated during the Sub-Boreal time (cf. NILSSON 1935 p. 411).

In the upper 0.5 m of the peat profile there is another discrepancy in the mineral composition compared with that found in subjacent strata. The ash content shows very high values, up to around 7 per cent in the uppermost layer. Among the mineral constituents there is a distinct increase in the amounts of SiO_2, Fe and Al through the sample series 4 to 1. It has been demonstrated earlier that the mineral composition of the peat shows such a pattern in the top layer of bogs (see e.g. v. POST 1925, MATTSON & KOUTLER-ANDERSSON 1954 p. 363, ASSARSSON 1961 p. 19 and CHAPMAN 1964). — It has been interpreted partly as an effect of the mineral salt uptake of the plant cover and partly as an effect of the deposition of air-borne mineral particles from arable land. — It is worth noticing that the uppermost samples may contain some living rootlets and other living material even if those visible to the naked eye have been sorted away. It is likely that the high amount of K in these samples is bound in the fraction of living material. MALMER (1958 p. 283; see also MALMER & SJÖRS 1955 p. 286) concludes that the total K involved in the biogeochemical cycle is stored to a great extent in the living material. However, it is likely that the increase of SiO_2, Fe and Al in the three uppermost samples ought to be due to deposition of air-borne mineral particles. Microscopic examination carried out on small portions separated from the peat samples down to 1 m has shown that mineral particles are present in the upper 0.5 m only. These particles may have originated from the intense reclamation of the land area in Scania during the last five centuries.

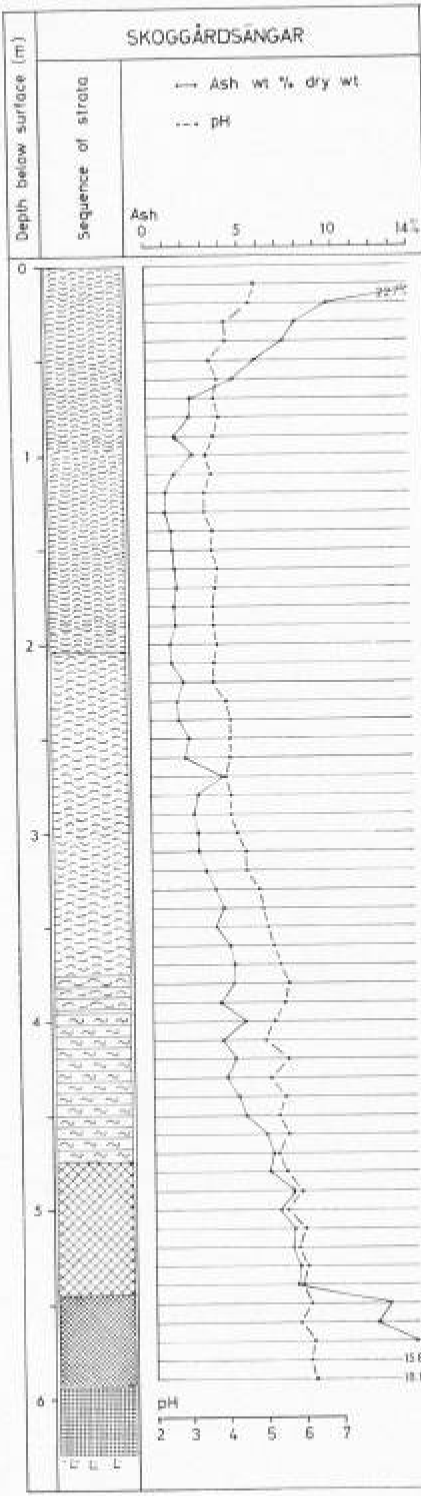
Throughout the bog peat there is only a small variation in the total amount of Ca and Mg. With the exception of the three uppermost samples the proportion between these two elements is about the same, too, varying about 0.2 to 0.3. The corresponding ratios in samples 1 to 3 are 0.5 to 1.0. It depends on gradually increasing figures for Ca and decreasing figures for Mg. These conditions may be explained through an increasing supply of Ca from arable land. According to the Donnan equilibrium, such an increasing supply of Ca may result in increasing leaching of Mg. Thus it is not necessary that there has been a decrease in the supply of this element even if there is a decrease in the contents in peat.

The profile from Skoggårdsängar.

The results are given in Fig. 5. The bottom layer of this profile includes sediments of the ancient lake. The *Carex-Bryales* peat (H 4) overlying the gyttja is composed of radicells of tall sedges, mainly *Carex lasiocarpa*, and remains of *Drepanocladus aduncus* coll., upwards replaced by *Meesia triquetra*. There is no intermingling of detritus in the peat. The *Carex-Sphagnum* peat (H 4) is composed of radicells of *Carex lasiocarpa* and remains of *Sphagnum teres* in addition to scattered leaves of *Aulacomnium palustre*. The peat genous vegetation of both the peat kinds mentioned ought to be classified as rich fen vegetation and consequently the corresponding peat genous site is rich fen. Above the *Carex-Sphagnum* peat there is a layer of *Sphagnum* peat up to the surface. In its basal part it is sharply delimited from the subjacent fen peat layer. The *Sphagnum* peat is composed of *Sphagnum fuscum* and *S. rubellum* in addition to remains of ericoid plants and fibres of *Eriophorum vaginatum*. The peat genous vegetation of this peat ought to be classified as bog vegetation. Consequently the *Sphagnum* peat is termed bog peat. There is a shift in the degree of humification in the bog peat; H 3—4 in the lower part of the layer and H 6—7 in the upper half. — At the top of the profile roots from the vegetation cover penetrate down to about 0.2 m.

There is a rather uniform distribution of most of the mineral constituents in the gyttja and overlying fen peats. The decrease in SiO_2 through the gyttja reflects the decreasing supply of inorganic material as a consequence of the incipient overgrowth of the ancient lake. As has been stated before the contact line between gyttja and peat is very sharp. Chemically it can be characterized by a distinct change in SiO_2

Fig. 5. The profile from Skoggårdsängar. — For explanation of the stratigraphical symbols see Fig. 3.



Total contents of mineral constituents calculated per g dry peat.

Sample No.	SiO_2 mg	Na µmol	K µmol	Mg µmol	Ca µmol	Mn µmol	Fe µmol	Al µmol	Ca/Mg
1	31.2	12	5.3	24	370	0.31	28	7	15
2	27.7	12	5.3	24	250	0.19	24	8	10
3	30.0	14	4.0	33	220	0.25	17	8	6.7
4	6.5	18	1.3	49	110	0.19	12	7	2.2
5	5.0	21	1.3	55	150	0.17	8.7	7	2.7
6	4.0	21	1.5	53	56	0.14	7.8	6	0.9
7	4.6	19	1.7	45	55	0.19	6.8	5	1.2
8	4.5	18	2.3	39	84	0.27	9.6	6	2.2
9	2.5	19	1.6	39	120	0.50	15	3	3.1
10	3.5	12	1.7	29	180	0.63	22	2	6.2
11	2.1	16	1.6	48	320	0.98	34	3	6.7
12	6.5	12	1.8	34	360	1.4	23	3	11
13	3.1	12	1.5	28	380	1.3	22	4	14
14	3.7	12	2.1	25	320	1.5	28	2	13
15	3.6	12	1.6	23	310	1.4	70	4	13
16	3.4	11	2.0	18	290	1.5	55	1	16
17	12.1	9.5	2.7	17	350	2.0	110	2	21
18	20.0	9.3	4.0	15	310	2.2	67	1	21
19	30.0	9.0	6.8	18	380	2.2	78	2	21

Fig. 5.

which occurs in very low amounts in the peat. This fact also supports the interpretation that the overgrowth of the ancient lake took place by floating carpets. The peat genous vegetation of the *Carex-Bryales* peat ought to have been developed within the regime of the ancient lake water. It has been classified as rich fen vegetation. It is noteworthy that the mineral composition in this peat resembles that in the top layer of the profile, which actually is the site of rich fen vegetation today.

The geobotanical boundary between minerotrophic mire peat and ombrotrophic mire peat lies at the level 3.7 m below the surface. In the chemical pattern there is no well-delimited geochemical boundary indicating a change from mineral soil water regime to ombrogenous water regime. In none of the samples collected from the bog peat do there appear such pronounced ombrotrophic chemical conditions as in the bog peat of Fjällmossen. Only in the interval below 1.2 m to somewhat more than 2 m below the surface does the chemical pattern approach rather closely that characterizing ombrotrophic conditions. Here the content of ash is around 1—1.5 per cent and the Ca/Mg ratio is 0.9 at the lowest. Most figures are, however, higher than in the corresponding part of the profile from Fjällmossen. The chemical pattern of the bog peat below this interval is clearly indicative of the influence of mineral soil water. Particularly significant are the high Ca/Mg ratios and the high content of Ca occurring in the sample series 12 to 8. — The similar disturbance appearing in the basal part of the bog peat bed in Fjällmossen was stated to be secondarily introduced, conditioned by an elevation of the subsoil water level. Also as to the present profile it seems most likely that the basal half of the bog peat bed has been disturbed by mineral soil water secondarily introduced. Here the disturbance seems to be associated with dislocations of the peat bed. The curvature of the stratigraphical lines (cf. the stratigraphical section Fig. 3) in the basin is a consequence of a secondary compression of the sediment layers by the heaviness of the bog peat bed. At the time of incipient bog development the surface of the mire ought to have had a position somewhat above the sediment limit (the sediment limit approximatively indicates the paleohydrological limit of mineral soil water level). The sediment limit lies about 1.8 m below the top level of the peatland. The dislocation of the bog peat bed can be estimated to about 2 m. This means that the lowest 2 m of the bog peat bed have been displaced to a region where mineral soil water is retained in the surrounding deposits. On an examination of the peat profile one notices

Table 1. Chemical properties of water from Skoggårdsängar.

Sample	pH	κ red*	Concentrations in µmol/litre					
			Na	K	Mg	Ca	Mn	Fe
A	5.5	120	540	14	56	480	0.9	2
B	5.6	90	510	9	47	320	1.2	2

Sample A: water from a pit dug near the investigated profile. Sample B: open water in a peat-hag. The samples were collected on Oct. 12, 1966. The elements are determined by atomic absorption.

* the specific conductivity at 20°C multiplied by 10^6 and with the conductivity due to the hydrogen ions subtracted.

that it is in particular the lowest 2 m of the bog peat which show a disturbed chemical pattern.

In the uppermost meter of the profile there is a chemical stratification which obviously is conditioned by the artificial water covering of the peatland. — The chemistry of water actually occurring close to the profile is shown in Tab. 1. — Down to about 0.6 m the chemical pattern is strongly minerotrophic as shown by the high content of ash as well as SiO_2, Ca, Mn and Fe and high Ca/Mg ratios. The highest figures for K are found in the uppermost two samples. It is likely that the bog peat bed has been percolated by the mineral soil water down to this depth. The high values of SiO_2 met with in the samples 1 to 3 are in part assignable to mineral particles. This fraction has been found to be rather great in the top layer. Below the depth of 0.6 m the influence decreases though it is still observable down to about 1.2 m indicated by the Ca/Mg ratio 2.7 (sample 5). Here it seems more probable that the influence is brought about by diffusion of ions. — With increasing Ca content there are in the top layer decreasing figures for Mg as in the profile from Fjällmossen.

DISCUSSION

In the profiles from both the peatlands studied the distinct difference between the chemical pattern of minerotrophic mire peat and that of ombrotrophic mire peat is clearly demonstrated. Compared with the ombrotrophic mire peat the minerotrophic mire peat exhibits higher values of pH, higher content of ash and SiO_2 as well as higher content of Ca, Mn, Fe and Al. The Ca/Mg ratios are well above 1 in the minerotrophic mire peat, whereas in the ombrotrophic mire peat the ratios are markedly lower, often 0.2 to 0.3. In both profiles the contents of Mg are considerable higher in the middle part of the bog peat bed than in the other parts. These high figures coincide with the lowest figures of Ca. Compared with these differences the variation in contents of Na and K are rather small and without significance for characterizing the main types of peat. In the main these general relationships are in accordance with those found when studying the peat substrate of corresponding recent plant communities.

In the minerotrophic mire peat there are certain differences in the chemical pattern that are characteristic of the stratigraphy and botanical character of the peats, for example, between peat derived from carr vegetation and peat derived from poor fen vegetation. This is seen in the profile from Fjällmossen. The chemical differences between minerotrophic mire peat from Fjällmossen and corresponding peat from Skoggårdsängar seem to be of minor importance. In this case a comparison is somewhat difficult as the vegetational successions of the sites are different.

As the ombrotrophic mire peat ought to have received all its minerals from precipitation great similarities in the mineral composition would be expected in this case both between the two peatlands investigated and between the different stratigraphic layers. In the profile from Fjällmossen the series of bog peat samples, except those from the basal part and those from the top layer, exhibit such a purely rain-water conditioned mineral composition. In most of these samples the Ca/Mg ratios are low, close to that in sea water, 0.2. They are also largely in accordance with those found by MATTSON & KOUTLER-ANDERSSON (1954, Tab. 1 p. 330) in the profile from Ramna bog in northwestern Scania. No bog peat samples collected from Skoggårdsängar show such low figures for most minerals as the samples from Fjällmossen at corresponding levels. The lowest Ca/Mg ratio found in Skoggårdsängar is 0.9. It is impossible to decide whether these deviations depend on differences in the environment during the formation of the bog or whether they are due to secondarily disturbances.

In both profiles the basal part of the bog peat bed shows a chemical pattern deviating from the general pattern characterizing pure ombrotrophic conditions. The pattern found here is of minerotrophic appearance, more or less pronounced. This deviation is probably due to influence of mineral soil water since the time of the formation of the bog peat. As to the situation in Fjällmossen such a secondary influence may have been brought about by an elevation of the subsoil water level in the surroundings. The corresponding deviation in the profile from Skoggårdsängar is obviously associated with dislocations in the peat bed resulting in a sinking of the peat layers to a level influenced by mineral soil water.

The uppermost peat layer in both profiles exhibits a mineral composition deviating from that found at a deeper level. The rather high amounts of K found in the top layer may due to the importance of this element for living plants. The mineral particles found in the uppermost samples as well as the higher figures for Ca, Mn, Fe, Al and SiO_2 ought to be due to increased cultivation of the land area during the last centuries, as to Skoggårdsängar essentially due to supply of mineral soil water. In the case of Fjällmossen this increased supply of minerals is due to air-borne drift only and thus is on a minor scale. This supply has probably not affected the pH and acid-base conditions nor the composition of the vegetation. By inundation of the peat ground in Skoggårdsängar the bog peat has received a great supply of minerals from the surrounding mineral soil. This great supply has brought about considerable changes in the mineral composition as well as in pH and acid-base conditions of the bog peat. As a consequence of this great environmental change the composition of the vegetation has changed from a pre-existent bog vegetation to that rich minerotrophic fen vegetation actually growing on the bog peat ground.

ACKNOWLEDGEMENTS

I wish to express my sincere gratitude to Laborator NILS MALMER, Head of the Department of Plant Ecology, for offering valuable criticism concerning the manuscript. I also want to thank my colleagues at the department, JAN NILSSON for suggestions and assistance in dealing with the chemical investigation, ÅKE RÜHLING and GERMUND TYLER for valuable discussions concerning chemical calculations. Thanks are also due to Mrs. MIMMI VARGA for technical assistance in the laboratory.

LITERATURE CITED

ASSARSSON, G. 1961. Södra Sveriges torvtillgångar. II. Kemiska analyser. (The supply of peat in southern Sweden. II. Chemical analyses.) — Sveriges Geol. Undersökn. Ser. C. 578. 25 pp.

CHAPMAN, S. B. 1964. The ecology of Coom Rigg Moss, Northumberland II. The chemistry of peat profiles and the development of the bog system. — Journ. Ecol. 52: 315—321.

Du Rietz, G. E. 1954. Die Mineralbodenwasserzeigergrenze als Grundlage einer natürlichen Zweigliederung der nord- und mitteleuropäischen Moore. — Vegetatio 5—6: 571—585.

— 1949. Huvudenheter och huvudgränser i svensk myrvegetation. (Main units and main limits in Swedish mire vegetation.). — Sv. Bot. Tidskr. 43: 274—309.

— 1950. Blängen, ett mossemyrreservat på Billingen. — In N.-G. Karvik [Ed.] Från Falbygd till Vänerkust, pp. 175—196. Lidköping.

Malmer, N. 1958. Notes on the relation between the chemical composition of mire plants and peat. — Bot. Notiser 111: 274—288.

— 1962. Studies on mire vegetation in the Archaean area of southwestern Götaland (South Sweden). I. Vegetation and habitat conditions on the Åkhult mire. — Opera Bot. 7 (1). 322 pp.

— 1965. The southern mires. — Acta Phytogeogr. Suec. 50: 149—158.

— & Sjörs, H. 1955. Some determinations of elementary constituents in mire plants and peat. — Bot. Notiser 108: 46—80.

Mattson, S., Sandberg, G. & Terning, P.-E. 1944. Electrochemistry of soil formation. VI. Atmospheric salts in relation to soil and peat formation and plant composition. — Lantbrukshögsk. Annaler (Annals Agr. Coll. Sweden) 12: 101—118.

Mattson, S. & Koutler-Andersson, E. 1954. Geochemistry of a raised bog. — Ibid. 21: 321—366.

Mörnsjö, T. in prep. (Preliminary title: Studies on vegetation and development of a peatland in Scania, South Sweden.) — Opera Bot.

Nilsson, T. 1935. Die pollenanalytische Zonengliederung der spät- und postglazialen Bildungen Schonens. — Geol. För. Stockholm Förh. 57: 385—562.

— 1961. Ein neues Standardpollendiagramm aus Bjärsjöholmssjön in Schonen. — Lunds Univ. Årsskr. N. F. Avd. 2. 56. 34 pp.

Olausson, E. 1957. Das Moor Roshultsmyren. Eine geologische, botanische und hydrologische Studie in einem südwestschwedischen Moor mit exzentrisch gewölbten Mooselementen. — Lunds Univ. Årsskr. N. F. Avd. 2. 53. 72 pp.

Post, L. v. 1925. Einige Aufgaben der regionalen Moorforschung. — Sveriges Geol. Undersökn. Ser. C. 337. 41 pp.

Sjörs, H. 1961. Some chemical properties of the humus layer in Swedish natural soils. — K. Skogshögsk. Skr. (Bull. Roy. School Forestry Stockholm, Sweden) 37. 51 pp.

— 1965. Northern mires. Regional ecology of mire sites and vegetation. — Acta Phytogeogr. Suec. 50: 180—188.

Contributions to the Flora of Rhodesia XI[1]
Pteridophyta

By E. A. C. L. E. Schelpe

Bolus Herbarium

University of Cape Town, South Africa

ABSTRACT

The fifty five taxa of *Pteridophyta* collected by the FRIES, NORLINDH and WEIMARCK expedition in the eastern districts of Rhodesia are treated systematically. *Cheilanthes leachii* SCHELPE is newly recorded for Rhodesia. The distribution of each taxon in Africa is given and distribution maps of *Elaphoglossum hybridum* (BORY) BRACK., *Gleichenia umbraculifera* (KUNZE) MOORE, *Hymenophyllum tunbridgense* (L.) SM., *Pellaea goudotii* (KUNZE) C. CHR., *Pteris cretica* L., and *Xiphopteris flabelliformis* (POIR.) MORTON in Africa are given.

LYCOPODIACEAE

Lycopodium cernuum L., Sp. Pl. 2, 1753, 1103. — *Lepidotis cernua* (L.) BEAUV., Prod. Aeth. 1805, 101. — *Lycopodium boryanum* A. RICH., Sert. Astrol. 1834, 42. — *Lycopodium heeschii* K. MUELL. in Bot. Zeit., 19, 1861, 164. — *Lycopodium secundum* K. MUELL. in Bot. Zeit., 19, 1861, 164.

Inyanga: Pungwe infra dejectum fluminis in silvula ad rivulum, c. 1500 m s.m., 18 Dec. 1930 — 3888.

Distribution: Cosmopolitan in the tropics and subtropics.

Lycopodium clavatum L. var. **inflexum** (BEAUV.) SPRING, Monogr. Lycopod. 1, 1842, 90. — *Lepidotis inflexa* BEAUV., Prod. Aeth., 1805, 109. — *Lycopodium inflexum* (BEAUV.) SW., Syn. Fil., 1806, 179. — *Lycopodium clavatum* var. *natalense* NESSEL in Fedde Rep. Sp. Nov. 36, 1934, 191. — *Lycopodium aberdaricum* CHIOV. in Lav. Ist. Bot. Univ. Modena 6, 1935, 147.

Inyanga: Prope dejectum fluminis Pungwe in proclivitate, c. 1800 m s.m., 6 Nov. 1930 — 2679; Inyangani c. 3 km occidentem versus a monte, ad rivulum, c. 2000 m s.m., 6 Dec. 1930 — 3455; Pungwe supra dejectum fluminis in silvula ad rivulum, c. 1700 m s.m., 18 Dec. 1930 — 3836.

Distribution: Cape Province, Orange Free State, Lesotho, Natal, Swaziland, Transvaal, Rhodesia, Mozambique, Malawi, Tanganyika, Kenya, Ethiopia, Uganda, Congo, Sudan (Imatong Mtns.), Cameroons, São Tomé, Madagascar, Mauritius, Réunion.

[1] Issued by T. NORLINDH and H. WEIMARCK as a continuation of their series "Beiträge zur Kenntnis der Flora von Süd-Rhodesia" of which nos. I—X have been published in Botaniska Notiser 1932—1958.

Lycopodium carolinianum L. var. **grandifolium** SPRING in Mém. Acad. R. Brux. 24, 1849—50, 46. — *Lycopodium sarcocaulon* WELW. & A. BR. ex KUHN, Fil. Afr. 1868, 210.

I n y a n g a: Inyangani, c. 3 km occidentem versus a monte in palude, frequens, c. 2000 m s.m., 6 Dec. 1930 — 3470.

D i s t r i b u t i o n: Natal, Rhodesia, Mozambique, Malawi, Zambia, Angola.

SELAGINELLACEAE

Selaginella abyssinica SPRING in Mém. Acad. R. Belg. 24, 1850, 99. — *Selaginella kirkii* BAK. in Journ. Bot. 23, 1855, 176. — *Selaginella goetzei* HIERON. in Bot. Jahrb. 30, 1901, 265 et in ENGL. & PRANTL, Nat. Pflanzenfam. I: 4, 1901, 686. — *Selaginella whytei* HIERON. in ENGL. & PRANTL., Nat. Pflanzenfam. I: 4, 1901, 697. — *Selaginella preussii* HIERON., op. cit. 1901, 686. — *Selaginella bueensis* HIERON. in Hedwigia 43, 1904, 20.

I n y a n g a: C. 3 km in septentriones a pago in clivis ad rivulum, c. 1750 m s.m., 24 Jan. 1931 — 4578.

D i s t r i b u t i o n: Rhodesia, Mozambique, Malawi, Zambia, Tanganyika, Kenya, Ethiopia, Uganda, Sudan (Imatong Mtns.), Congo, Cameroons, Nigeria, Ghana, Fernando Po.

Selaginella krauusiana (KUNZE) A. BR., Ind. Sem. Hort. Berol. 1860, App., 22. — *Lycopodium kraussianum* KUNZE in Linnaea 18, 1844, 114.

I n y a n g a: Pungwe infra dejectum fluminis in praecipitio madido montis, c. 1400 m s.m., 18 Dec. 1930 — 3927.

D i s t r i b u t i o n: E. Cape Province, Natal, Swaziland, Transvaal, Rhodesia, Mozambique, Malawi, Tanganyika, Kenya, Uganda, Ethiopia, Sudan (Imatong Mtns.), Congo, Cameroons, Fernando Po, Madeira, Azores.

EQUISETACEAE

Equisetum ramosissimum DESF., Fl. Atlant. 2, 1799, 398. — *Hippochaete ramosissimum* (DESF.) BOERN., Fl. Deutsche Volk, 1912, 282. — *Equisetum campanulatum* POIR. in LAM., Encycl. Méth. Bot., 5, 1804, 613. — *E. ramosum* LAM. & DC., Syn. Pl. Fl. Gallica, 1806, 118. — *E. elongatum* WILLD. Sp. Pl., ed. IV, 5, 1810, 8. — *E. pannonicum* KITAIB. in WILLD., Sp. Pl., ed. IV, 5, 1810, 6. — *E. thunbergii* WIKSTR. in K. Vet. Acad. Handl. Stockh. 2, 1821, 4. — *E. burchellii* VAUCH., Monogr. Prêles 1821, 375. — *E. multiforme* VAUCH., op. cit. 375. — *E. incanum* VAUCH., op. cit. 382. — *E. azoricum* GANDOG. in Bull. Soc. Bot. France, 66, 1920, 304.

I n y a n g a: Prope pagum ad rivulum, c. 1700 m s.m., 30 Oct. 1930 — 2464; prope pagum Cheshire in alveo exsiccato, c. 1300 m s.m., 15 Jan. 1931 — 4341; in palude in proclivitate montis prope pagum Cheshire, c. 1500 m s.m., 4 Feb. 1931 — 4817.

Distribution: E. Cape Province, Orange Free State, Lesotho, Natal, Transvaal, Rhodesia, Mozambique, Malawi, Zambia, Angola, Ethiopia, Somalia, Eritrea, Sudan, Morocco, Tunisia, C. Sahara, Cape Verde Is., Canary Is., Madagascar, Mauritius, Réunion. Also temperate Europe through Asia Minor and Asia to the Philippine Is. and New Guinea.

OPHIOGLOSSACEAE

Ophioglossum reticulatum L., Sp. Pl. ed. II, 2, 1763, 1063.

Inyanga: Prope villam Inyanga Down in palude, c. 2000 m s.m., 29 Jan. 1931 — 4663; ad montem Inyangani in solo humido ad rivulum, c. 2000 m s.m., 14 Feb. 1931 — 5050.

Distribution: E. Cape Province, Natal, Rhodesia, Zambia, Mozambique, Angola, Congo, Uganda, Zanzibar, Tanganyika, Kenya, Sudan, Cameroons, Nigeria, Ghana, Liberia, Cape Verde Is., Sierra Leone, São Tomé, Fernando Po, Madagascar, Mauritius.

MARATTIACEAE

Marattia fraxinea SM. ex GMEL. var. **salicifolia** (SCHRAD.) C. CHR. in PERRIER, Cat. Pl. Madag., 1932, 67. — *M. salicifolia* SCHRAD. in Gött. Gel. Anz., 1818, 920. — *M. natalensis* PRESL, Suppl. Tent. Pterid., 1845, 9. — *M. dregeana* PRESL, op. cit. 9.

Inyanga: Pungwe infra dejectum fluminis in silvula ad rivulum, 1500 m s.m., 18 Dec. 1930 — 3891.

Distribution: S. and E. Cape Province, Natal, Swaziland, Transvaal, Rhodesia, Mozambique, Malawi, Zambia, Tanganyika, Congo, Sudan, Kenya, Madagascar, Mauritius.

OSMUNDACEAE

Osmunda regalis L., Sp. Pl. 2, 1753, 1065. — *Osmunda capensis* PRESL, Suppl. Tent. Pterid., 1845, 63 (non L. 1771). — *Struthiopteris regalis* (L.) BERNH. in Schrad., Journ. Bot. 1800 (2), 1801, 126. — *Osmunda regalis* var. *capensis* (PRESL) MILDE, Fil. Europ., 1867, 179.

Inyanga: Prope pagum ad rivulum, c. 1700 m s.m., 31 Oct. 1930 — 2495; Pungwe supra dejectum fluminis ad litorem, c. 1700 m s.m., 17 Dec. 1930 — 3885.

Distribution: S. and E. Cape Province, Lesotho, Natal, Transvaal, Rhodesia, Mozambique, Malawi, Zambia, Tanganyika, Kenya, Uganda, Sudan, Congo, Angola, Cameroons, Nigeria, Liberia, Sierra Leone, Fernando Po, Madagascar, Mauritius.

GLEICHENIACEAE

Gleichenia umbraculifera (KUNZE) MOORE, Ind. Fil., 1862, 384. — *Mertensia umbraculifera* KUNZE in Linnaea 18, 1844, 144. — *Sticherus umbraculiferus* (KUNZE) CHING in Sunyatsenia 5, 1940, 285.

Inyanga: Ad radices montis Inyangani in convalle rivuli, c. 2000 m s.m., 6 Dec. 1930 — 3522; inter pagum Inyanga et dejectum fluminis Pungwe, c. 7 km a Pungwe in valle rivuli, c. 1800 m s.m., 16 Dec. 1930 — 3764; supra dejectum fluminis Pungwe, in solo humido, c. 1700 m s.m., 18 Dec. 1930 — 3831; ad villam Inyanga Down, in valle fluminis Tsunga, c. 1850 m s.m., 30 Jan. 1931 — 4735.

Distribution: E. Cape Province, Natal, Swaziland, Transvaal, Rhodesia. Map, Fig. 1.

SCHIZAEACEAE

Anemia simii TARDIEU emend. ALSTON in Contr. Conhec. Fl. Mozamb., 2, 1954, 8, t. 36. — *A. simii* TARDIEU in Not. Syst. 14, 1952, 208 pro parte, excl. spec. Angolenses.

Belingwe: Ad pagum Mnene in saxosis in silva, 26 Feb. 1931 — 5174.

Distribution: Transvaal, Rhodesia, Mozambique.

Mohria caffrorum (L.) DESV. in Mém. Soc. Linn. Paris, 6, 1827, 198. — *Polypodium caffrorum* L., Mant. Pl., 1771, 307. — *Adiantum caffrorum* (L.) L. f., Suppl. Pl., 1781, 447. — *Osmunda marginalis* SAV. in LAM., Encycl. Méth. Bot. 4, 1797, 655. — *Lonchitis caffrorum* (L.) BERNH. in Schrad. Journ. Bot. 1800 (2), 1801, 124. — *Osmunda thurifera* SW. in op. cit. 1801, 105. — *Osmunda thurifraga* BORY, Voy. Quatre Princ. Iles 1, 1804, 348. — *Mohria thurifraga* (BORY) SW., Syn. Fil., 1806, 159, 385, t. 5. — *Mohria crenata* DESV. in Mag. Ges. Naturf. Berl. 5, 1811, 307. — *Cheilanthes fuscata* BLUME, Enum. Pl. Jav., 1828, 116. — *Mohria achilleifolia* LOWE, New Ferns, 1862, t. 42 B. — *Mohria vestita* BAK. in Trans. Linn. Soc. Lond., Bot. 2, 1887, 355. — *Colina caffrorum* (L.) E. GREEN in Erythea 1, 1893, 247. — *Mohria caffrorum* var. *multisquamosa* BONAP., Not. Pterid. 4, 1917, 85.

Inyanga: Inyangani, c. 3 km occidentem versus a monte in clivis rivuli, c. 2000 m s.m., 6 Dec. 1930 — 3520; ad villam Inyanga Down in palude, c. 1950 m s.m., 29 Jan. 1931. — 4664.

Distribution: Cape Province, Orange Free State, Lesotho, Natal, Transvaal, Swaziland, Rhodesia, Mozambique, Malawi, Zambia, Tanganyika, Madagascar, Réunion.

CYATHEACEAE

Cyathea dregei KUNZE in Linnaea 10, 1836, 551. — *C. burkei* HOOK., Sp. Fil. 1, 1844, 23, t. 17, f.b. — *C. angolensis* WELW. ex HOOK., Syn. Fil., 1865, 22.

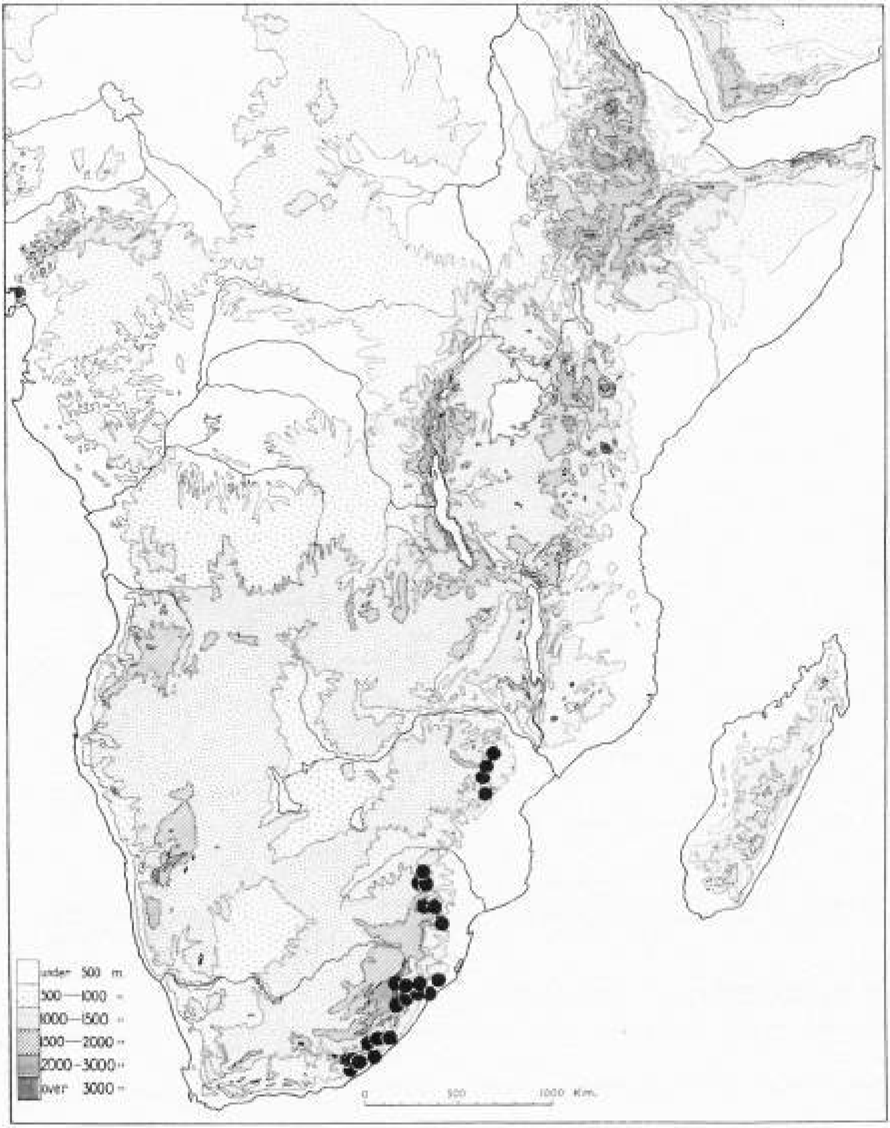


Fig. 1. Distribution of *Gleichenia umbraculifera* (KUNZE) MOORE.

I n y a n g a: Prope dejectum fluminis Pungwe frequens in vallibus ad rivulos, c. 1750 m s.m., truncus 3—5 m altus, 6 Nov. 1930 — 2734; Inyangani c. 3 km occidentem versus a monte in valle ad rivulum, c. 2000 m s.m., 8 Dec. 1930 — 3663.

Distribution: E. Cape Province, Natal, Swaziland, Transvaal, Rhodesia, Mozambique, Malawi, Zambia, Angola, Tanganyika, Congo, Uganda, Cameroons, Guinée, Sierra Leone, Madagascar.

HYMENOPHYLLACEAE

Hymenophyllum polyanthus Sw. var. **kuhnii** (C. Chr.) Schelpe in Bol. Soc. Brot., ser. 2, 40, 1966, 156. — *H. meyeri* Kuhn in Phys. Abh. K. Acad. Berl. 2, 94 et in Engler, Hochgebirgspfl. Trop. Afr., 1892, 95 (non Presl 1843). — *H. kuhnii* C. Chr., Ind. Fil. 1905, 363. — *H. henkelii* Sim in S. Afr. Journ. Sci. 20, 1923, 309, t. 9. — *Mecodium kuhnii* (C. Chr.) Copel. in Philipp. Journ. Sci. 67, 1938, 19.

Inyanga: Pungwe, ad dejectum fluminis in rimis saxosis, c. 1700 m s.m., 18 Dec. 1930 — 3817.

This specimen is a xeromorph with the segments typically overlapping but with the laminae only about 2 cm long and 1 cm broad.

Hymenophyllum tunbridgense (L.) Sm. in Sowerby, Engl. Bot., 1794, t. 162. — *Trichomanes tunbridgense* L., Sp. Pl. 2, 1753, 1098. — *H. dregeanum* Presl, Hymenophyll. 1843, 32, 52. — *H. thomassettii* C. H. Wright in Kew Bull. 1906, 170.

Inyanga: In latere montis Inyangani in saxis ad rivulum, c. 2300 m s.m., 7 Dec. 1930 — 3684.

Distribution: Cape Province, Natal, Swaziland, Transvaal, Rhodesia, Mozambique (Gorongosa), Malawi (Mlanje), Tanganyika (Ulugurus and Kilimanjaro), Kenya (Mt. Kenya), Madagascar, Madeira, W. and S. Europe. Map, Fig. 2.

DENNSTAEDTIACEAE

Pteridium aquilinum (L.) Kuhn in v. Deck., Reisen Ost. Afr. 3(3), 1879, 11. — *Pteris aquilina* L., Sp. Pl. 2, 1753, 1073. — *Asplenium aquilinum* (L.) Bernh. in Schrad. Journ. Bot. 1, 1799, 310. — *Pteris capensis* Thunb., Prodr. Pl. Cap., 1800, 172. — *Pteris lanuginosa* Bory ex Willd., Sp. Pl., ed. IV, 5, 1810, 403. — *Allosorus acquilinus* (L.) Presl, Tent. Pterid., 1836, 153. — *Allosorus lanuginosus* (Bory ex Willd.) Presl, Tent. Pterid., 1836, 154. — *Pteris coriifolia* Kunze in Linnaea, 18, 1844, 120. — *Pteris aquilina* var. *lanuginosa* (Bory ex Willd.) Hook., Sp. Fil., 2, 1858, 196. — *Allosorus capensis* (Thunb.) Pappe & Rawson, Syn. Fil. Afr. Austr., 1858, 32. — *Allosorus coriifolia* (Kunze) Pappe & Rawson, op. cit. 31. — *Paesia aquilina* (L.) Keys., Pol. Cyath. Herb. Bung., 1873, 22. — *Cincinalis aquilina* (L.) Gled. ex Trev. in Atti Soc. Ital. Sci. Nat., 17, 1874, 239. — *Ornithopteris aquilina* (L.) J. Sm., Hist. Fil. 1875, 298. — *Pteridium capense* (Thunb.) Krasser in Ann. Hofmus. Wien 15, 1900, 6. — *Pteridium aquilinum* subsp. *capense* (Thunb.) C. Chr., Ind. Fil., 1906, 591.

Inyanga: Ad pedes montis Inyangani in campo graminoso, c. 2000 m s.m., 8 Dec. 1930 — 3671; ad pedes montis Inyangani in campo graminoso, c. 1900 m s.m., 15 Feb. 1931 — 5094.

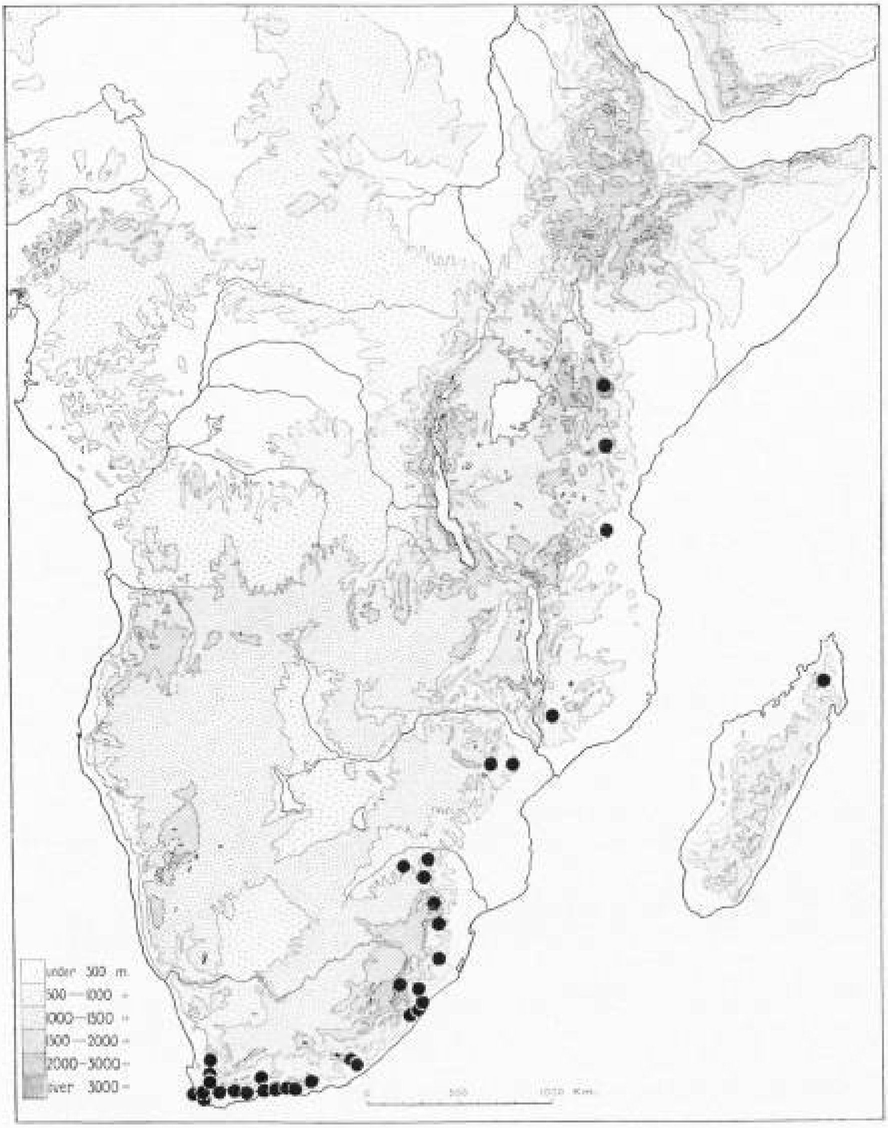


Fig. 2. Distribution of *Hymenophyllum tunbridgense* (L.) Sm. in Africa.

Distribution: Cape Province, Orange Free State, Lesotho, Natal, Swaziland, Transvaal, Rhodesia, Mozambique, Zambia, Angola, Tanganyika, Kenya, Ethiopia, Uganda, Sudan, Congo, Cameroons, Nigeria, Ghana, Liberia, Sierra Leone, São Tomé, Fernando Po, Zanzibar, Madagascar, Comoro Is., Mauritius.

ADIANTACEAE

Adiantum poiretii WIKSTR. in K. Vet. Akad. Handl. Stockh., 1825, 1826, 443. — *Adiantum thalictroides* WILLD. ex SCHLECHTEND., Adumbr. Pl. 5, 1832, 53. — *A. cycloides* ZENKER, Pl. Ind., 1835, 11. — *A. pellucidum.* MART. & GALEOTT. in Mém. Acad. R. Brux. 15, 1842, 72, t. 19.

Inyanga: C. 3 km in septentriones a pago in speluncuIis montis ad Chemeo, c. 1800 m s.m., 24 Jan. 1931 — 4558.

Distribution: E. Cape Province, Natal, Lesotho, Orange Free State, Transvaal, Rhodesia, Mozambique, Malawi, Zambia, Tanganyika, Kenya, Ethiopia, Sudan, Uganda, Congo, Angola, Cameroons, Nigeria, Madagascar, Comoro Is. Also in Tristan da Cunha, India, Mexico, S. America.

Aspidotis schimperi (KUNZE) PIC. SERM. in Webbia 7, 1950, 326. — *Cheilanthes schimperi* KUNZE, Farnkr. 1, 1840, 52, t. 26. — *Hypolepis schimperi* (KUNZE) HOOK., Sp. Fil. 2, 1852, 70.

Inyanga: In proclivitate prope flumen Niarerue, c. 1700 m s.m., 22 Jan. 1931 — 4532; versus Chemeo in proclivitate ad rivulum, c. 1750 m s.m., 26 Jan. 1931 — 4532.

Distribution: Rhodesia, Malawi, Zambia, Tanganyika, Ethiopia, Sudan, Uganda, N. Nigeria.

Pteris cretica L., Mant. Pl., 1767, 130. — *Pteris semiserrata* FORSK., Fl. Aegypt.-Arab, 1775, 186. — *P. nervosa* THUNB., Fl. Jap., 1784, 332. — *P. serraria* SW. in Schrad. Journ. Bot. 1800 (2), 1801, 65. — *P. pentaphylla* WILLD., Sp. Pl., ed. IV, 5, 1810, 362. — *Pycnodoria cretica* (L.) SMALL, Ferns Florida, 1932, 91.

Inyanga: Prope pagum Inyanga in silvula ad rivulum, c. 1750 m s.m., 4 Nov. 1930 — 2586; ad rivulum Niarerue in proclivitate, c. 1700 m s.m., 7 Nov. 1930 — 2747; ad pedes montis Inyangani in silvula ad rivulum, c. 2000 m s.m., 15 Feb. 1931 — 5071.

Distribution: S. and E. Cape Province, Lesotho, Natal, Orange Free State, Transvaal, Rhodesia, Malawi, Zambia, Tanzania, Congo, Angola, Uganda, Ascension Is., St. Helena, Madagascar, Mauritius, Réunion, and from S. Europe eastwards through Asia to Japan. Map, Fig. 3.

Pteris dentata FORSK. ssp. **flabellata** (THUNB.) RUNEMARK in Bot. Notiser, 115, 1962, 190. — *Lonchitis adscensionis* FORST. in Comm. Soc. Reg. Gött., 9, 1789, 72. — *Pteris flabellata* THUNB., Prodr. Pl. Cap. 1800, 172. — *P. adscensionis* SW., in Schrad. Journ. Bot. 1800 (2), 1801, 67. — *Asplenium adscensionis* (SW.) BERNH. in Schr. Akad. Erfurt 1802, 18. — *Pteris semiserrata* ROXB. in BEATS., St. Helena 1816, 319 (non FORSK. 1775). — *P. arguta* var. *flabellata* (THUNB.) METT. in KUHN, Fil. Afr. 1868, 76.

Inyanga: Prope pagum Inyanga in silvula ad rivulum, s. 1750 m s.m., 4 Nov. 1930 — 2591.

Distribution: Cape Province, Lesotho, Natal, Transvaal, Rhodesia, Malawi, Tanganyika, Kenya, Ethiopia, Uganda, Congo, Fernando Po, Ascension Is., St. Helena, Mauritius, Madagascar, Rodrigues.

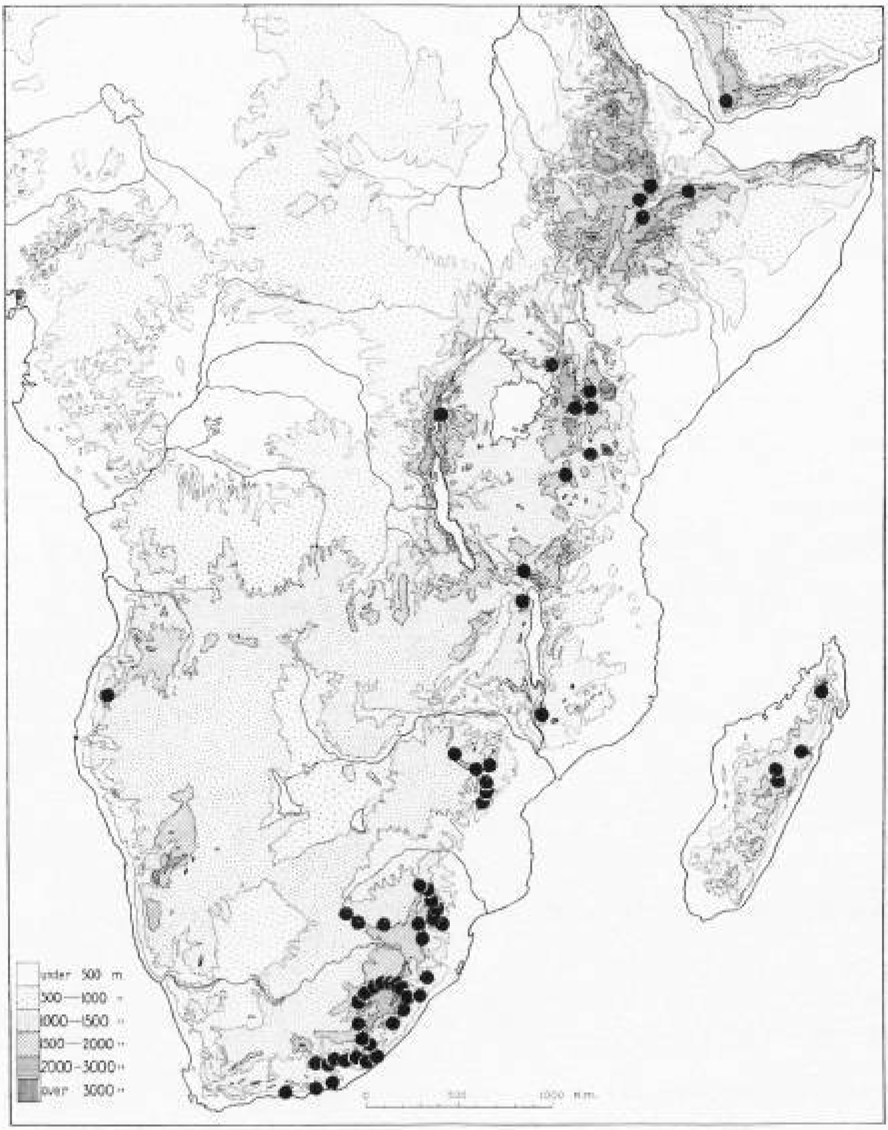


Fig. 3. Distribution of *Pteris cretica* L. in central and southern Africa.

Pteris friesii Hieron. in Fries, Wiss. Ergebn. Schwed. Rhod.-Kongo Exped. 1, 1915, 5. — *Pteris abrahamii* Hieron. in Bot. Jahrb. 53, 1915, 409.

Inyanga: Prope pagum Inyanga in silvula ad rivulum, c. 1750 m s.m., 4 Nov. 1930 — 2587.

Distribution: Swaziland, Transvaal, Rhodesia, Mozambique, Malawi, Zambia, Angola.

Doryopteris concolor (LANGSD. & FISCH.) KUHN var. **kirkii** (HOOK.) FRIES, Wiss. Ergebn. Schwed. Rhod.-Kongo Exped. 1, 1914, 4. — *Cheilanthes kirkii* HOOK., Sec. Cent. Ferns, 1861, t. 81. — *Doryopteris kirkii* (HOOK.) ALSTON in Bol. Soc. Brot., ser. 2, 30, 1956, 14.

Makoni: C. 9 km a pago Rusapi versus "The Springs" in rimis montis, c. 1500 m s.m., 30 Nov. 1930 — 3353.

Distribution: South West Africa, E. Cape Province, Orange Free State, Natal, Swaziland, Transvaal, Botswana, Rhodesia, Mozambique, Malawi, Zambia, Angola, Tanganyika, Kenya, Sudan, Congo, Uganda, Nigeria, Ghana, Guinée. Also Madagascar, India, Ceylon.

Cheilanthes multifida (SW.) SW., Syn. Fil., 1806, 129, 334. — *Adiantum multifidum* SW. in Schrad. Journ. Bot., 1800 (2), 1801, 85. — *Adiantum globatum* POIR., Encycl. Méth. Bot., Suppl. 1, 1810, 144. — *Cheilanthes bolusii* BAK. in HOOK., Ic. Pl., 1886, t. 1636.

Inyanga: C. 30 km meridiem versus a pago in saxosis, c. 1900 m s.m., 19 Nov. 1930 — 3035; prope Nianoli in rimis umbrosis siccis ruinae, c. 1700 m s.m., 20 Nov. 1930 — 3135; Inyangani in vertice montis in rimis saxorum, c. 2500 m s.m., 7 Dec. 1930 — 3590; Inyanga in saxosis, c. 1800 m s.m., 22 Jan. 1931 — 4520.

Distribution: South West Africa, Cape Province, Natal, Transvaal, Rhodesia, Mozambique, Malawi, Zambia, Tanganyika, Kenya, St. Helena.

Cheilanthes hirta SW., Syn. Fil., 1806, 128, 329. — *Adiantum caffrorum* SW. in Schrad. Journ. Bot., 1800 (2), 1801, 85 (non L. f. 1781). — *Adiantum hirtum* (SW.) POIR., Encycl. Méth. Bot., Suppl. 1, 1810, 142. — *Notholaena capensis* SPRENG., Tent. Suppl. Syst. Veg. 1828, 32. — *Cheilanthes hirta* var. *intermedia* KUNZE in Linnaea 10, 1836, 539. — *Cheilanthes hirta* var. *laxa* KUNZE op. cit. 540. — *Notholaena hirta* (SW.) J. SM. in Journ. Bot. 4, 1841, 50. — *Myriopteris intermedia* (KUNZE) FÉE, Mém. Fam. Foug., 5, 1852, 149. — *Cheilanthes glandulosa* PAPPE & RAWSON, Syn. Fil. Afr. Austr. 1858, 35 (non SW. 1817).

Inyanga: C. 3 km in septentriones a pago in proclivitate ad rivulum prope Chemeo, c. 1800 m s.m., 26 Jan. 1931 — 4616.

Makoni: C. 20 km a pago Rusapi versus Inyanga in saxosis, c. 1500 m s.m., 2 Dec. 1930 — 3425.

Distribution: South West Africa, Cape Province, Orange Free State, Lesotho, Natal, Transvaal, Botswana, Angola, Rhodesia, Mozambique, Kenya, Madagascar, Réunion.

The two specimens cited here are of the narrow fronded form to which the name *C. hirta* var. *contracta* has previously been misapplied.

Cheilanthes leachii (SCHELPE) SCHELPE in Bol. Soc. Brot., ser. 2, 41, 1967. — *Notholaena leachii* SCHELPE in Journ. S. Afr. Bot., 30, 1964, 185, t. 1, fig. a.

Makoni: Ad viam Rusapi, The Springs c. 9 km occidentem versus a pago Rusapi in rimis in proclivitate montium, c. 1500 m s.m., 30 Nov. 1930 — 3354.

Distribution: Rhodesia, Mozambique, Malawi, Zambia, Tanganyika. This specimen constitutes the first record of this species from Rhodesia.

Cheilanthes inaequalis (KUNZE) METT. in Abhandl. Senckenb. Nat. Ges. 3, 1859, 68, reimpr. in METT., Farngatt. Cheil., 1859, 24. — *Notholaena inaequalis* KUNZE, Farnkr. 1, 1844, 146. — *N. tricholepis* BAK., in Journ. Bot., 21, 1883, 245. — *N. bipinnata* SIM, Ferns S. Afr., 1915, 224, pro parte, excl. t. 109, fig. 2 (non LIEBM. 1849).

Inyanga: In proclivitate humida montis, c. 1800 m s.m., 22 Jan. 1931 — 4522.

Distribution: Natal, Transvaal, Rhodesia, Malawi, Zambia, Angola, Sudan, Congo, Cameroons, Guinée, Nigeria.

Cheilanthes inaequalis var. **buchananii** (BAK.) SCHELPE in Bol. Soc. Brot., sér. 2, 41, 1967. — *Notholaena buchananii* BAK., Syn. Fil., 1868, 373.

Inyanga: Pungwe supra dejectum fluminis in rimis saxosis ad litorem, c. 1700 m s.m., 18 Dec. 1930 — 3815.

Distribution: Natal, Transvaal, Rhodesia, Mozambique, Zambia.

Pellaea dura (WILLD.) BAK. in Journ. Bot. 18, 1880, 327. — *Pteris dura* WILLD., Sp. Pl., ed. IV, 5, 1810, 376. — *Allosorus durus* (WILLD.) PRESL, Tent. Pterid., 1836, 153. — *Litobrochia dura* (WILLD.) MOORE, Ind. Fil. 1857, 44. — *Pteris burkeana* HOOK., Sp. Fil. 2, 1858, 213. — *Pellaea burkeana* (HOOK.) BAK., Syn. Fil., 1867, 153. — *Pellaeopsis burkeana* (HOOK.) J. SM., Hist. Fil., 1875, 290. — *Pteridella dura* (WILLD.) KUHN, V. DECK., Reisen, Bot. 3 (3), 1879, 14.

Inyanga: Ad pagum Inyangani in convalle rivuli Niarerue, 31 Nov. 1930 — 2504.

Makoni: Ad viam Rusapi, The Springs, c. 9 km occidentem versus a pago Rusapi in rimis in proclivitate montis, c. 1500 m s.m., 30 Nov. 1930 — 3356.

Distribution: Natal, Transvaal, Rhodesia, Malawi, Mozambique, Zambia, Angola, Tanzania, Madagascar, Comoro Is., Mauritius, Réunion.

Pellaea calomelanos (SW.) LINK, Fil. Sp. Hort. Berol., 1841, 51. — *Pteris calomelanos* SW. in Schrad. Journ. Bot., 1800 (2), 1801, 70. — *Allosorus calomelanos* (SW.) PRESL, Tent. Pterid., 1836, 153. — *Platyloma calomelanos* (SW.) J. SM. in Curtis Bot. Mag. 72 Comp., 1846, 21. — *Notholaena calomelanos* (SW.) KEYS., Pol. Cyath. Herb. Bung., 1873, 29.

Inyanga: Ad pagum Inyanga in convalle rivuli Niarerue in rimis, c. 1700 m s.m., 31 Oct. 1930 — 2503; prope pagum Inyanga in saxosis, c. 1600 m s.m., 24 Nov. 1930 — 3187.

Makoni: Ad villam Maidstone in saxosis, c. 1600 m s.m., 4 Jan. 1931 — s.n.

Distribution: South West Africa, Cape Province, Orange Free State, Lesotho, Natal, Swaziland, Transvaal, Botswana, Rhodesia, Malawi, Angola, Mozambique, Tanganyika, Kenya, Madagascar.

Pellaea quadripinnata (FORSK.) PRANTL in Bot. Jahrb. 3, 1882, 420. — *Pteris quadripinnata* FORSK., Fl. Aegypt.-Arab., 1775, 186. — *Allosorus quadripinnatus* (FORSK.) PRESL, Tent. Pterid., 1836, 154. — *Pteris consobrina* KUNZE in Linnaea 10, 1836, 526. — *Cheilanthes triangula* KUNZE in Linnaea 10, 1836, 536. — *Cheilanthes atherstonei* HOOK., Sp. Fil., 2, 1852, 107. — *Cheilanthes firma* MOORE in Journ. Bot. 5, 1853, 225. — *C. linearis* MOORE, op. cit. 226. — *Pellaea consobrina* (KUNZE) HOOK., Sp. Fil. 2, 1858, 145. — *Allosorus consobrinus* (KUNZE) PAPPE & RAWSON, Syn. Fil. Afr. Austr., 1858, 31. — *Cheilanthes quadripinnata* (FORSK.) KUHN, Fil. Afr., 1868, 74. — *Pteridella quadripinnata* (FORSK.) METT. ex KUHN, v. DECK., Reisen, Bot. 3 (3), 1879, 16.

Inyanga: Prope montem Inyangani, ad rivulum, c. 1950 m s.m., 8 Dec. 1930 — 3657; ad rivum Tsanga, prope villam Inyanga Downs, c. 1850 m s.m., 30 Jan. 1931 — 4726; supra villam Cheshire in campo montano, c. 1200 m s.m. — 4831.

Pallaea viridis (FORSK.) PRANTL var. **glauca** (SIM) SIM, Ferns. S. Afr., 1915, 209. — *Pellaea hastata* var. *glauca* SIM, Kaffrarian Ferns., 1891, 30, t. 19.

Makoni: C. 8 km a pago Rusapi versus villam "The Springs", c. 1450 m s.m., 30 Nov. 1930 — 3357.

Distribution: E. Cape Province, Natal, Transvaal, Botswana, Angola, Rhodesia, Mozambique, Malawi, Congo, Uganda, Ethiopia, Madagascar, Mauritius.

Actiniopteris dimorpha PIC. SERM. in Webbia, 17, 1962, 18, t. 2, figs. a—c.

Makoni: C. 9 km a pago Rusapi versus villam "The Springs" in rimis montium, c. 1500 m s.m., 30 Nov. 1930 — 3355.

Distribution: Rhodesia, Malawi, Mozambique, Zambia, Tanganyika, Madagascar, Mascarene Is.

GRAMMITIDACEAE

Xiphopteris flabelliformis (POIR.) SCHELPE in Bol. Soc. Brot., sér. 2, 41, 1967, 217. — *Polypodium flabelliforme* POIR. in LAM., Encycl. Méth. Bot., 5, 1804, 519. — *Polypodium rigescens* BORY ex WILLD., Sp. Pl., ed. IV, 5, 1810, 184. — *Ctenopteris rigescens* (BORY ex WILLD.) J. SM., Hist. Fil., 1875, 184. — *Xiphopteris rigescens* (BORY ex WILLD.) ALSTON in Bol. Soc. Brot., sér. 2, 30, 1956, 26. — *Grammitis flabelliformis* (POIR.) MORTON in Contrib. U.S. Nat. Herb., 38, 1967, 57.

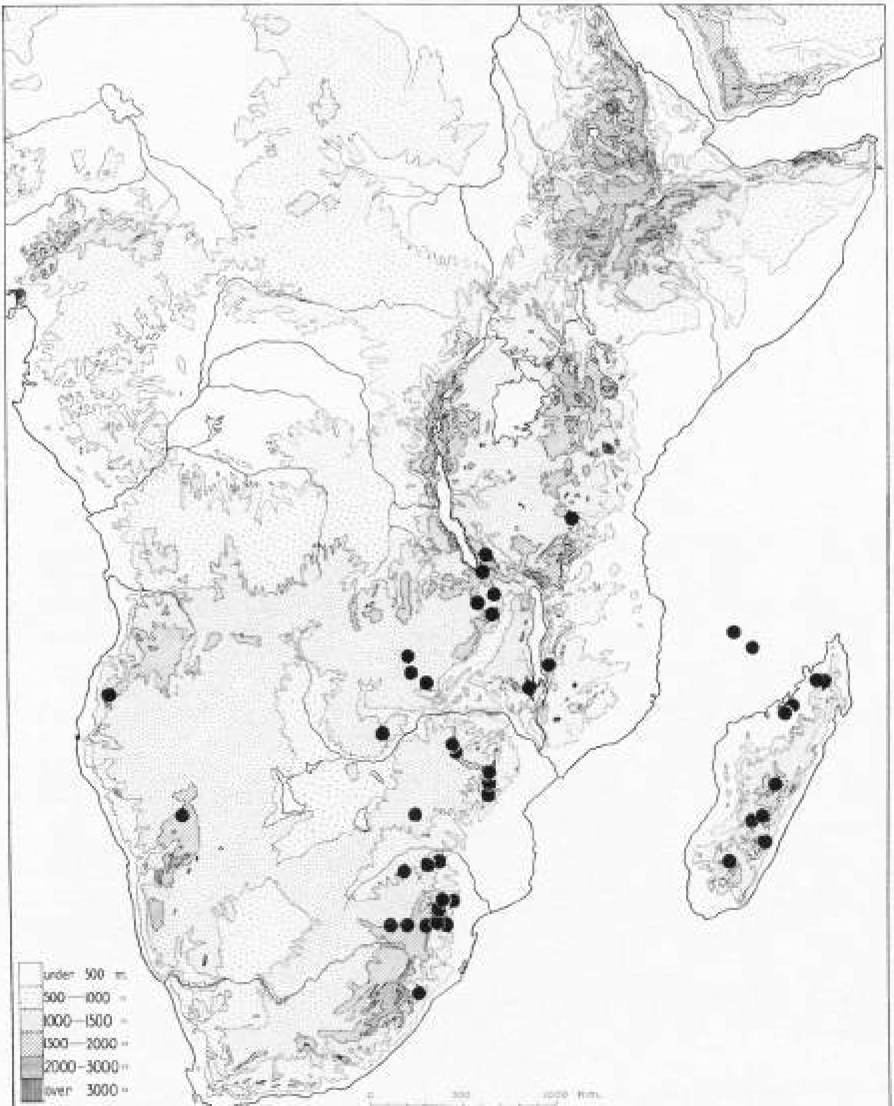


Fig. 4. Distribution of *Pellaea goudotii* (KUNZE) C. CHR., a species not collected by the FRIES, NORLINDH & WEIMARCK expedition.

I n y a n g a: Inyangani in saxosis in muscis, 7 Dec. 1930 — 3593; Inyangani in saxis, c. 2450 m s.m., 14 Feb. 1931 — 4995.

D i s t r i b u t i o n: Natal (Drakensberg), Rhodesia (Chimanimani and Inyangani), Mozambique, Malawi (Luchenya and Nyika Plateaux), Tanganyika, Kenya, Uganda, Congo, Cameroons, Fernando Po, Madagascar, Réunion and tropical America. Map, Fig. 5.

POLYPODIACEAE

Pleopeltis excavata (Bory ex Willd.) Sledge in Bull. Brit. Mus. Nat. Hist. 2, 1960, 138. — *Polypodium simplex* Sw. in Schrad. Journ. Bot. 1800 (2), 1801, 19 (non Burm. 1768). — *Polypodium excavatum* Bory ex Willd. Sp. Pl., ed. IV, 5, 1810, 158. — *Phymatodes excavata* (Bory ex Willd.) Presl, Tent. Pterid., 1836, 196. — *Phymatodes simplex* (Sw.) Presl, op. cit. 196. — *Drynaria excavata* (Bory ex Willd.) Fée, Mém. Fam. Foug. 5, 1852, 270. — *Pleopeltis simplex* (Sw.) Beddome, Handb. Ferns Brit. India, 1883, 347.

Inyanga: Pungwe supra dejectum fluminis in silvula ad rivulum in trunco arboris, c. 1700 m s.m., 6 Nov. 1930 — 2700; in monte Inyangani in saxosis, c. 2400 m s.m., 7 Dec. 1930 — 3595; Inyangani, in monte in trunco arboris, c. 2400 m s.m., 7 Dec. 1931 — 3595a; prope villam Inyanga Down in saxis in campo graminoso, c. 1950 m s.m., 29 Jan. 1931 — 4715.

Distribution: Transvaal, Rhodesia, Mozambique, Malawi, Zambia, Tanganyika, Ethiopia, Sudan, Uganda, Congo, Cameroons, Nigeria, Sierra Leone, Liberia, Fernando Po, Madagascar, Mauritius, Réunion.

The distribution range given here applies to the whole *P. excavatum* complex in which the rhizome scales vary considerably among different populations throughout the continent and to a lesser extent in the degree to which the sori are sunken and in the frequency of scales on the midrib.

Pleopeltis macrocarpa (Bory ex Willd.) Kaulf. in Berl. Jahrb. Pharm., 21, 1820, 41. — *Polypodium lanceolatum* L., Sp. Pl., 2, 1753, 1082. — *Polypodium macrocarpum* Bory ex Willd., Sp. Pl., ed. IV, 5, 1810, 127. — *Polypodium marginale* Bory ex Willd., tom. cit., 149. — *Polypodium adspersum* Schrad. in Gött. Gel. Anz. 1818, 915. — *Pleopeltis ensifolia* Carm. ex Hook., Exot. Fl. 1, 1823, t. 62. — *Pleopeltis marginalis* (Bory ex Willd.) Kaulf. in Berl. Jahrb. Pharm. 21, 1820, 41. — *Pleopeltis lanceolata* Kaulf., Enum. Fil. 1824, 245. — *Polypodium lepidotum* Willd. ex Schlechtend., Adumbr., 1825, 17, t. 8. — *Pleopeltis lepidota* (Willd. ex Schlechtend.) Presl, Tent. Pterid. 1836, 193. — *Pleopeltis kaulfussiana* Presl, Tent. Pterid. 1836, 193. — *Drynaria macrocarpa* (Bory ex Willd.) Fée, Mém. Fam. Foug. 5, 1852, 270. — *Drynaria lepidota* (Willd. ex Schlechtend.) Fée, loc. cit.

Inyanga: Pungwe supra dejectum fluminis in silvula ad rivulum, c. 1700 m s.m., 18 Dec. 1930 — 3838.

Distribution: Cape Province, Orange Free State, Lesotho, Natal, Swaziland, Transvaal, Rhodesia, Mozambique, Malawi, Tanganyika, Kenya, Ethiopia, Uganda, Congo, Angola, Cameroons, Nigeria, Sierra Leone, Fernando Po, St. Helena, Madagascar, Réunion. Also in tropical America.

DAVALLIACEAE

Arthropteris orientalis (Gmelin) Posthumus in Rec. Trav. Bot. Néerl. 21, 1924, 218. — *Polypodium orientale* Gmelin, Syst. Nat., ed. XIII, 2, 1791, 1312. — *Polypodium pectinatum* Forsk., Fl. Aegypt.-Arab., 1775, 185 (non

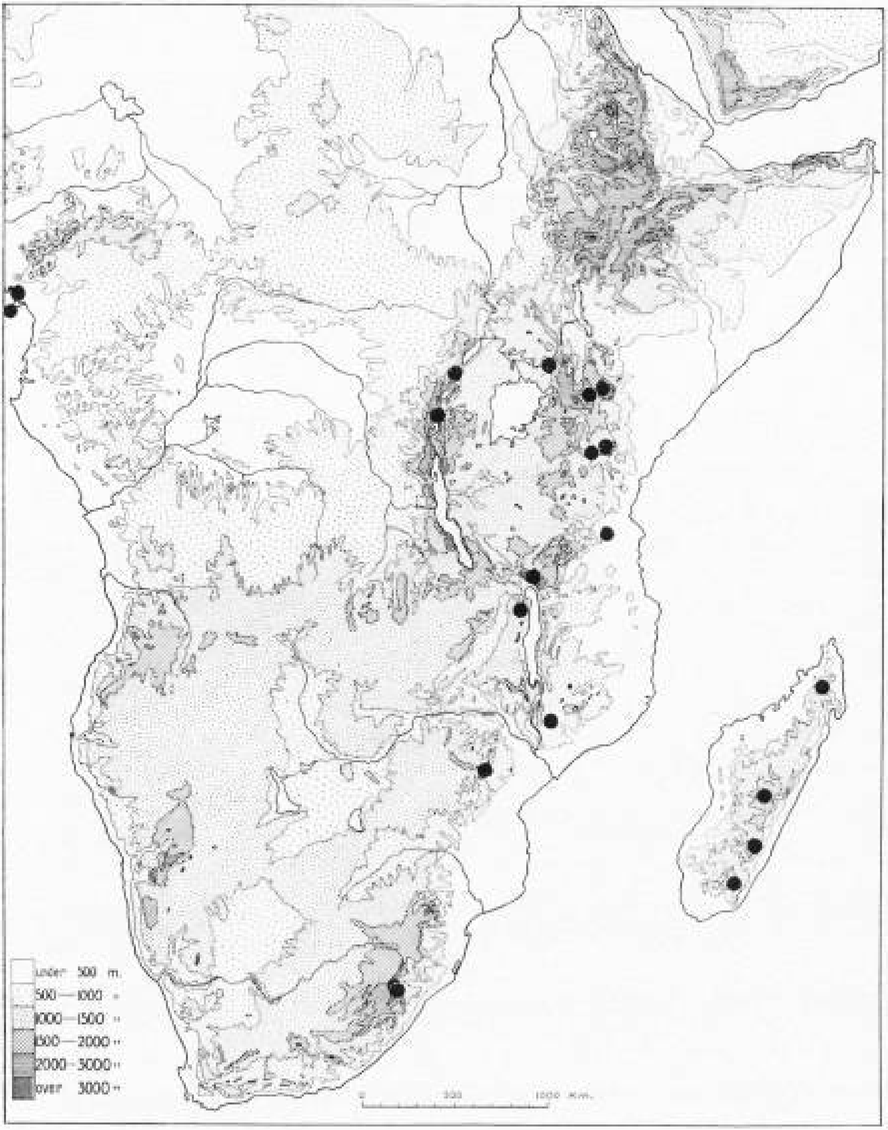


Fig. 5. Distribution of *Xiphopteris flabelliformis* (POIR.) SCHELPE in Africa.

L. 1753) — *Aspidium albopunctatum* BORY ex WILLD., Sp. Pl., ed. IV, 5, 1810, 242. — *Nephrodium albopunctatum* (BORY ex WILLD.) DESV. in Mém. Soc. Linn. Paris, 6, 1927, 255. — *Aspidium thonningii* SCHUM. in K. Danske Vid. Selsk. Nat. & Math. Afh., 4, 1829, 229. — *Aspidium leucosticton* KUNZE in Linnaea, 23, 1850, 227, 301. — *Dryopteris orientalis* (GMELIN) C. CHR., Ind. Fil. 1905, 281.

Inyanga: Ad pagum Inyanga in fruticetis, c. 1700 m s.m., 22 Jan. 1931 — 4528.

Distribution: Rhodesia, Mozambique, Malawi, Zambia, Angola, Tanganyika, Kenya, Sudan, Ethiopia, Yemen, Uganda, Congo, Cameroons, Nigeria, Liberia, Sierra Leone, Fernando Po, São Tomé, Annobon, Madagascar, Comoro Is., Mauritius, Réunion.

ASPLENIACEAE

Asplenium anisophyllum KUNZE in Linnaea, 10, 1836, 511. — *A. geppii* CARR., Cat. Afr. Pl. Welw. 2 (2), 1901, 269.

Inyanga: Supra dejectum fluminis Pungwe in silva, c. 1700 m s.m., 17 Dec. 1930 — 3880.

Distribution: Cape Province, Natal, Swaziland, Transvaal, Rhodesia, Mozambique, Malawi, Tanganyika, Angola, Uganda, Madagascar.

Asplenium friesiorum C. CHR. in Notizbl. Bot. Gart. Berl. 9, 1924, 181. — *A. serra* var. *natalense* BAK., Syn. Fil., ed. II, 1883, 485. — *A. pseudoserra* DOMIN in Preslia, 8, 1929, 6. — *A. monilisorum* DOMIN, tom. cit., 7. — *Tarachia friesiorum* (C. CHR.) MOMOSE in Journ. Jap. Bot. 35, 1960, 34.

Inyanga: Supra dejectum fluminis Pungwe in silva, c. 1700 m s.m., 16 Dec. 1930 — 3742; supra dejectum fluminis Pungwe in silvula, c. 1700 m s.m., 18 Dec. 1930 — 3796.

Distribution: Natal, Transvaal, Rhodesia, Mozambique, Malawi, Zambia, Tanganyika, Kenya, Sudan, Uganda, Congo, Cameroons, Nigeria.

Asplenium aethiopicum (BURM.) BECHERER in Candollea, 6, 1935, 22. — *Trichomanes aethiopicum* BURM., Fl. Cap. Prodr. in Fl. Ind., 1768, 28. — *Asplenium adiantoides* LAM., Encycl. Méth. Bot. 2, 1786, 309 [non. (L.) C. CHR. 1905]. — *A. falsum* RETZ., Obs. Bot. 6, 1791, 38. — *A. furcatum* THUNB., Prodr. Pl. Cap., 1800, 172. — *Tarachia furcata* (THUNB.) PRESL, Epim. Bot., 1851, 80. — *Asplenium gueinzianum* METT. ex KUHN, Fil. Afr., 1868, 103.

Inyanga: Ad pagum Inyanga in rimis, c. 1700 m s.m., 26 Nov. 1930 — 3258; supra dejectum fluminis Pungwe in silva, c. 1700 m s.m., 16 Dec. 1930 — 3790; supra dejectum fluminis Pungwe in silvula, c. 1700 m s.m., 18 Dec. 1930 — 3797.

Makoni: C. 8 km a pago Rusapi prope villam "The Springs" in rimis, c. 1450 m s.m., 30 Nov. 1930 — 3352.

Distribution: Cape Province, Lesotho, Orange Free State, Natal, Transvaal, Swaziland, Rhodesia, Mozambique, Malawi, Angola, Tanganyika, Kenya, Ethiopia, Somalia, Yemen, Uganda, Congo, Cameroons, Nigeria, Sierra Leone, Fernando Po, Madagascar, Comoro Is.

Asplenium sandersonii HOOK., Sp. Fil., 3, 1860, 147. — *A. vagans* BAK., Syn. Fil., 1867, 195. — *A. debile* METT. ex KUHN, Fil. Afr., 1868, 101 (non FÉE

1865). — *A. melleri* METT. ex KUHN, op. cit., 106. — *A. punctatum* METT. ex KUHN, op. cit., 114. — *A. hanningtonii* BAK. in Journ. Bot. 21, 1883, 245. — *A. comorense* C. CHR., Ind. Fil. 1906, 105.

Inyanga: Pungwe infra dejectum fluminis in truncis arborum in silvula ad rivulum, 18 Dec. 1930 — 3960.

Distribution: E. Cape Province, Natal, Transvaal, Rhodesia, Mozambique, Malawi, Tanganyika, Kenya, Ethiopia, Sudan (Imatong Mtns.), Uganda, Congo, Angola, São Tomé, Madagascar, Comoro Is., Mauritius.

Asplenium theciferum (H.B.K.) METT. var. **concinnum** (SCHRAD.) SCHELPE in Bol. Soc. Brot., ser. 2, 41, 1967. — *Davallia concinna* SCHRAD. in Gött. Gel. Anz., 1818, 918. — *Davallia campyloptera* KUNZE in Linnaea 10, 1836, 544. — *Loxoscaphe concinnum* (SCHRAD.) MOORE in Journ. Bot. 5, 1853, 227. — *Asplenium concinnum* (SCHRAD.) KUHN, Fil. Afr., 1868, 99. — *Loxoscaphe theciferum* var. *concinnum* (SCHRAD.) C. CHR., in Dansk Bot. Arkiv, 7, 1932, 104.

Inyanga: Inyangani ad pedem montis in silva ad rivulum, c. 2100 m s.m., 14 Dec. 1931 — 5031.

Distribution: E. Cape Province, Natal, Transvaal, Rhodesia, Mozambique, Malawi, Zambia.

Ceterach cordatum (THUNB.) DESV. in Mém. Soc. Linn. Paris, 6, 1827, 223. — *Acrostichum cordatum* THUNB., Prodr. Pl. Cap., 1800, 171. — *Asplenium cordatum* (THUNB.) SW., in Schrad. Journ. Bot. 1800 (2), 1801, 54. — *Grammitis cordata* (THUNB.) SW., Syn. Fil., 1806, 23, 217. — *Cincinalis cordata* (THUNB.) DESV. in Mag. Ges. Naturf. Fr. Berlin 5, 1811, 311. — *Notholaena cordata* (THUNB.) DESV. in Journ. Bot. (Paris), App. 1, 1813, 92. — *Ceterach crenata* KAULF., Enum. Fil. 1824, 85, nom. illegit. — *Gymnogramma cordata* (THUNB.) SCHLECHTEND., Adumbr., 1825, 16. — *Gymnogramma capensis* SPRENG.; KAULF. in Linnaea 6, 1831, 183, nom. nud. — *Ceterach capense* KUNZE in Linnaea 10, 1836, 496. — *Grammitis capensis* (KUNZE) MOORE, Ind. Fil., 1857, 232.

Makoni: C. 9 km occidentem versus a pago Rusapi in rimis montis, c. 1500 m s.m., 30 Nov. 1930 — 3351.

Distribution: South West Africa, Cape Province, Orange Free State, Lesotho, Natal, Transvaal, Botswana, Rhodesia, Tanganyika (Musoma distr.), Kenya (Lukema, Nyeri).

THELYPTERIDACEAE

Thelypteris confluens (THUNB.) MORTON in Contrib. U.S. Nat. Herb., 38, 1967, 71. — *Pteris confluens* THUNB., Prodr. Pl. Cap., 1800, 171. — *Aspidium thelypteris* var. *squamigerum* SCHLECHTEND., Adumbr., 1825, 23, t. 11. — *Lastrea squamulosa* PRESL, Tent. Pterid., 1836, 76, nom. nud. — *Nephrodium squamulosum* HOOK. f., Fl. N. Zeal., 2, 1855, 39. — *Aspidium squamigerum* (SCHLECHTEND.) FÉE, Mém. Fam. Foug., 8, 1857, 104. — *Lastrea thelypteris* var. *squamigerum* (SCHLECHTEND.) BEDDOME, Handb. Ferns Brit. India, Suppl., 1892, 54. — *Dryopteris thelypteris* var. *squamigera* (SCHLECHTEND.) C. CHR., Ind. Fil., 1905, 297. — *Thelypteris squamulosa* (HOOK. f.) CHING in Bull. Fan Mem. Inst. Biol. Bot., 6, 1936, 5, 329.

Inyanga: Prope pagum Inyanga in silvula ad rivulum, c. 1750 m s.m., 4 Nov. 1930 — 2592; prope pagum Inyanga in solo humido ad rivulum, c. 1700 m s.m., 20 Jan. 1931 — 4463.

Makoni: Ad villam Maidstone in campo graminoso, solo humido, c. 1450 m s.m., 5 Jan. 1931 — 4113.

Distribution: South West Africa, Cape Province, Lesotho, Natal, Swaziland, Transvaal, Rhodesia, Mozambique, Malawi, Zambia, Angola, Tanganyika, Kenya, Uganda, Sudan, Congo. Also in Australia and New Zealand.

Thelypteris bergiana (SCHLECHTEND.) CHING in Bull. Fan Mem. Inst. Biol. Bot. 10, 1941, 251. — *Polypodium bergianum* SCHLECHTEND., Adumbr., 1825, 20, t. 9. — *Lastrea bergiana* (SCHLECHTEND.) MOORE, Ind. Fil., 1858, 86. — *Nephrodium bergianum* (SCHLECHTEND.) BAK., Syn. Fil., 1867, 269. — *Nephrodium sewellii* BAK. in Journ. Linn. Soc. Lond., 15, 1876, 418. — *Nephrodium anateinophlebium* BAK., op. cit. 16, 1877, 202. — *Dryopteris bergiana* (SCHLECHTEND.) O. KUNTZE, Rev. Gen. Pl., 2, 1891, 812. — *Aspidium maranguense* HIERON. in ENGLER, Pflanzenw. Ost-Afr., C, 1895, 85. — *Dryopteris anateinophlebia* (BAK.) C. CHR., Ind. Fil., 1905, 252. — *D. maranguensis* (HIERON.) C. CHR., op. cit., 276. — *D. sewellii* (BAK.) C. CHR., op. cit., 292. — *Dryopteris palmii* C. CHR. in Arkiv Bot., 14, 1916, 1. — *Lastrea maranguensis* (HIERON.) COPEL., Gen. Fil., 1947, 139.

Inyanga: Ad pedes montis Inyangani ad rivulum, c. 2000 m s.m., 8 Dec. 1930 — 3656.

Distribution: Cape Province, Natal, Swaziland, Transvaal, Rhodesia, Malawi, Zambia, Tanganyika, Ethiopia, Uganda, Congo, Sudan, Cameroons, Fernando Po.

Thelypteris strigosa (WILLD.) TARDIEU in HUMBERT, Fl. Madag., Polypod., 1, 1958, 274. — *Aspidium strigosum* WILLD., Sp. Pl., ed. IV, 5, 1810, 249. — *Aspidium pulchrum* BORY ex WILLD., op. cit., 253. — *Nephrodium strigosum* (WILLD.) DESV. in Mém. Soc. Linn. Paris, 6, 1827, 256. — *Nephrodium pulchrum* (BORY ex WILLD.) DESV., loc. cit., 256. — *Lastrea strigosa* (WILLD.) PRESL, Tent. Pterid., 1836, 75. — *Lastrea pulchra* (BORY ex WILLD.) PRESL, loc. cit., 75. — *Dryopteris strigosa* (WILLD.) C. CHR., Ind. Fil., 1905, 295.

Inyanga: Ad radices montis Inyanga in silvula ad rivulum, c. 2000 m s.m., 15 Feb. 1931 — 5079.

The fronds in this collection are unusually large, with stipes 16 cm long, the oblanceolate—elliptic laminae 85 × 17 cm and the pinnae up to 8.5 × 1 cm.

Distribution: Rhodesia, Madagascar, Mauritius.

Thelypteris gueinziana (METT.) SCHELPE in Journ. S. Afr. Bot., 31, 1965, 262, err. "*gueintziana*". — *Aspidium gueinzianum* METT., Farngatt. Pheg. u. Asp., 1858, 83, err. "*gueintziana*". — *Lastrea gueinziana* (METT.) MOORE, Ind.

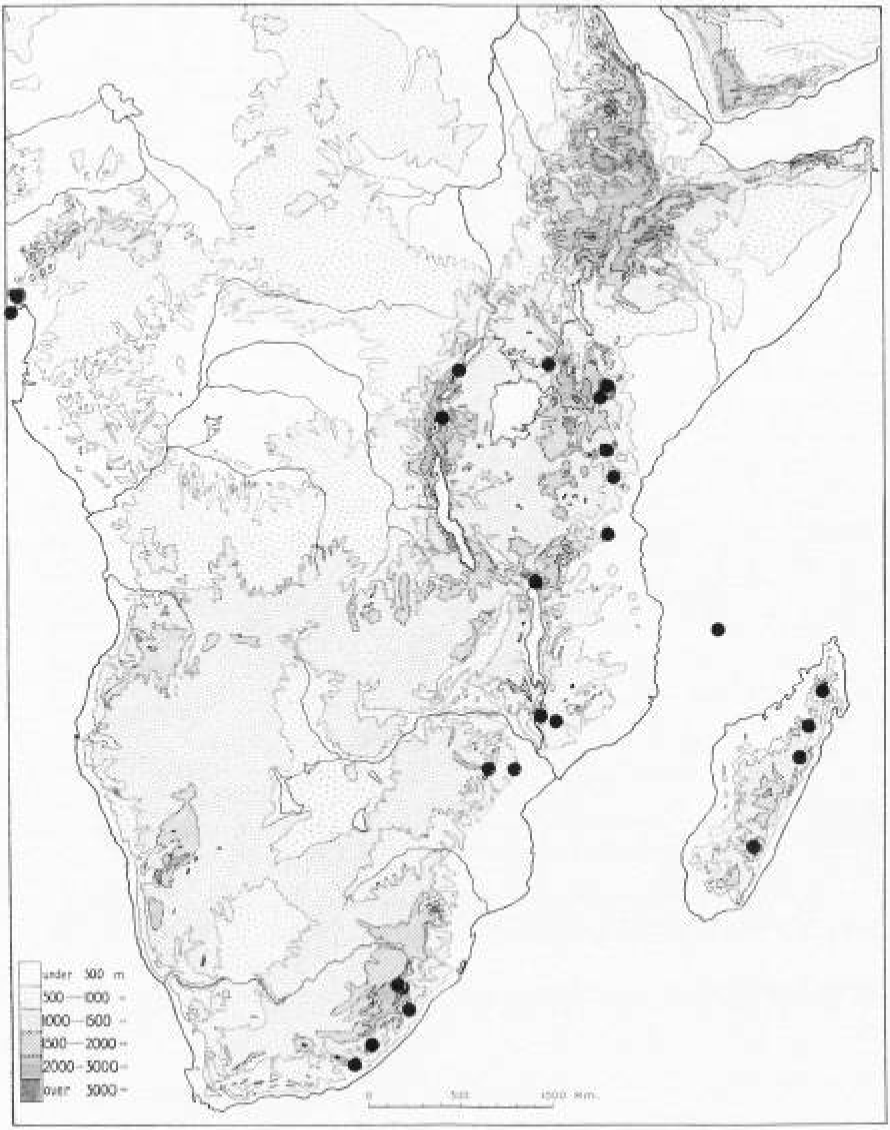


Fig. 6. Distribution of *Elaphoglossum hybridum* (Bory) Brack. in Africa.

Fil., 1858, 93. — *Nephrodium gueinzianum* (Mett.) Hieron. in Bot. Jahrb. 28, 1900, 341.

Inyanga: Infra dejectum fluminis Pungwe in valle fluminis, c. 1400 m s.m., 27 Dec. 1930 — 3906.

Distribution: Cape Province, Natal, Swaziland, Rhodesia, Mozambique.

Thelypteris chaseana SCHELPE in Journ. S. Afr. Bot., 31, 1965, 263.

Inyanga: Prope pagum Inyanga in silvula ad rivulum, c. 1750 m s.m., 4 Nov. 1930 — 2592a.

Distribution: South West Africa, Rhodesia, Malawi, Zambia, Tanganyika, Angola.

ATHYRIACEAE

Athyrium schimperi MOUG. ex FÉE, Mém. Fam. Foug. 5, 1852, 187. — *Asplenium schimperi* (MOUG. ex FÉE) A. BR. in SCHWEINF., Beitr. Fl. Aeth. 1, 1867, 224.

Inyanga: Ad flumen Tsanga prope villam Inyanga Down, c. 1900 m s.m., 30 Jan. 1931 — 4728.

Distribution: E. Cape Province, Lesotho, Natal, Transvaal, Rhodesia, Zambia, Tanganyika, Ethiopia, Uganda, Sudan (Imatong Mtns.), Cameroons, Nigeria, Ghana.

LOMARIOPSIDACEAE

Elaphoglossum hybridum (BORY) BRACK., U.S. Expl. Exped. 16, 1854, 69. — *Acrostichum hybridum* BORY, Voy. Quatre Princ. Iles 3, 1804, 95. — *Acrostichum ciliare* CARM. in Trans. Linn. Soc. Lond. 12, 1818, 510. (non THOUARS 1804). — *Acrostichum ciliatum* DESV. in Mag. Ges. Naturf. Berl. 5, 1811, 310. — *Olfersia hybrida* (BORY) PRESL, Tent. Pterid., 1836, 235. — *Acrostichum tricholepis* BAK. in Journ. Bot., 1891, 5. — *Elaphoglossum tricholepis* (BAK.) C. CHR., Ind. Fil., 1905, 317.

Inyanga: In monte Inyangani in saxis ad rivulum, c. 2350 m s.m., 7 Dec. 1930 — 3560.

Distribution: E. Cape Province, Natal, Rhodesia, Mozambique, Malawi, Tanganyika, Kenya, Madagascar, Comoro Is., Mauritius, Réunion. Also Tristan da Cunha, Gough Is. and tropical America. Map, Fig. 6.

ASPIDIACEAE

Dryopteris inaequalis (SCHLECHTEND.) O. KUNTZE, Rev. Gen. Pl. 2, 1891, 813. — *Aspidium inaequale* SCHLECHTEND, Adumbr., 1825, 23, t. 12. — *Lastrea inaequalis* (SCHLECHTEND.) PRESL, Tent. Pterid., 1836, 77. — *Lastrea pentagona* MOORE in Journ. Bot. 5, 1853, 227. — *Nephrodium inaequale* (SCHLECHTEND.) HOOK., Sp. Fil. 4, 1862, 125 (non SCHRAD. 1824). — *Polystichum inaequale* (SCHLECHTEND.) KEYS., Pol. Cyath. Herb. Bung., 1873, 44. — *Nephrodium pentheri* KRASSER in Ann. Hofmus. Wien, 15, 1900, 5. — *Dryopteris pentheri* (KRASSER) C. CHR., Ind. Fil., 1905, 284.

Inyanga: Ad pagum Inyanga in silvula ad rivulum, c. 1750 m s.m., 22 Jan. 1931 — 4546.

Distribution: Cape Province, Orange Free State, Lesotho, Natal, Swaziland, Transvaal, Rhodesia, Mozambique, Tanganyika, Kenya, Cameroons, Fernando Po, Madagascar, Mauritius, Comoro Is.

Dryopteris athamantica (KUNZE) O. KUNTZE, Rev. Gen. Pl. 2, 1891, 812. — *Aspidium athamanticum* KUNZE in Linnaea 18, 1844, 123. — *Lastrea athamantica* (KUNZE) MOORE in Journ. Bot., 5, 1853, 311. — *Lastrea plantii* MOORE, op. cit. 227. — *Nephrodium athamanticum* (KUNZE) HOOK., Sp. Fil. 4, 1826, 125. — *Nephrodium eurylepium* A. PETER in Fedde Rep. Sp. Nov., Beih. 40, 1929, 57.

Inyanga: in silva ad rivulum, c. 1700 m s.m., 19 Nov. 1930 — 3015; Inyangani c. 3 km occidentem versus a monte, c. 2000 m s.m., 6 Dec. 1930 — 3502; Inyangani c. 3 km occidentem versus a monte ad rivulum c. 2000 m s.m., 8 Dec. 1930 — 3661; Pungwe supra dejectum fluminis in campo graminoso c. 1800 m s.m. 16 Dec. 1930 — 3750; Pungwe supra dejectum fluminis in campo graminoso c. 1700 m s.m., 18 Dec. 1930 — 3822; prope villam Inyanga Down in campo graminoso c. 1950 m s.m., 30 Jan. 1931 — 4761.

Distribution: E. Cape Province, Orange Free State, Lesotho, Natal, Swaziland, Transvaal, Rhodesia, Mozambique, Malawi, Zambia, Congo, Uganda, Sudan, Angola, Cameroons, Nigeria, Ghana, Guinée, Sierra Leone.

Polystichum zambesiacum SCHELPE in Bol. Soc. Brot., sér. 2, 41, 1967, .

Inyanga: Ad dejectum fluminis Pungwe in margine silvulae, c. 1700 m s.m., 18 Dec. 1930 — 3795.

Distribution: Rhodesia, S. Mozambique.

This distinctive species with very markedly attenuate pinnae has previously been erroneously referred to *P. ammifolium* (POIR.) C. CHR. *P. zambesiacum* is only known from the forests of the Inyanga and Umtali districts of Rhodesia and from Gorongosa Mountain in southern Mozambique.

Tectaria gemmifera (FÉE) ALSTON in Journ. Bot. 77, 1939, 228. — *Sagenia gemmifera* FÉE, Mém. Fam. Foug. 5, 1852, 313. — *Aspidium coadunatum* var. *gemmiferum* (FÉE) METT. ex KUHN, Fil. Afr., 1868, 128. — *Aspidium gemmiferum* (FÉE) CHING in Bull. Fan Mem. Inst. Biol. Bot. 10, 1941, 237.

Inyanga: Pungwe infra dejectum fluminis in valle, c. 1400 m s.m., 18 Dec. 1930 — 3907.

Distribution: Transvaal, Rhodesia, Mozambique, Malawi, Tanganyika, Congo, Angola, Uganda, Sudan, Ethiopia.

BLECHNACEAE

Blechnum attenuatum (SW.) METT. var. **giganteum** (KAULF.) BONAP. in SARASIN & ROUX, Nova Caledonis, 1, 1914, 43. — *Lomaria gigantea* KAULF., Enum. Fil., 1824, 150. — *Lomaria heterophylla* DESV. in Mag. Ges. Naturf.

Berl. 5, 1811, 330. — *Lomaria hamata* KAULF., Enum. Fil., 1824, 150. — *Blechnum giganteum* (KAULF.) SCHLECHTEND., Adumbr., 1827, 36. — *Blechnum heterophyllum* (DESV.) SCHLECHTEND., Adumbr., 1827, 37. — *Lomaria decipiens* PAPPE & RAWSON, Syn. Fil. Afr. Austr., 1858, 29.

Inyanga: Pungwe in valle infra dejectum fluminis, c. 1400 m s.m., 18 Dec. 1930 — 3826.

Distribution: Cape Province, Natal, Swaziland, Transvaal, Rhodesia, Mozambique, Malawi, Zambia.

The variety *giganteum* differs from the Mascarene type in having much longer tufted fronds borne on a much more massive rhizome and is nearly always terrestrial.

Blechnum tabulare (THUNB.) KUHN, Fil. Afr., 1868, 94. — *Pteris tabularis* THUNB., Prodr. Pl. Cap., 1800, 171. — *Lomaria coriacea* SCHRAD., in Gött. Gel. Anz., 1818, 916. — *Lomaria gueinzii* MOUG. ex FÉE, Mém. Fam. Foug. 5, 1852, 69. — *Lomaria dalgairnsiae* PAPPE & RAWSON, Syn. Fil. Afr. Austr., 1858, 27. — *Lomaria cycadoides* PAPPE & RAWSON, tom. cit., 28. — *Blechnum cycadoides* (PAPPE & RAWSON) KUHN, Fil. Afr., 1868, 91. — *Blechnum dalgairnsiae* (PAPPE & RAWSON) KUHN, tom. cit., 92. — *Lomaria tabularis* (THUNB.) METT. ex BAK., Fl. Brasil. 1 (2), 1870, 418.

Inyanga: Ad villam Inyanga Down in campo graminoso, c. 1950 m s.m., 29 Jan. 1931 — 4687.

Distribution: Cape Province, Natal, Swaziland, Transvaal, Rhodesia, Mozambique, Malawi, Zambia, Angola, Congo, Uganda, Cameroons, Nigeria.

Embryology and Systematic Position of Morina longifolia Wall.

By M. R. Vijayaraghavan and G. S. Sarveshwari

Department of Botany, University of Delhi
Delhi 7, India

ABSTRACT

The morphology and embryology of *Morina longifolia* WALL. have been investigated and an attempt has been made to ascertain its systematic position.

The flowers are borne in clusters in the axil of long, upcurving, spiny involucels. Flowers are bracteate, zygomorphic and bisexual. The calyx is two lobed and the corolla consists of five petals fused to a greater part of their length to form the corolla tube. There are two epipetalous stamens and staminodes. The ovary is inferior, unilocular and bears a single ovule. There are numerous unicellular hairs present on the bract, calyx, corolla and pericarp. Multicellular glands are present only on the corolla. Both the hairs and glands develop from epidermal initials. The mature gland has a head made up of variable number of cells on an elongated stalk.

The ontogeny of the anther wall conforms to the Dicotyledonous type. The middle layer is persistent and the tapetum is of the secretory type. Microspore tetrads are either tetrahedral or isobilateral. Pollen grains are triporate and are shed at the two-celled stage.

The staminode is an irregularly four lobed structure. There is no differentiation of the sporogenous and parietal cells. However, the vasculature is well developed and differentiation of xylem and phloem occurs.

The ovule is anatropous, unitegmic, tenuinucellar with long narrow micropyle. There is a well developed hypostase. The archesporial cell functions directly as the megaspore mother cell and meiosis results in a linear tetrad of megaspores. The chalazal megaspore is functional and the development of the embryo sac conforms to the Polygonum type. Double fertilization occurs. — The endosperm is ab initio Cellular. The division of the primary endosperm nucleus is followed by either a transverse or an oblique wall. The growth of the endosperm consumes the entire seed coat except for the outer epidermis and its surface is almost in direct contact with the inner zone of the pericarp. The endosperm in the mature seed is ruminate.

The seed coat is 8—10 layered at the megaspore mother cell stage but becomes 25 layered during the post fertilization stages. The inner epidermis forms a prominent endothelium. In the mature fruit, except for the flimsy outer epidermis all the other layers are crushed.

On embryological grounds the genus *Morina* is removed from the *Dipsaca-*

ceae to a family of its own, *Morinaceae* since it differs in many important features such as persistent middle layer in the anther, secretory anther tapetum, pollen grains shed at the two-celled stage, absence of intergumentary vascular bundles, persistent pollen tube, ruminate endosperm, transverse division of the zygote and Solanad type of embryogeny.

INTRODUCTION

Dipsacaceae, an Old World taxon, comprises eight genera and approximately 150 species (WILLIS 1966). The family is a natural taxon except for the genus *Morina* which many suggested should be raised to a family of its own. SCHNARF (1931) and DAVIS (1966) have reviewed the embryological literature of the family. PODDUBNAJA-ARNOLDI (1933) has described the male gametophyte in *Scabiosa purpurea* and observed that the pollen are shed at the 3-celled stage. RAZI & SUBRAMANYAM (1952) noted periplasmodial anther tapetum and Polygonum type of embryo sac development in *Cephalaria ambrosioides*, *Dipsacus leschenaultii* and *Scabiosa caucasica*. SOUÈGES (1957, 1963 a, b, c) described the embryogeny of *Scabiosa columbaria*, *Dipsacus sylvestris*, *Cephalaria tatarica* and *Knautia arvensis* and reported the division of the zygote to be oblique. ERDTMAN (1952) concluded that the exine pattern in the pollen grains of *Morina* differs from other genera of the *Dipsacaceae*. The present work deals with the embryology and systematic position of *Morina longifolia* WALL.

MATERIAL AND METHODS

Buds, flowers and fruits of *Morina longifolia* were collected at an altitude of 2,400 metres from Gulmarg, Kashmir, India. The material was fixed in FAA (formalin, 5 ml; glacial acetic acid, 5 ml; 50 per cent ethyl alcohol, 90 ml) and subsequently preserved in 70 per cent ethanol. Dehydration and clearing was done in alcohol-xylol series. Fruits were trimmed on both sides for proper infiltration and processed in the usual way. For easy sectioning, the embedded flowers and fruits were partially exposed by slicing a portion of the material, and were soaked in Gifford's solution (GIFFORD 1950) for 3—7 days. Sections were cut between 5 and 16 microns. Safranin, crystal violet and orange G or Heidenhain's iron-alum haematoxylin with a counterstain of fast green or erythrosin were used for staining.

Fig. 1. *Morina longifolia*. — A: Portion of twig with inflorescence. — B: An young closed inflorescence. — C: An involucel. — D, E: Groups of flowers in the axil of involucel. — F—L: Flower buds at various stages of development. — M: Mature flower. — N, O: Epipetalous stamens and staminodes. — P: A bract enlarged. — Q, R: Young fruits. — S, T: Mature fruits. — A ×4, B ×7, C—M ×1.4, N, O ×3.5, P—R ×1.4, S, T ×3.5.

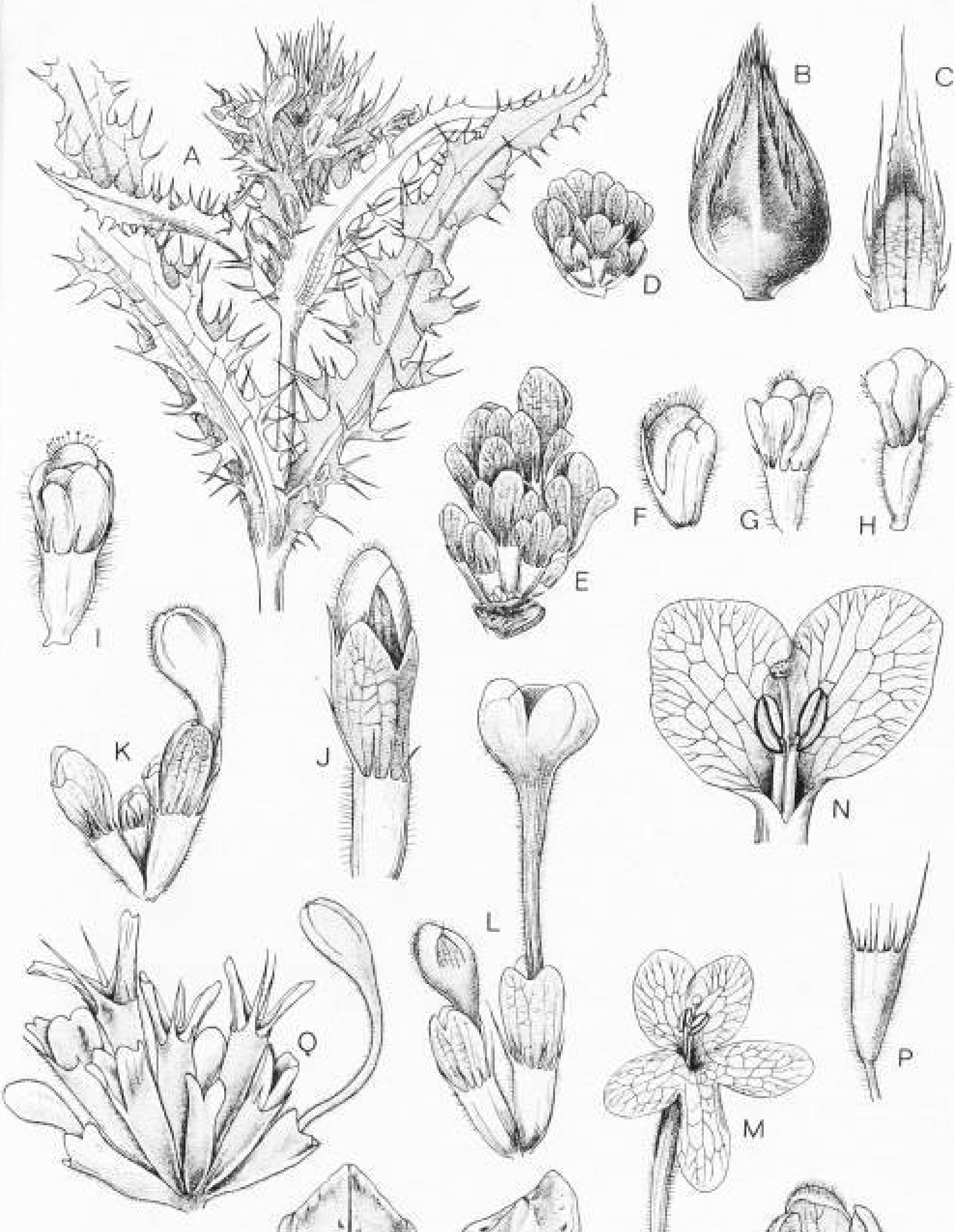


Fig. 1.

OBSERVATIONS

External Morphology

Morina longifolia, a herbaceous perennial, rarely exceeding one metre in height, grows at an altitude of 2,000—4,500 metres and extends from Kashmir to Bhutan. It flowers during July and August. The flowers are borne in clusters (Fig. 1 D, E) in the axils of the upper leaves (Fig. 1 A). In the younger stages the inflorescence is enclosed by elongated, upcurving, funnel shaped, spiny involucel (Fig. 1 B, C). Each flower is bracteate (Fig. 1 P), zygomorphic and bisexual (Fig. 1 F—H). The sepals are two and bilobed (Fig. 1 J, K). The corolla consists of five petals, adnate to a greater part of their length forming a narrow corolla tube (Fig. 1 L). The petals are unequal and spread out in an open flower (Fig. 1 M). There are two stamens and two staminodes inserted in the corolla tube. Anther lobes are four and unequal. The filament is short (Fig. 1 N). The staminodes are anterior in position and are situated below the level of the stamens (Fig. 1 O). The ovary is inferior, unilocular with a single ovule. The fruit is an achene with persistent bract and calyx (Fig. 1 Q, R). At maturity the pericarp is hard, brown and has an uneven rugose surface (Fig. 1 S, T).

Microsporangium

The young anther is four lobed and delimited by a well developed epidermis. The cells in the central region are smaller than the surrounding cells and form the future vascular trace of the connective. In each lobe of the anther, one or two archesporial cells divide peri-

---

Fig. 2. *Morina longifolia* (*end*, endothecium; *epi*, epidermis; *ml*, middle layer; *mmc*, microspore mother cell; *pc*, procambium; *ppl* primary parietal layer; spl_1, parietal layer 1; spl_2, parietal layer 2; *spor*, sporogenous cells; *t*, tapetum). — A—C: Transections of anthers at various stages of development. — D: Enlarged view of the portion marked *d* in A showing developing wall layers. — E, F: Magnified view of the areas marked *e* and *f* in B to show 4 wall layers and primary sporogenous cells. — G: Longisection of a sector of the anther magnified to show microspore mother cells. — H: Portion marked *h* in C enlarged to show the elongated tapetal cells at the microspore tetrad stage. — I, J: Transection of mature anthers. — K: Magnified view of portion marked *k* in I to show multinucleate tapetum at uninucleate pollen grains stage. — L: Portion of the connective of the mature anther in I magnified to show the stellate calcium oxalate crystals. — M: Portion marked *m* in J to show fibrous thickenings in the endothecium and the persistent middle layer. — N—R: Tapetal cells with polyploid nuclei. — S, T: Tetrahedral and isobilateral tetrads. — U, V: One- and two-celled pollen grains. — A, B ×139, C ×85, D—H ×551, I, J ×29, K ×226, L—T ×551, U, V × 226.

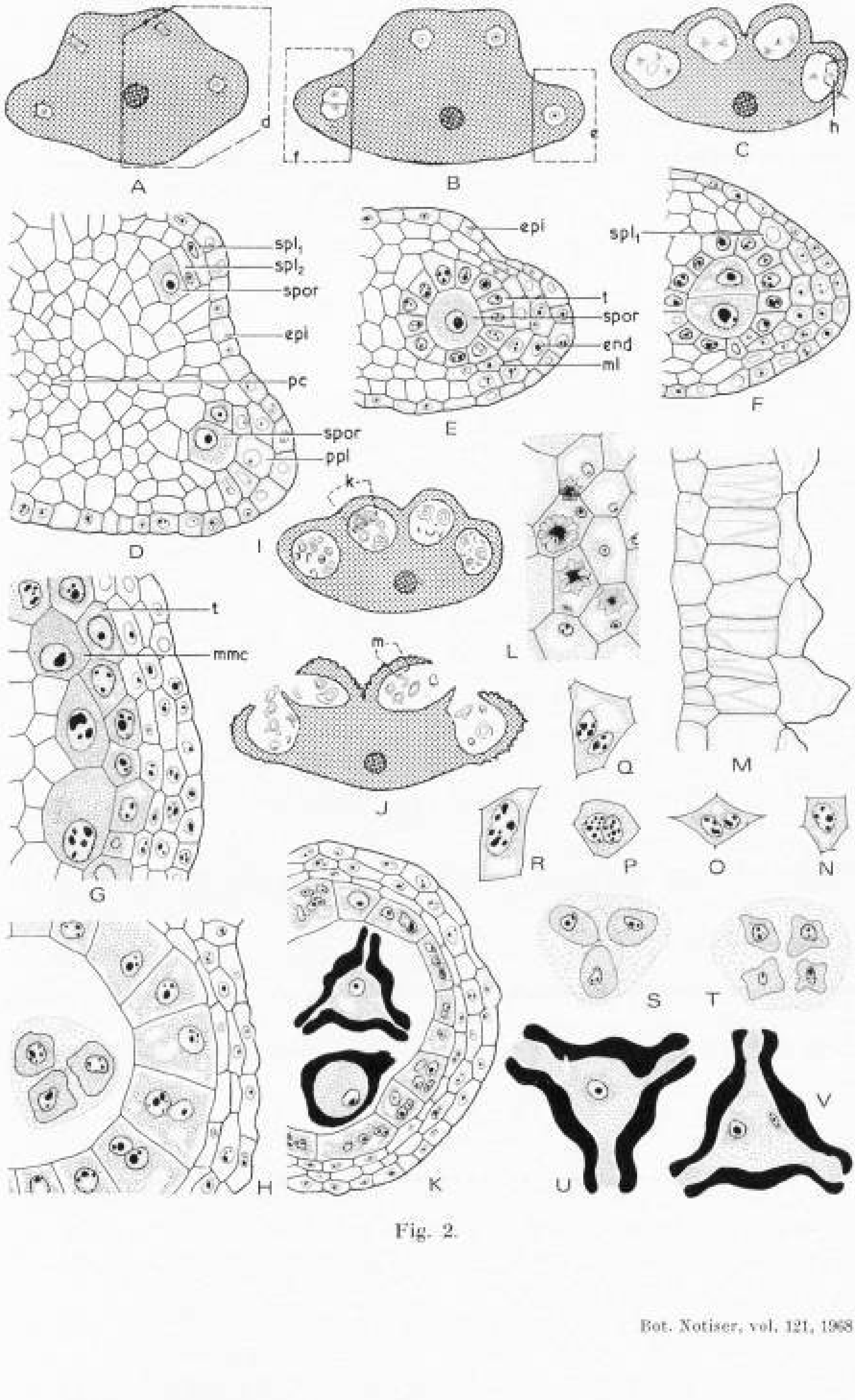

A
B
C
d
e
f
h
D
E
F
spl1
spl2
spor
epi
pc
ppl
t
end
ml
G
mmc
I
k
J
m
L
M
Q
R
P
O
N
S
T
H
K
U
V

Fig. 2.

clinally to form an outer primary parietal cell and an inner sporogenous cell (Fig. 2 A, D). The primary sporogenous cell undergoes a few mitotic divisions in various planes to form the sporogenous tissue (Fig. 2 G). The cells of the primary parietal layer divide periclinally resulting in secondary parietal cells (Spl_1 and Spl_2; Fig. 2 D). The inner of the two parietal cells develops into tapetum whereas the outer one (Spl_1) segments periclinally to form the endothecium and the middle layer (Fig. 2 B, E, F). Thus, four layers are organized (Fig. 2 I, K).

The following chart summarizes the development of anther wall:

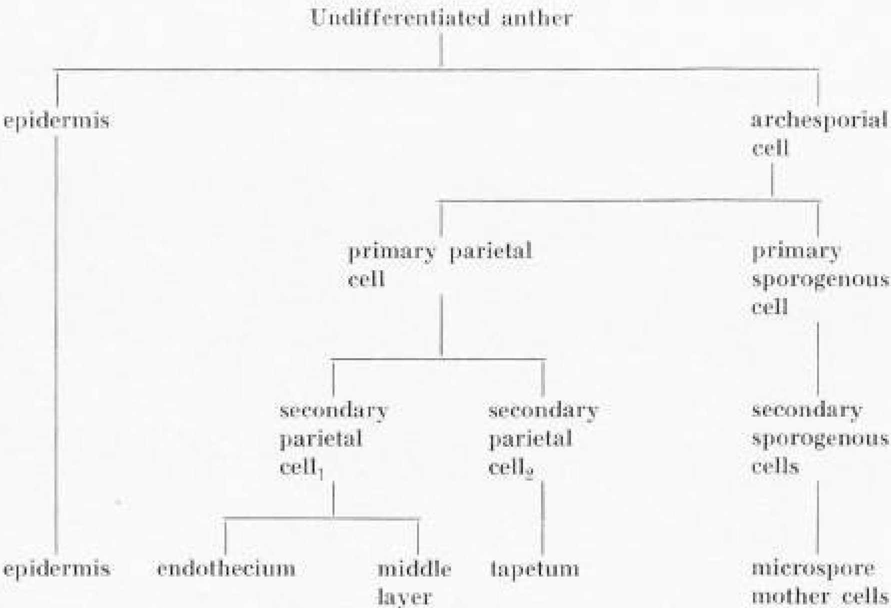


Fig. 3. *Morina longifolia* (*an*, anther; *c*, calyx; *co*, corolla; *cr*, crystal; *epi*, epidermis; *p*, phloem; *pc*, procambium; *st*, staminode; *sty*, style; *x*, xylem). — A: Diagrammatic representation of the transverse section of the flower showing the anterior position of the staminode. — B: Transverse section of an young staminode; the central smaller cells are the future vascular bundles. — C—E: Transections of staminodes at various stages of development. — F: Portion marked *f* in C enlarged to show the lobing in the staminode. — G: Magnified view of the portion marked *g* in D to show fully differentiated vascular bundle and a few cells which contain calcium oxalate crystals. — H: Enlargement of the portion marked *h* in E to show the cells of the staminode at a later stage; most of the cells are highly vacuolated. — A ×50, B ×532, C—E ×215, F—H ×532.

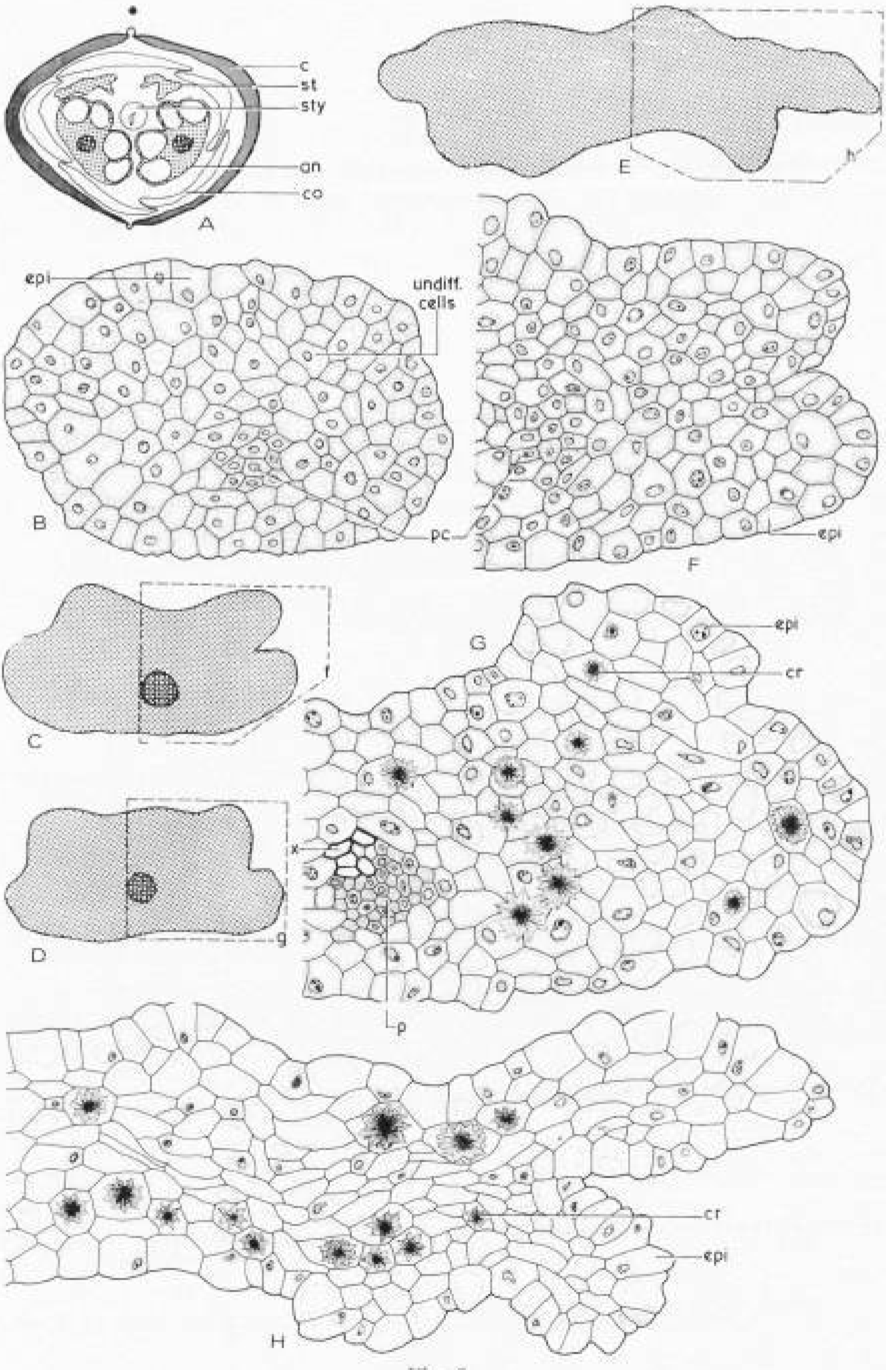

c
st
sty
an
co
A
E
h
epi
undiff. cells
B
pc
epi
F
f
C
G
epi
cr
x
D
g
p
cr
epi
H

Fig. 3.

The vascular strand of the connective shows a well developed xylem and phloem. Some of the cells of the connective have stellate crystals (Fig. 2 L). The endothecium at maturity consists of large cells with thickenings on their radial walls (Fig. 2 J, M). The middle layer is persistent (Fig. 2 M). The tapetal cells enlarge considerably and attain maximum development during microsporogenesis (Fig. 2 C, H). The tapetal cells are at first uninucleate but later become multinucleate (Fig. 2 N—R). These nuclei subsequently fuse and become polyploid (Fig. 2 R). The tapetal cells degenerate at the 2-celled stage of the pollen grains and is of the secretory type.

Microsporogenesis and Male Gametophyte

The microspore mother cells undergo meiosis and the microspore tetrads are either tetrahedral or isobilateral (Fig. 2 S, T). The pollen grains are triporate with thick exine and thin intine (Fig. 2 K, U). The nucleus of the microspore divides to form a large vegetative cell and a small generative cell. The pollen grains are shed at the 2-celled stage (Fig. 2 V).

Staminode

The staminodes are anterior in position (Fig. 3 A) and epipetalous. In transverse section, the young staminode comprises a mass of cells surrounded by an epidermis. In slightly older stages a smaller group of cells in the middle region develops into the vascular trace (Fig. 3 B). An interesting feature in the ontogeny of the staminode is the lack of differentiation of the usual hypodermal archesporial cell and parietal layer of the anther wall (Fig. 3 C, D, F, G). At maturity, the irregularly four lobed staminode consists of vacuolate thin walled cells with scanty cytoplasm. Many of the cells contain stellate, calcium oxalate crystals (Fig. 3 G). During further stages, the vascular bundle completely degenerates (Fig. 3 E, H).

Megasporangium and Hypostase

There is a single, pendulous, anatropous, unitegmic and tenuinucellar ovule. It develops as a small protuberance on the placenta, curves and eventually becomes anatropous. The integument is massive and the micropyle is long and narrow. The ovular vasculature is feebly developed.

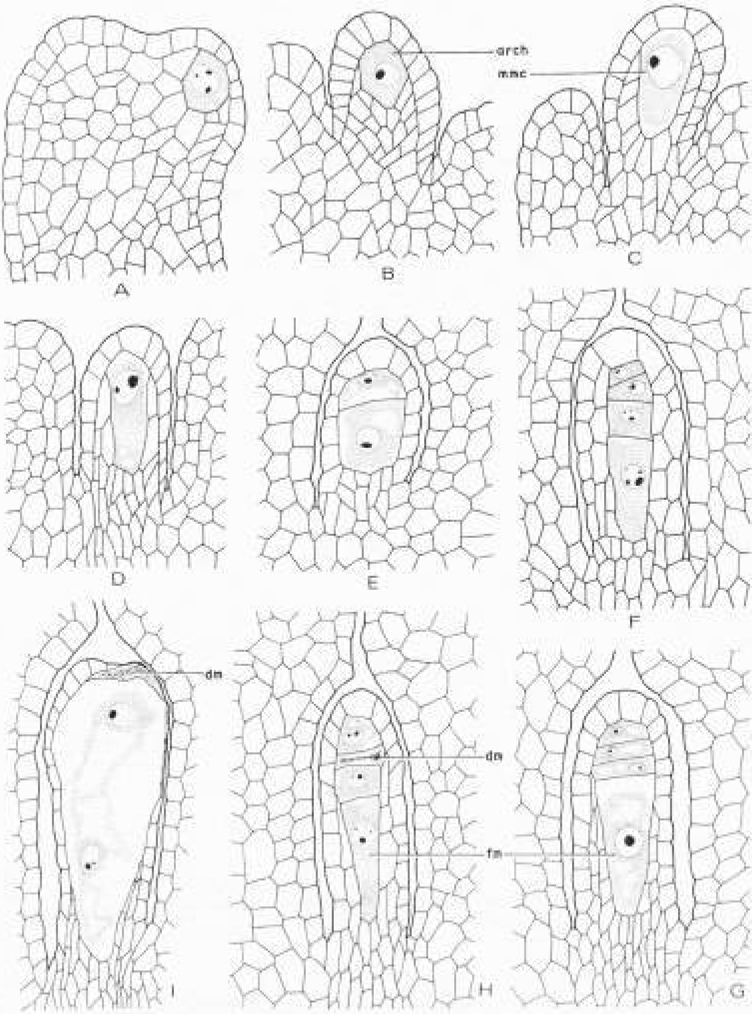


Fig. 4. *Morina longifolia* (*arch*, archesporial cell; *dm*, degenerating megaspore; *fm*, functional megaspore; *mmc*, megaspore mother cell). — A, B: Longitudinal sections of the nucellus showing archesporial cells. — C, D: Longitudinal section of ovules at megaspore mother cell stages. — E: Dyad. — F—H: Tetrads; the chalazal megaspore is functional. — I: Longisection of the ovule showing two-nucleate embryo sac and degenerating micropylar megaspore. — A—I ×589.

At about the four- or eight-nucleate stage of the embryo sac, the cells of the nucellus lying immediately below the gametophyte elongate, become densely cytoplasmic and show prominent nuclei. These cells comprise the hypostase. After fertilization, divisions in the cells of the hypostase result in a globular mass which protrudes towards the embryo sac. During the globular stage of the proembryo, the cells get highly stretched and become vacuolate. Ultimately, the hypostase cells degenerate due to the growth of the endosperm.

Megasporogenesis and Female Gametophyte

A single hypodermal archesporial cell (Fig. 4 A, B) elongates considerably and functions directly as the megaspore mother cell (Fig. 4 C, D). First meiotic division of the mother cell results in a dyad of which the micropylar cell is comparatively smaller than the chalazal one (Fig. 4 E). Both the cells of the dyad divide transversely forming a linear tetrad (Fig. 4 F). The chalazal megaspore is large and functional (Fig. 4 F—H). Figure 4 H shows early degeneration of the second megaspore.

The nucleus of the functional megaspore undergoes three successive mitotic divisions to produce an eight nucleate embryo sac (Fig. 5 A—D). One of the degenerated micropylar megaspores is persistent in the form of dark band at the two nucleate embryo sac stage (Fig. 4 I). The eight nuclei organize into an egg, two synergids, two polar and three antipodal cells (Fig. 5 F). The chalazal quartet organizes earlier (Fig. 5 E). The two polar nuclei fuse to form the secondary nucleus (Fig. 5 G). The development of the embryo sac conforms to the Polygonum type.

Fertilization

The entry of the pollen tube is porogamous (Fig. 6 A—G). One of the male nuclei fuses with the secondary nucleus (Fig. 5 H). The other male nucleus was not discernible due to the accumulation of densely staining bodies which surround the egg. The pollen tube is persistent (Fig. 6 A—G).

Endosperm

The primary endosperm nucleus divides before the zygote (Fig. 6 A). The division is followed by the formation of either a transverse or an oblique wall resulting in micropylar and chalazal chambers (Fig.

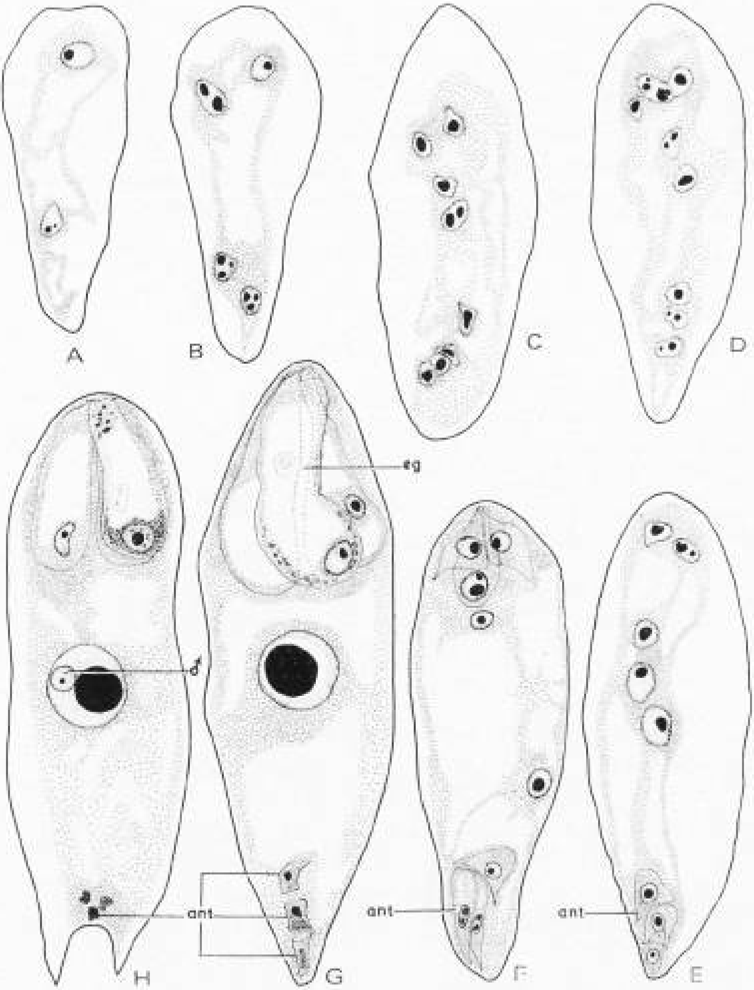


Fig. 5. *Morina longifolia* (*ant*, antipodal cells; *eg*, egg). — A, B: Two and four-nucleate embryo sacs. — C—E: 8-nucleate unorganized embryo sacs; in E the chalazal quartet has organized earlier. — F, G: Mature embryo sacs; the two polar nuclei have not fused in F whereas in G the antipodal cells are degenerated. — H: Embryo sac showing triple fusion. — A—H ×665.

6 B, C). The division of the nuclei in both the chambers is longitudinal and takes place simultaneously (Fig. 6 D) but further divisions are in various planes and a mass of endosperm is produced (Fig. 6 E, F). The development of the endosperm is rapid and at about the dicotyledonous stage of the embryo, the entire seed coat is consumed except

for the outermost flimsy epidermis. The endosperm in the mature seed is ruminate (Fig. 6 J). The cells of the endosperm are polygonal, uninucleate at globular embryo stage (Fig. 6 G, H) and at the dicotyledonous stage of the embryo, are packed with fat globules (Fig. 6 I).

Embryogeny

The zygote (Fig. 7 A) segments transversely resulting in a small terminal cell *ca* and a large basal cell *cb* (Fig. 7 B). Of these two cells, the terminal cell divides transversely resulting in two superposed cells *l* and *l′* (Fig. 7 C). Vertical divisions in *l* and *l′* give rise to quadrant (Fig. 7 D, E). Another vertical division in each of these tiers results in an octant (Fig. 7 F). Periclinal division now sets in demarcating the protoderm which covers a linear row of meristematic cells (Fig. 7 G). Anticlinal divisions occur in the protoderm, while both anticlinal and periclinal divisions occur in the central cells. Thus the proembryo becomes large and globular in shape (Fig. 7 H—J). The behaviour of the basal cell does not correspond to that of the terminal cell. Initially it segments transversely to form *m* and *ci* (Fig. 7 E) but further divisions occur in all planes forming a short massive suspensor (Fig. 7 I—K). The mature embryo is dicotyledonous and there is a single trace entering each cotyledon. The venation is reticulate (Fig. 7 L). The embryogeny follows the Solanad type (Maheshwari 1950).

Seed Coat

At about the megaspore mother cell stage, the integument consists of 4—6 layers of thin walled cells (Fig. 8 A, D). At the 8-nucleate embryo sac stage the testa becomes 14—16 layered (Fig. 8 B, E). Three or four layers of the cells at the micropylar region and seven to ten layers at the chalazal region surrounding the embryo sac becomes densely

---

Fig. 6. *Morina longifolia* (*emb*, embryo; *pen*, primary endosperm nucleus; *pt*, pollen tube; *rs*, ruminate surface; *z*, zygote). — A: Embryo sac showing zygote and primary endosperm nucleus; the pollen tube is persisent. — B—D: Two-celled endosperm; the wall is oblique in B whereas it is transverse in C. — E, F: Six and many celled endosperm. — G: Longitudinal section of the embryo sac at globular stage of the proembryo; the pollen tube is persistent. — H: Magnified view of the portion marked *h* in G to show endosperm cells. — I: A few cells of the endosperm at the dicotyledonous embryo stage enlarged to show the cells packed with fat globules. — J: Dissection of the endosperm at the dicotyledonous embryo stage showing ruminate surface. — A—F ×589, G ×56, H, I ×589, J ×4.3.

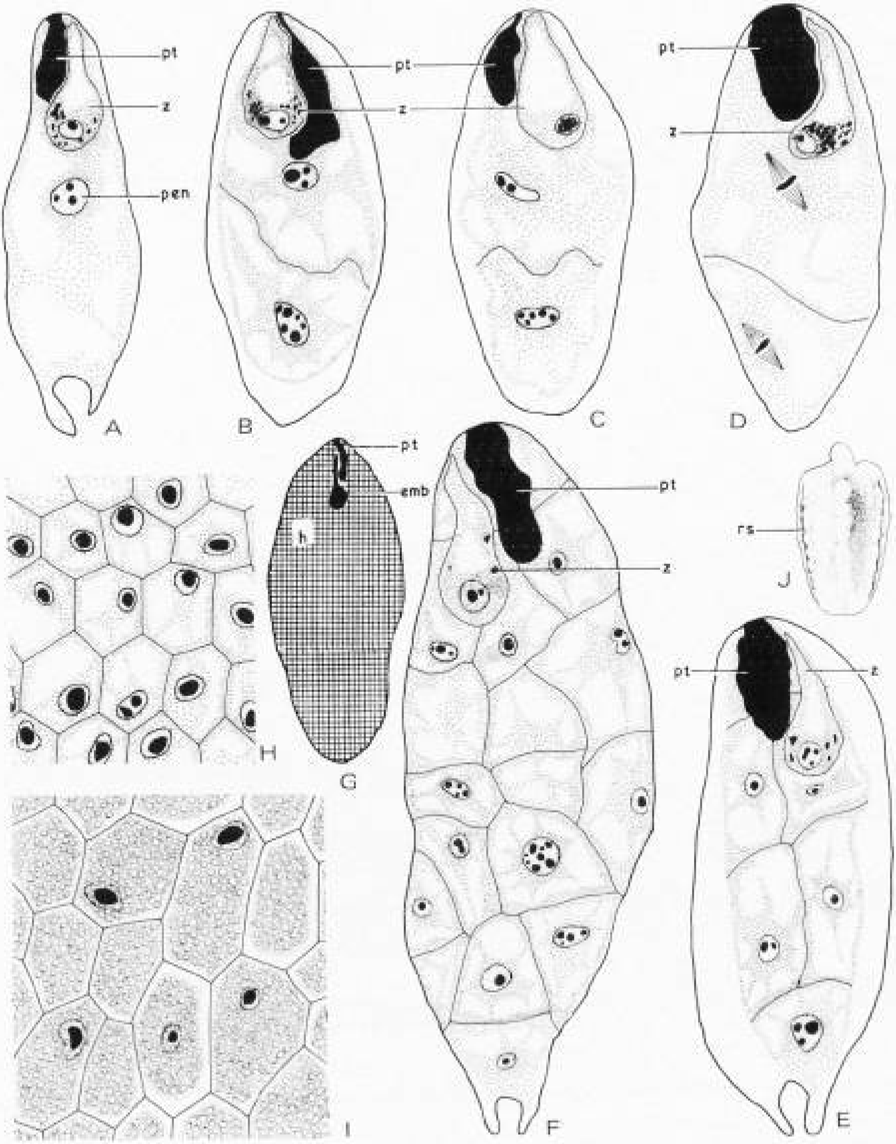


Fig. 6.

cytoplasmic and have very prominent nuclei. The inner epidermis lies adjacent to the embryo sac, elongates radially and forms prominent endothelium (Fig. 8 E, F). After fertilization, at the globular stage of the embryo, the testa becomes 20—25 layered (Fig. 8 C, F). At the dicotyledonous stage of the embryo, the testa comprises only the outer epidermis which consists of thin walled, vacuolate, and tangentially compressed cells (Fig. 8 G).

Hairs and Glands

Numerous unicellular hairs are present on the bract, calyx, corolla and ovary wall. The hair develops from an epidermal cell, which is more densely cytoplasmic than the adjoining cells (Fig. 8 H). The initial protrudes and elongates further to form the hair (Fig. 8 I—L). Multicellular glands are confined to the corolla. Any epidermal cell with dense cytoplasm and prominent nuclei acts as the gland initial. This cell elongates and protrudes out in the form of a papillate initial. It then divides transversely forming a smaller outer and a larger inner cell (Fig. 8 M). The lower cell does not divide further but elongates to form the stalk (Fig. 8 N). The upper cell undergoes transverse divisions to form an uniseriate row of cells (Fig. 8 O). Two vertical divisions in these cells form the head (Fig. 8 P, Q).

DISCUSSION

MICROSPORANGIUM, MICROSPOROGENESIS AND MALE GAMETOPHYTE. The young microsporangium wall comprises four layers. Ontogenetic studies have shown that the endothecium and the middle layer are derived from the secondary parietal layer 1, whereas the tapetum is derived from the secondary parietal layer 2. Thus, the development of the anther wall conforms to the Dicotyledonous type (see DAVIS 1966). Although RAZI & SUBRAMANYAM (1952) do not claim such a mode of development of anther wall in *Cephalaria ambrosioides*, *Dipsacus leschenaultii* and *Scabiosa caucasica*, DAVIS (1966) concludes that in these species also the same pattern exists. The middle layer in *M. longifolia* is persistent at maturity unlike in other genera of this

Fig. 7. *Morina longifolia* (*cot*, cotyledon; *sus*, suspensor). — A: Zygote. — B: Two-celled proembryo. — C—E: Quadrant stage of the proembryo. — F: Octant stage. — G: Young globular proembryo. — H—K: Globular embryos at various stages of development. — L: Dicotyledonous embryo. A—L ×627.

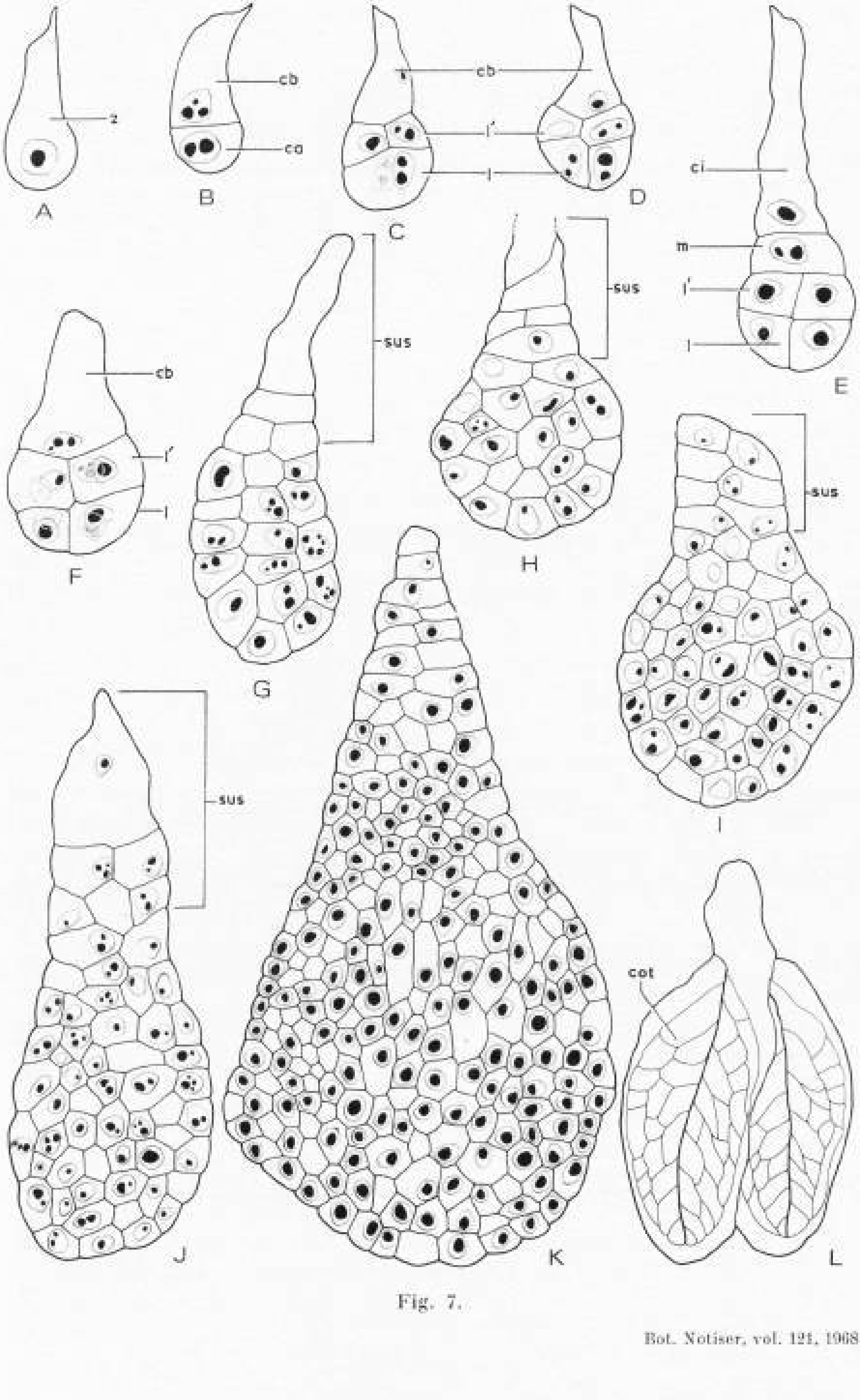


Fig. 7.

family where it is ephemeral. Further, the anther tapetum in *M. longifolia* contains polyploid, multinucleate cells and is of the secretory type, whereas in all other members of this family so far investigated, the tapetum is sensu stricto periplasmodial. The pollen grains are shed at the two-celled stage in contrast to the three-celled condition in other members of this family (RAZI & SUBRAMANYAM 1952; PODDUBNAJA-ARNOLDI 1933).

MEGASPORANGIUM, MEGASPOROGENESIS AND FEMALE GAMETOPHYTE. The ovule is anatropous, unitegmic and tenuinucellar as in other genera of the family. RAZI & SUBRAMANYAM (1952) reported that the vascular trace traverses the integument right up to the micropylar end in the ovule of *Cephalaria ambrosioides*, half way up in the integument of *Dipsacus leschenaultii* and terminates near the chalazal end of the ovule in *Scabiosa caucasica*. In *Morina longifolia* (present investigation) the integumentary vascular bundles are absent and the ovular vasculature is feebly developed. Double megaspores and dyads are reported in *Cephalaria ambrosioides* and *Scabiosa caucasica* (RAZI & SUBRAMANYAM 1952). However, in *Morina longifolia* no such features were observed. The sequence of degeneration of micropylar megaspores varied in *Morina*. In some instances, the third megaspore degenerated earlier than the rest. In *Cephalaria ambrosioides*, the third megaspore divided to form 2-nucleate embryo sac while the chalazal megaspore was still uninucleate (RAZI & SUBRAMANYAM 1952). The development of the embryo sac in all genera studied (including *M. longifolia*) follows the Polygonum type. The entry of the pollen tube is porogamous and the pollen tube is persistent. Persistent pollen tube has not been reported for other genera of *Dipsacaceae*. In *Morina longifolia* the three antipodal cells are uninucleate and degenerate before fertilization. However, in *Cephalaria ambrosioides* the antipodal cells become binucleate and are persistent (RAZI & SUBRAMANYAM 1952). BALIKA-IWANOWSKA (1869, quoted in COULTER & CHAMBERLAIN 1965) reported secondary multiplication in antipodal cells of *Morina longifolia*. Contrary to this,

Fig. 8. *Morina longifolia* (*end*, endosperm; *ie*, inner epidermis; *oe*, outer epidermis; *pt*, pollen tube). — A—C: Longisections of ovules at megaspore mother cell, mature embryo sac and globular stage of the embryo. — D: Portion marked *d* in A to show the prominent endothecium and the adjacent densely cytoplasmic cells; the epidermis in F consists of papillate cells. — G: Portion of the seed coat at the dicotyledonous stage of the embryo to show the outer epidermis and degenerated remnants of other layers. — H—Q: Stages in the development of hairs and glands. — A ×90, B, C ×13, D—Q ×608.

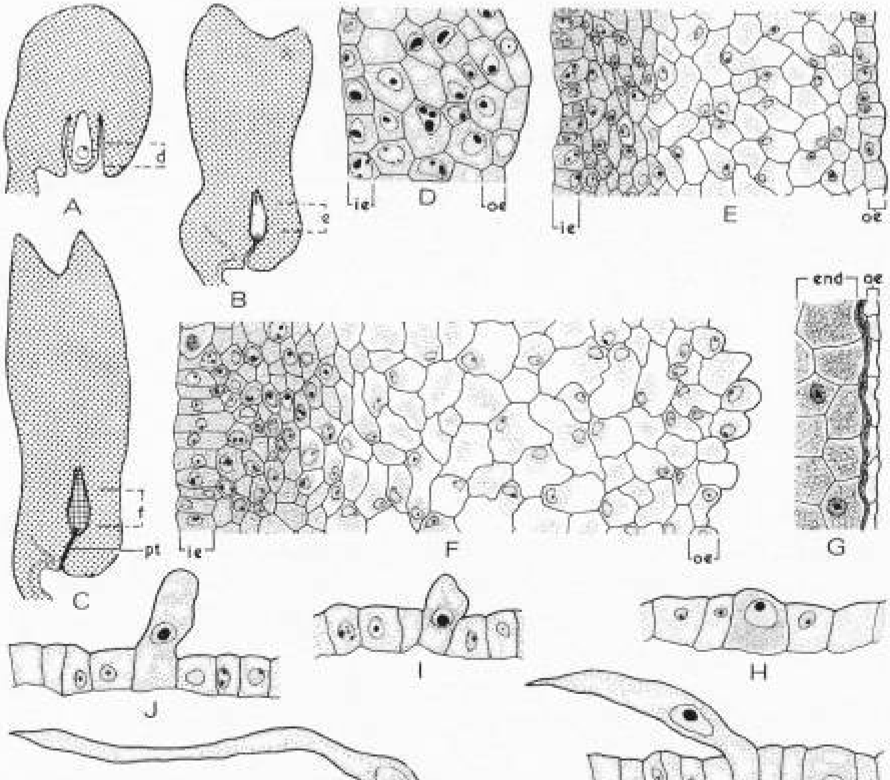


Fig. 8.

our observations on this genus showed only three antipodal cells which degenerate before fertilization and no secondary multiplication occurs. Interestingly, a prominent hypostase develops after fertilization which protrudes towards the embryo sac in the form of a globular mass. In off median sections, these cells simulate the multiple antipodal complex.

ENDOSPERM AND EMBRYO. The development of the endosperm is Cellular in *Dipsacaceae*. The present investigation on *Morina longifolia* confirms this. The first wall is either transverse or oblique. The growth of the endosperm is rapid after the proembryo attains the globular stage and when the embryo is dicotyledonous, the endosperm completely fills the seed. All layers except the outer flimsy epidermis of the testa are consumed and the endosperm is almost adjacent to the pericarp.

The zygote divides invariably by an oblique wall in *Scabiosa succisa*, *Cephalaria tatarica*, *Dipsacus sylvestris* and *Knautia arvensis* (Souèges 1957, 1963 a, b, c). Johansen (1950) included *Scabiosa succisa* as a variation under Piperad type. According to Souèges (1963 a, b, c) though the division of the zygote is vertical, the cell lineages are not similar in the above genera. Crété (1963) described the embryogeny of *Dipsacaceae* as an irregular type. In contrast to this, in *M. longifolia* the zygote divides transversely, and the embryogeny conforms to the Solanad type.

SYSTEMATIC POSITION

The inclusion of the genus *Morina* in the family *Dipsacaceae* has been questioned by Wagenitz (1964), Ferguson (1965) and Willis (1966). The following table summarizes the important embryological characters of *M. longifolia* and *Dipsacaceae* (for literature see Crété 1963; Davis 1966; Johansen 1950; Lavaille 1925; Maheshwari 1950; Poddubnaja-Arnoldi 1933; Razi & Subramanyam 1952; Schnarf 1931; Souèges 1957, 1963 a, b, c).

	Morina longifolia	*Dipsacaceae*
Anther wall	Dicotyledonous type	Dicotyledonous type
Endothecium	Fibrous	Fibrous
Middle layer	Persistent	Ephemeral
Tapetum	Secretory	Periplasmodial
Microspore tetrad	Tetrahedral or isobilateral	Tetrahedral
Shedding stage of the pollen	Two celled	Three celled

	Morina longifolia	*Dipsacaceae*
Staminodes	Present	Absent
Ovule	Anatropous, unitegmic and tenuinucellar	Anatropous, unitegmic and tenuinucellar
Integumentary vascular bundles	Absent	Present
Hypostase	Present, but no cavities formed	Present, cavities present which contain yellow liquid
Embryo sac	Polygonum type	Polygonum type
Antipodal cell	Three, uninucleate	Three, uni- or binucleate
Endosperm	Cellular, ruminate	Cellular, non-ruminate
Pollen tube	Persistent	Not persistent
Zygote	Divides by transverse wall	Divides invariably by vertical wall
Embryogeny	Solanad type	Piperad type
Testa	Only the outer epidermis persists as a flimsy layer	Not known

Morina longifolia resembles *Dipsacaceae* only in a few embryological features such as dicotyledonous type of anther wall development, anatropous ovule, Polygonum type of embryo sac, and Cellular endosperm. However, it differs from *Dipsacaceae* in many other characters such as persistent middle layer in the anther, secretory anther tapetum, pollen grains shed at two-celled stage, absence of integumentary vascular bundles, persistent pollen tube, ephemeral uninucleate antipodal cells, ruminate endosperm, transverse division of zygote and Solanad type of embryogeny.

Hence, the totality of embryological features suggest that *M. longifolia* should be separated from the *Dipsacaceae* to a family of its own, **Morinaceae.**

ACKNOWLEDGEMENTS

We are grateful to Professor B. M. Johri for encouragement and suggestions, to Dr P. S. Ganapathy and Mr. K. R. Shivanna for valuable discussions. Thanks are due to Miss Usha Kaul for collecting the material used in this investigation.

LITERATURE CITED

Coulter, J. M. & Chamberlain, C. J. 1965. Morphology of Angiosperms. — Allahabad.

Crété, P. 1963. Embryo. In Maheshwari, P. (Ed.) Recent advances in the embryology of Angiosperms, pp. 171—220. — Delhi.

Davis, G. L. 1966. Systematic embryology of the Angiosperms. — New York.

Erdtman, G. 1952. Pollen morphology and plant taxonomy: Angiosperms. — Waltham, U.S.A.

FERGUSON, I. K. 1965. The genera of Valerianaceae and Dipsacaceae in the southeastern Unted States. — Journ. Arnold Arb. 46: 218—231.

GIFFORD, E. M. Jr. 1950. Softening refractory plant material embedded in paraffin. — Stain Technol. 25: 161—162.

JOHANSEN, D. 1950. Plant embryology. — Waltham, U.S.A.

LAVAILLE, P. 1925. Sur le sac embryonnaire des Dipsacacées. — Compt. Rend. Acad. Sci. (Paris) 180: 1127—1129.

MAHESHWARI, P. 1950. An introduction to the embryology of Angiosperms. — New York.

PODDUBNAJA-ARNOLDI, P. 1933. Spermazellen in der Familie Dipsacaceae. — Planta 21: 381—386.

RAZI, B. A. & SUBRAMANYAM, K. 1952. Embryology of the Dipsacaceae. 1. Glands, the male and female gametophytes. — Proc. Indian Acad. Sci. B. 36: 249—257.

SCHNARF, K. 1931. Vergleichende Embryologie der Angiospermen. — Berlin.

SOUÈGES, E. C. R. 1957. Embryogénie des Dipsacacées. Développement de l'embryon chez le Scabiosa columbaria L. — Compt. Rend. Acad. Sci. (Paris) 245: 465—469.

— 1963 a. Embryogénie des Dipsacacées. Développement de l'embryon chez Cephalaria tatarica Schrad. — Compt. Rend. Acad. Sci. (Paris) 256: 45—48.

— 1963 b. Embryogénie des Dipsacacées. Développement de l'embryon chez le Dipsacus sylvestris Mill. — Compt. Rend. Acad. Sci. (Paris) 256: 2268—2273.

— 1963 c. Embryogénie des Dipsacacées. Développement de l'embryon chez le Knautia arvensis Coult. — Compt. Rend. Acad. Sci. (Paris) 256: 1190—1194.

WAGENITZ, G. 1964. Dipsacales. In ENGLER, A. Syllabus der Pflanzenfamilien. Ed. 12. 2: 472—478. — Berlin.

WILLIS, J. C. 1966. The dictionary of the flowering plants and ferns. Ed. 7. Rev. by H. K. AIRY SHAW. — Cambridge.

Chromosome Numbers in the Flora of Ogotoruk Creek, N.W. Alaska

By A. W. Johnson and J. G. Packer

Department of Biological Sciences, San Diego State College, San Diego, California, U.S.A., and

Department of Botany, The University of Alberta, Edmonton, Alberta, Canada, respectively

ABSTRACT

Chromosome numbers determined from local material are reported for a number of species occurring in the Ogotoruk Creek Valley. Taxonomic and phytogeographical comments for selected species are presented including one nomenclatural change.

INTRODUCTION

Two papers by the present authors, JOHNSON and PACKER (1965, 1967), dealing with cytological aspects of the Ogotoruk Creek Flora, have been published. The first of these reported the frequency of diploids and polyploids in the flora and demonstrated a gradient of increasing polyploidy correlated with certain edaphic gradients. These data were used to draw conclusions about the history of the arctic flora prior to and during the Pleistocene period. In the second paper the question of the history of the arctic flora was approached in a different way, employing the method of FAVARGER (1961) in which observations are based on the frequency of polyploids in different age groups. It was found that different elements in the Ogotoruk Creek flora have different polyploid spectra, most probably reflecting differences in their historical development. Of the two major elements in the flora it was suggested that the 'arctic element' has mainly evolved in situ, by changes in components of the pre-existing Arcto-Tertiary Flora, whereas a major part of the 'arctic-montane' element has most likely migrated into the Arctic from more southerly mountain ranges. The view expressed in these two papers is that the arctic flora existed at the beginning of the Pleistocene period much as it does today as regards species composition, but that the distribution of most species has been profoundly affected by the glaciations which major disturbance was also important in the formation and survival of many neopolyploid taxa.

In this paper the chromosome numbers on which these findings were based are presented. Apart from the use already made of these counts they have significance in that they contribute to our knowledge of the cytological conditions existing in northern taxa. The importance of such information in taxonomy, ecology, phytogeography and in fact all studies directed toward an understanding of the evolution and relationships of this flora is well known; chromosome counts, whether they confirm earlier reports or deviate from them are equally important in building up our knowledge of the flora and we make increasing use of these data in all our investigations.

The northern flora is better known cytologically than any other flora and the fact that the compilation produced by LÖVE and LÖVE (1961 A) certainly could not be made, even now, for any other part of the world testifies to this. In the meantime however, several papers reporting chromosome numbers in arctic species have appeared, covering several different geographical regions and these have added significantly to our knowledge of this flora. Because of this we feel a useful purpose would be served by including in this paper, in addition to the chromosome numbers for species occurring in the Ogotoruk Creek flora, the previously published numbers listed by LÖVE and LÖVE and for publications since that date both chromosome number and locality. By doing this, additional perspective may be obtained with regard to variation in chromosome numbers in arctic species and the geographical distribution of the chromosome races. It could also be helpful in pointing to those arctic species most likely to reward detailed taxonomic investigation. There is good reason to draw attention to those arctic species most urgently in need of investigation. Cytological data are accumulating rapidly, but they raise taxonomic problems that form an ever increasing backlog, a situation about which we should not be complacent. If we are to derive the optimum benefit from cytological investigations these have to be accompanied by broadly based taxonomic studies. It is only these that can provide the precise distributional information of taxa in the northern flora that are a cornerstone for the understanding of its origin and evolution.

This is not an academic question but a practical problem with which the authors have had experience. In their recent paper, JOHNSON and PACKER (1967) were unable to utilise cytological data obtained for

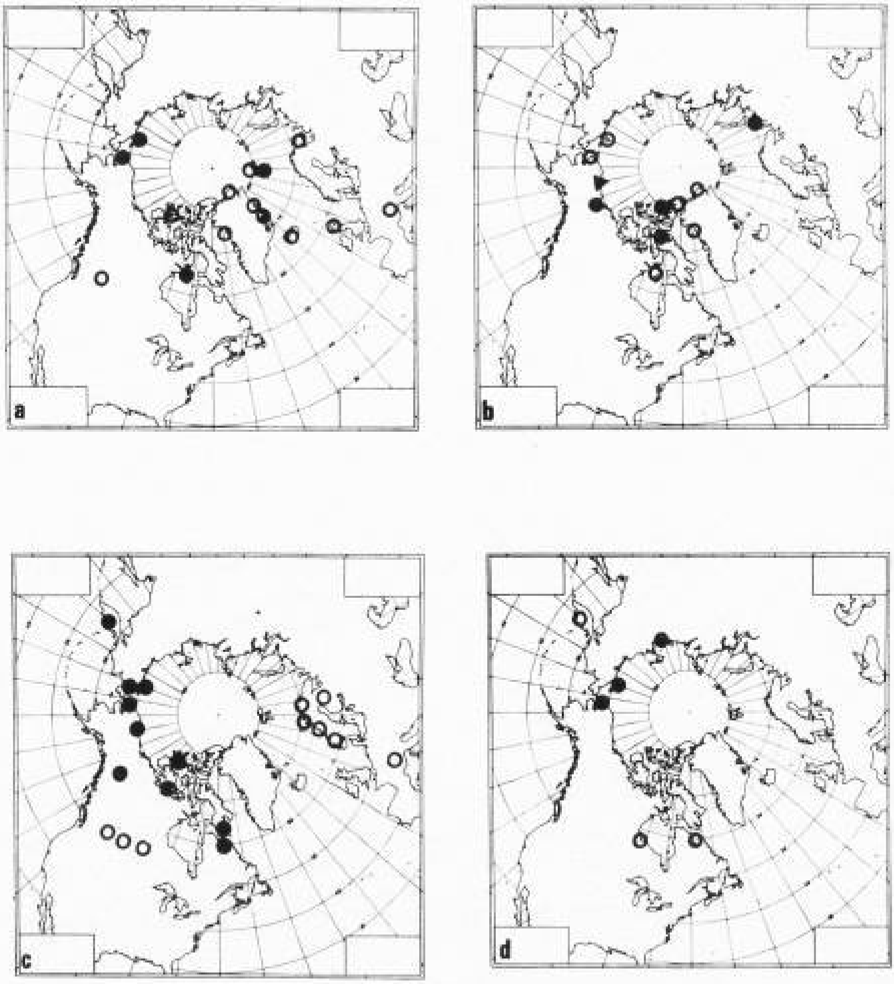


Fig. 1. Maps showing location of chromosome counts.

a. *Saxifraga oppositifolia*	open circles	2n=26
	half-open circle	2n=39
	dots	2n=52
b. *Eutrema edwardsii*	triangle	2n=18
	open circles	2n=28
	dots	2n=42
c. *Astragalus alpinus*	open circles	2n=16
	dots	2n=32
d. *Ranunculus gmelinii*	open circles	2n=16
	dots	2n=32

37 species in the Ogotoruk Creek flora because two or more chromosome numbers were known to occur in them and distributional information about the different chromosome races was for the most part totally lacking. It might be added that if this study were being made today an even higher number of taxa would have to be excluded from consideration for this reason. The compilation of distribution maps of chromosome races from published cytological data is hardly possible at present; counts are insufficient in number and mostly fail to adequately cover the geographical distribution of the taxon. The maps in Fig. 1 are instructive in this respect.

With regard to *Saxifraga oppositifolia* and *Eutrema edwardsii*, Fig. 1 a & b, though both have been counted from ten or more localities, the distribution of the chromosome races presents no meaningful pattern. In the case of *Astragalus alpinus*, Fig. 1 c, there is geographical separation of the diploid and tetraploid, which invites speculation, though in the absence of counts from vast expanses of Asia that is the most it can be. Only when the chromosome numbers are correlated with other taxonomic characters, that would allow analysis of a much larger sample, will the distribution of the chromosome races be known with any certainty. *Ranuculus gmelinii*, Fig. 1 d, is typical of most arctic species in which chromosome races occur; counted from so few localities that virtually nothing can be said regarding the distribution of the chromosome races.

We reiterate that cytological data is a supremely valuable tool for the taxonomist and phytogeographer but it is not a substitute for taxonomic studies. Many arctic species in which two or more chromosome numbers are known are in need of modern revision. Invaluable to the phytogeographer in any such undertaking would be the exploration of a possible polytopic origin for the polyploids. We suspect that this is not such an infrequent phenomenon but it is one that could lead to faulty phytogeographical conclusions if polyploid taxa are always assumed to have originated once; in one place and at one time, JOHNSON et al. (1965).

THE OGOTORUK CREEK VALLEY

The Ogotoruk Creek Valley is located on the N.W. coast of Alaska at 68°06′ N.; 165°46′ W.; has a southwestern aspect; occupies an area of above 110 sq./km. and supports about 300 vascular plant species. The valley is characterised by extensive tundra flats and low hills up to slightly more than 325 m. Mudstone, sandstone, dolomite, limestone, chert and argillite of Mississippian to Cretaceous age are the most common bedrocks. The area was unglaciated, but unconsolidated quaternary sediments 6—18 m thick cover some 50 percent of the area, WEICHOLD (1962).

The climate is quite typical for arctic Alaska; winter temperatures reach lows of —40°C and a mean summer maximum of over 10°C occurs only in July. Precipitation is slight, about 20 cm, occurring most in the summer. Snowfall is light and invariably redistributed into extensive beds by the winter winds that average 36 km/hr., summer velocities being some 14 km/hr. lower on average. Permafrost is a feature of the area and penetrates to depths of 300 m with the upper limit lying close to the soil surface.

Temperature and precipitation are relatively constant throughout the valley and the distribution of plants is correlated primarily with edaphic factors. Soil texture varies from the lowlands, where fine grained mineral fractions and organic materials predominate to the slopes and ridge tops where 20—40 percent of the soil mass consists of coarse angular rock fragments. Other soil characteristics are correlated with these topographic differences; soil moisture is high in lowlands and low on the slopes and upland areas; permafrost comes closer to the surface in lowlands (less than 1/2 m) compared with 1—2 m in the uplands. For a comprehensive consideration of edaphic conditions in the Ogotoruk area, see HOLOWAYCHUK et al. (1966), WEICHOLD (1962), ALLEN and WEEDFALL (1966), JOHNSON and PACKER (1965).

The flora and vegetation of the Ogotoruk Creek area have been described in detail by JOHNSON et al. (1966). They recognise three major vegetation types which dominate the valley, accounting for about 85 percent of the total cover, and a number of smaller more restricted types that depend for their presence on local environmental conditions.

Eriophorum — Carex Wet Meadow

The wet meadow vegetation covers about 15 percent of the valley, occupying the lowest and wettest, non-aquatic sites. The dominant species of *Carex aquatilis* and *Eriophorum angustifolium*. Apart from a few other cyperaceous species only *Salix arbutifolia*, *Betula nana* and *Pedicularis pennellii* occur with any frequency. In ridged wet meadow, a subtype of wet meadow distinguished by JOHNSON et al. (l.c.), the ridges support a somewhat richer flora, including *Salix reticulata*, *Vaccinium gaultherioides*, *Vaccinium vitis-idaea* and herbaceous species such as *Eutrema edwardsii*, *Aconitum delphinifolium*, *Corydalis pauciflora*, and *Valeriana capitata*.

Eriophorum Tussocks

The most important species component of this vegetation type, which covers about 40 percent of the land surface in the Ogotoruk Creek area, is *Eriophorum vaginatum*. A few species, for example, *Ledum palustre* ssp. *decumbens*, *Betula nana*, *Salix pulchra*, and *Vaccinium vitis-idaea* are normally found growing on or around the tussocks, but this vegetation is not floristically rich. Tussock vegetation presents an aspect of monotonous uniformity in areas of low relief where the low-humic gley soils are wet and cold, but variation does exist, especially in connection with frost scars. The microenvironment of frost scars is such that frequently species occur that are entirely absent from the surrounding tussock vegetation, for example, *Luzula nivalis*, *Juncus biglumis*, *Deschampsia caespitosa*, and *Petasites frigidus*.

Dryas Fell-field, Dryas Steps and Stripes, Talus and Scree Slopes

Dryas fell-fields occur on the upland areas bordering both sides of the valley and on dry ridges and bedrock exposures in the valley itself. These areas are characterised by coarse soils which exhibit a profile typical of arctic brown soils. The soils are well drained, relatively warm and much more stable than the more frost affected soils of the valley bottom. About 30 percent of the valley is occupied by the *Dryas* fell-field type of vegetation. Apart from *Dryas octopetala* commonly occurring species include *Oxytropis nigrescens*, *Oxytropis pygmaea*, *Silene acaulis*, *Salix arctica*, *Saxifraga eschscholtzii*, and *Hierochloë alpina*. On certain well-drained slopes the typical *Dryas* fell-field pattern of vegetation becomes modified, by frost action and down slope movement, into alternating bands of vegetation and bare rock, which, depending on the angle of slope may run vertically (stripes) or horizontally (steps). This is one of the minor vegetation types recognised by JOHNSON et al. (l.c.). The stripes and steps are floristically richer than any other association in the valley, sometimes exceeding 60 species to the acre. The species found here include, *Phlox sibirica*, *Eritrichum chamissonis*, *Astragalus umbellatus*, *Oxytropis maydelliana*, *Pedicularis capitata*, *Diapensia lapponica* ssp. *obovata*, *Myosotis alpestre*, *Carex nardina*, and *Carex scirpoidea*. Where slopes on the valley sides are steep or precipitous the accumulation of fallen rock has led to the formation of talus and scree, sometimes of considerable dimensions.

Species occurring in these habitats, which may merge with *Dryas* fell-field in less precipitous areas, include *Leucanthemum integrifolium*, *Smelowskia calycina*, and *Draba caesia*.

Of the other minor vegetation types considered by JOHNSON et al. (l.c.) mention should be made here of the following.

Saline Marsh

An alluvial area at the mouth of Ogotoruk Creek, supporting species such as *Dupontia psilosantha*, *Puccinellia langeana*, *Puccinellia phryganodes*, *Stellaria humifusa*, and *Leucanthemum hultenii*.

The Coastal Strand

Here are found the widespread species typical of the habitat, including *Honckenya peploides*, *Mertensia maritima*, *Elymus mollis*, *Senecio pseudoarnica*, and *Lathyrus japonicus*.

Gravel Bars and Benches

On gravel bars and benches along Ogotoruk Creek a characteristic flora exists, including species such as *Arabis lyrata* ssp. *kamtschatica*, *Stellaria monantha*, *Festuca rubra*, *Festuca vivipara*, *Salix pulchra*, and *Epilobium latifolium*.

Snow-bed Communities

Snow-bed communities whose species composition varies with the local environmental conditions develop where winter snow is drifted into hollows and gullies. Taken collectively snow-bed communities include such as *Cassiope tetragona*, *Orthilia secunda*, *Cardamine bellidifolia*, *Ranunculus pygmaeus*, and *Saxifraga hyperborea*.

Aquatic Associations

Scattered throughout the Ogotoruk Creek Valley are shallow pools, in which are found *Hippuris vulgaris*, *Ranunculus pallasii*, *Comarum palustre*, *Ranunculus gmelinii* among other species.

METHODS

Chromosome number determinations were mostly made from root tips prepared according to the method of TJIO and LEVAN (1950). Root tips were collected in the field, pretreated with 8-hydroxyquinoline and processed the same day in a field laboratory. In some cases root tips were fixed in Karpechenko's fixative for later processing. These were eventually sectioned and stained with crystal violet using standard techniques. Determinations from PMCs alone (flower buds collected in the field and fixed in acetic-alcohol) account for a relatively small number of species but were employed in many cases to confirm somatic counts. Living material of a few species was collected for cultivation from the root tips of which counts were eventually obtained. Root tips from germinating seeds were also employed to obtain counts or confirm them in a few species. Voucher specimens for the chromosome number determinations presented in this paper are deposited in the University of Alberta herbarium, ALTA.

CHROMOSOME NUMBERS AND COMMENTS

The chromosome numbers determined for species in the Ogotoruk Creek area are listed in Table 1. A substantial number of these were included in an unpublished progress report, JOHNSON and PACKER (1963), not readily available though occasional reference to it appears in the literature. Taxonomically we have adopted a rather conservative approach, proper to a flora that is far from well known. This is reflected in our nomenclature which broadly follows HULTÉN (1941—1950). Where a recent revision has been published that resolves former taxonomic confusion we have generally accepted the taxonomic views of the author, for example LÖVE (1960), LÖVE and BOSCAIU (1966). In selecting species for discussion we have mainly chosen those in which the chromosome counts from Ogotoruk Creek in conjunction with those published for other localities illuminate some taxonomic or phytogeographic problem.

Deschampsia caespitosa (L.) BEAUV. s.l.

As reported by JOHNSON et al. (1966) material of *D. caespitosa* from the Ogotoruk Creek Valley is closer to var. *glauca* than any of the other intraspecific taxa recognized by HULTÉN (1942) as occurring in Alaska. Cytological examination of *D. caespitosa* at Ogotoruk Creek shows that two chromosome races are present, one with 2n=26 and the other with 2n=c. 52. According to KAWANO (1964), the populations with higher chromosome numbers are mostly northern, while the 2n=26 populations are more widespread. At Ogotoruk Creek, the population with 2n=26 occurs in stable habitats along the creek, while the tetraploid plants grow very commonly on active frost scars. Whether the 2n=c. 52 material can be equated with *D. alpina* is not clear. HEDBERG (1958) has suggested that *D. alpina* has arisen polytopically from the widespread *D. caespitosa* since the last glaciation and we regard this as a definite possibility.

Poa brachyanthera HULT.

The relationship of this diploid Alaskan endemic to the diploid (ZHUKOVA 1965 B) Asiatic-E. Siberian endemic *P. pseudoabbreviata* needs to be investigated. Material of *P. brachyanthera* examined revealed many points of similarity with the description of *P. pseudoabbreviata*. A comparison of material of the two species may show them to be identical. In our opinion it would be something of a coincidence if two diploid *Poa* species, rather similar in their morphology, were both limited in their distribution by the Bering Strait.

Puccinellia phryganodes (TRIN.) SCRIBN. & MERR. s.l.

Puccinellia phryganodes is a circumpolar species in which four races have been recognized, SORENSEN (1953). These are a "Beringian" race found in the Arctic of western N. America, a "Greenland" race, found in the Arctic of eastern N. America, a "Spitzbergen" race found in Spitzbergen and Novaya Zemlaya, and a "Scandinavian" race found in Scandinavia and Siberia. Apart from differences in morphology and geographical distribution, cytological investigations by various workers, cf. LÖVE and LÖVE (1961 A), have revealed that the latter two races are tetraploid while the Greenland race is a sterile triploid.

In a recent nomenclatural revision of this species LÖVE and LÖVE (1961 B) have recognized two species, *P. phryganodes* comprising the "Beringian" and "Greenland" races and *P. vilfoidea* made up to the "Spitzbergen" and "Scandinavian" races. In carrying out this revision LÖVE and LÖVE (l.c.) have assumed that the "Beringian" race, which is sterile, is like the "Greenland" race in being triploid. The authors speculate on the parentage of the "Beringian" and "Greenland" races and suggest, on the basis of morphological similarity that the "Spitzbergen" race is the tetraploid parent of the "Beringian" race and the "Scandinavian" tetraploid may be the tetraploid parent of the "Greenland" triploid.

Our investigations reveal that the "Beringian" race of *P. phryganodes* is a tetraploid with $2n=28$, and this is confirmed by ZHUKOVA (1966) in material from Wrangel Is. A somewhat different origin for the "Beringian" race of *P. phryganodes*, to that proposed by LÖVE and LÖVE (l.c.) would appear to be indicated. Examination of PMCs in the "Beringian" material revealed meiotic abnormalities that no doubt account for its sterility.

Arenaria chamissonis MAGUIRE

This species is rather poorly known and it was only recently, HULTÉN (1944), that its fruiting and floral characteristics became sufficiently well known to allow precise classification. HULTÉN (l.c.), who recognises *Minuartia* and *Arenaria* as separate genera, furnished with the knowledge that in this species the capsule teeth are twice as many as the styles, published a new

Table 1. *Chromosome numbers in the Ogotoruk Creek flora.*

Species	Ogotoruk counts (2n)	Previously published counts (2n)	Localities for previously published counts	References	Year
Selaginellaceae					
Selaginella sibirica (MILDE) HIERON.	20				
Gramineae					
Alopecurus alpinus J. E. SMITH	> 100	c. 100±	Cornwallis Is.	HEDBERG	1967
		105—130	....	LÖVE & LÖVE	1961a
Arctagrostis latifolia (R.BR.) GRIS.	56	56	....	LÖVE & LÖVE	1961a
			Southampton Is.	LÖVE & RITCHIE	1966
			Wrangel Is.	ZHUKOVA	1967
			Chukchi Mts. (R. Kuek'vun)		
			Chukchi (Peveek)		
		56±	Southampton Is.	HEDBERG	1967
		62	....	LÖVE & LÖVE	1961a
Arctophila fulva (TRIN.) RUPR.	42	42	....	LÖVE & LÖVE	1961a
			Southampton Is.	LÖVE & RITCHIE	1966
			Victoria Is.	HEDBERG	1967
			Anyuyskiy Mts. (Bilibino)	ZHUKOVA	1967
Bromus pumpellianus SCRIBN.		28	Chukchi Mts. (R. Kuek'vun)	ZHUKOVA	1967
	56	56	Alaska	MITCHELL	1967
			N. America	ELLIOT	1949
			Mackenzie District (Ft. Smith)	BOWDEN	1960
			Central Alaska	WILTON	1965
			Wrangel Is.	ZHUKOVA	1967
			Anyuyskiy Mts. (Bilibino)		
Calamagrostis canadensis (MICHX.) BEAUV.			Alaska	MITCHELL	1967
var. *langsdorfii* (LINK) INMAN	28	28	....	LÖVE & LÖVE	1961a
			Kamchatka	SOKOLOVSKAJA	1963
		42	Kamchatka	SOKOLOVSKAJA	1963
		56	....	LÖVE & LÖVE	1961a
			Kamchatka	SOKOLOVSKAJA	1963
			New Hampshire (Mt. Washington)	LÖVE & LÖVE	1965
Calamagrostis deschampsioides TRIN.	28	28	....	LÖVE & LÖVE	1961a
Calamagrostis lapponica (WAHL.) HARTM.			Chukchi (Apapel'khino)	ZHUKOVA	1967
		28—140	....	LÖVE & LÖVE	1961a
Calamagrostis stricta (TIMM.) KOEL.	112	c. 112	S. Norway	BERG	1965
ssp. *stricta*		28	....	LÖVE & LÖVE	1961a
ssp. *borealis* (LAEST.) LÖVE & LÖVE	42	28	Quebec	HEDBERG	1967
	28	28	....	LÖVE & LÖVE	1961a
Calamagrostis purpurascens R.BR.	28	28	N. America	BOWDEN	1960
		42	Anyuyskiy Mts. (Bilibino)	ZHUKOVA	1967
			N. America	BOWDEN	1960
			Alberta (Jasper Nt. Pk.)	TAYLOR & BROCKMAN	1966
		40—57	N. America (various localities)	NYGREN	1954
		84	Alaska	BOWDEN	1960
Deschampsia caespitosa (L.) BEAUV. s.l.	26	26	....	LÖVE & LÖVE	1961a
			Finland	SORSA	1962
			North temperate zone (various localities)	KAWANO	1964
			West Chukchi (Apapel'khino)	ZHUKOVA	1967
			Anyuyskiy Mts. (Bilibino)		
			Kolymskoe Mts. (Karamken)		
			Alberta (Jasper Nt. Pk.)	TAYLOR & BROCKMAN	1966
		26+IF	North temperature zone (various localities)	KAWANO	1964
		27	....	LÖVE & LÖVE	1961a
		28	....	LÖVE & LÖVE	1961a
			Chukchi (Providence Bay)	ZHUKOVA	1965
			Norway (East Finnmark)	LAANE	1966
	c. 52	52	....	LÖVE & LÖVE	1961a
			Chukchi Mts.	ZHUKOVA	1967
			Wrangel Is.		
			Quebec (Ft. Chimo)	HEDBERG	1967
Dupontia psilosantha RUPR.		56	....	LÖVE & LÖVE	1961a
		42	Wrangel Is.	ZHUKOVA	1966
			W. Chukchi (Apapel'khino)		
	44	44	....	LÖVE & LÖVE	1961a
Elymus mollis TRIN.	28	28	Southampton Is.	LÖVE & RITCHIE	1966
			....	LÖVE & LÖVE	1961a
			Kamchatka	SOKOLOVSKAJA	1963
			Manitoba (Churchill)	LÖVE & RITCHIE	1966
			Quebec (Gt. Whale River)	HEDBERG	1967
			Baffin Is.		
			Alaska (Anchorage)		
Festuca altaica TRIN.	28	28	Altai	SOKOLOVSKAJA & STRELKOVA	1948

Species	Ogotoruk counts (2n)	Previously published counts (2n)	Localities for previously published counts	References	Year
Festuca altaica TRIN. (cont.)	28	28	Alaska	BOWDEN	1960
			Mackenzie Mts.		
			Alaska (Arctic Slope)	HOLMEN	1964
			Wrangel Is.	ZHUKOVA	1965
			Chukchi (Val'kumey)	ZHUKOVA	1967
Festuca baffinensis POL.	28	28	....	LÖVE & LÖVE	1961a
			Alaska (Arctic Slope)	HOLMEN	1964
			Wrangel Is.	ZHUKOVA	1965b
			Ellesmere Is.	MOSQUIN & HAYLEY	1966
			Victoria Is.	HEDBERG	1967
Festuca brachyphylla SCHULTES		28	Melville Is.	MOSQUIN & HAYLEY	1966
	42	42	....	LÖVE & LÖVE	1961a
			Alaska (Arctic Slope)	HOLMEN	1964
			Chukchi (Providence Bay)	ZHUKOVA	1965a
			Wrangel Is.	ZHUKOVA	1965b
			Baffin Is.	HEDBERG	1967
		c. 42	Melville Is.	MOSQUIN & HAYLEY	1966
Festuca ovina L. ssp. *alaskanum* HOLMEN	14	14	Alaska (Arctic Slope)	HOLMEN	1964
Festuca rubra L. s.l. (incl. *F. cryophila*)		14, 28, 42	....	LÖVE & LÖVE	1961a
	42	42	Alaska (Arctic Slope)	HOLMEN	1964
			Alaska (Kenai)	HEDBERG	1967
			Norway (Troms, Norland)	KNABEN & ENGELSKJÖN	1967
			Chukchi Mts. (R. Kuek'vun)	ZHUKOVA	1967
		45—70	....	LÖVE & LÖVE	1961a
		56	Wrangel Is.	ZHUKOVA	1965b
Festuca vivipara (L.) SM.		21	Norway (Dovre Mts.)	KNABEN & ENGELSKJÖN	1967
	56	28	....	LÖVE & LÖVE	1961a
		63	Alaska (Arctic Slope)	HOLMEN	1964
Hierochloë alpina (SW.) ROEM. & SCHULTES	56	56	....	LÖVE & LÖVE	1961a
			Kamchatka	SOKOLOVSKAJA	1963
			Southampton Is.	LÖVE & RITCHIE	1966
			Wrangel Is.	ZHUKOVA	1967
			Baffin Is.	HEDBERG	1967
			Norway (Troms)	KNABEN & ENGELSKJÖN	1967
Hierochloë pauciflora R.BR.	28	28	Wrangel Is.	ZHUKOVA	1967
Koeleria asiatica DOMIN	28	28	Wrangel Is.	ZHUKOVA	1967
			Chaunskaya Guba		
Phippsia algida (SOL.) R.BR.	28	28	....	LÖVE & LÖVE	1961a
			Wrangel Is.	ZHUKOVA	1966
			Melville Is.	MOSQUIN & HAYLEY	1966
			Baffin Is.	HEDBERG	1967
			Cornwallis Is.		
			Ellef Ringnes Is.		
			Norway (Norland)	KNABEN & ENGELSKJÖN	1967
Poa alpina L.		14—74	....	LÖVE & LÖVE	1961a
	35	c. 30—34	Southampton Is.	HEDBERG	1967
		42	Manitoba (Churchill)	LÖVE & RITCHIE	1966
			Alberta (Jasper Nt. Pk.)	TAYLOR & BROCKMAN	1966
Poa brachyanthera HULT.	14				
Poa leptocoma TRIN.	42	42	Kamchatka	SOKOLOVSKAJA	1963
Puccinellia langeana (BERL.) TH. SØR.	14	14	Greenland	JØRGENSEN et al.	1958
Puccinellia phryganodes (TRIN.) SCRIBN. & MERR. s.l.		21	....	LÖVE & LÖVE	1961a
	28	28	....	LÖVE & LÖVE	1961a
			Melville Is.	MOSQUIN & HAYLEY	1966
			Wrangel Is.	ZHUKOVA	1967
Puccinellia vaginata (LGE.) FERN. & WEATH.	42	56	West Chukchi (Apapel'khino)	ZHUKOVA	1967
			Southampton Is.	HEDBERG	1967
Roegneria borealis (TURCZ.) NEVSKI	28	28	....	LÖVE & LÖVE	1961a
			Anyuyskiy Mts. (Bilibino)	ZHUKOVA	1967
			Chukchi Mts. (R. Kuek'vun)		
Trisetum sibiricum RUPR.	14	14	Kamchatka	SOKOLOVSKAJA	1963
			Primorye Territory	SOKOLOVSKAJA	1966
			Chukchi Mts. (Apapel'khino)	ZHUKOVA	1967
			Japan	TATEOKA	1967
Trisetum spicatum (L.) RICHT.	28	28	....	LÖVE & LÖVE	1961a
			Chukchi (Providence Bay)	ZHUKOVA	1965a
			Wrangel Is.	ZHUKOVA	1965b
			Ellesmere Is.	MOSQUIN & HAYLEY	1966
			Melville Is.		
			Chukchi Mts. (R. Kuek'vun)	ZHUKOVA	1967
			Kolymskoe Mts. (Karamken)		
			Baffin Is.	HEDBERG	1967
			Southampton Is.		
			Central Norway	KNABEN & ENGELSKJÖN	1967
			Japan	TATEOKA	1967

Species	Ogotoruk counts (2n)	Previously published counts (2n)	Localities for previously published counts	References	Year
Cyperaceae					
Carex aquatilis Wg. ssp. *stans* (Drej.) Hult.	c. 80	76	....	Löve & Löve	1961
				Löve & Ritchie	1966
Carex atrofusca Schkuhr.	38	36	....	Löve & Löve	1961
		38	....	Löve & Löve	1961
			Manitoba (Churchill)	Löve & Ritchie	1966
			Norway (Dovre Mts.)	Knaben & Engelskjön	1967
		42±	Baffin Is. (Frobisher Bay)	Hedberg	1967
Carex bigelowii Torr. s.l.	70—76	68	....	Löve & Löve	1961
		70	New Hampshire (Mt. Washington)	Löve & Löve	1966
Carex capillaris L.	c. 54	54	....	Löve & Löve	1961
Carex glareosa Wahl.	66	66	....	Löve & Löve	1961
Carex maritima Gunn.	60	60	....	Löve & Löve	1961
			Manitoba (Churchill)	Löve & Ritchie	1966
			Norway (Dovre Mts.)	Knaben & Engelskjön	1967
Carex membranacea Hook.	76—80				
Carex misandra R.Br.	40	40	....	Löve & Löve	1961
			Norway (Dovre Mts.)	Knaben & Engelskjön	1967
			Victoria Is.	Hedberg	1967
			Cornwallis		
		40±	Southampton Is.		
Carex nardina Fries	68	68	....	Löve & Löve	1961
		68±	Baffin Is.	Hedberg	1967
		70	....	Löve & Löve	1961
Carex physocarpa Presl	c. 80	60	Manitoba (Churchill)	Löve & Ritchie	1966
Carex podocarpa R.Br.	c. 32				
Carex rupestris All.	c. 52	50	....	Löve & Löve	1961a
		c. 50	....	Löve & Löve	1961a
		52	....	Löve & Löve	1961a
			Norway (Dovre Mts., Valdres)	Knaben & Engelskjön	1967
Carex scirpoidea Michx.	c. 62	62	....	Löve & Löve	1961a
			New Hampshire (Mt. Washington)	Löve & Löve	1966
			Manitoba (Churchill)	Löve & Ritchie	1966
		64	British Columbia (Penticton)	Moore & Calder	1964
Carex subspathacea Wormskj.	c. 78	78	....	Löve & Löve	1961a
		80	....	Löve & Löve	1961a
Eriophorum angustifolium Honck.	58	58	....	Löve & Löve	1961a
			Manitoba (Churchill)	Löve & Ritchie	1966
		c. 58	Finland	Sorsa	1963
Eriophorum russeolum Fries	62	58	....	Löve & Löve	1961a
Eriophorum scheuchzeri Hoppe	58	58	....	Löve & Löve	1961a
			Manitoba (Churchill)	Löve & Ritchie	1966
Eriophorum vaginatum L.	58	58	....	Löve & Löve	1961a
			New Hampshire (Mt. Washington)	Löve & Löve	1965
		c. 58	Finland	Sorsa	1963
		60±	Southampton Is.	Hedberg	1967
Kobresia hyperborea Pors.	54±				
Kobresia myosuroides (Vill.) Fiori & Paol.	58	52—66	....	Löve & Löve	1961a
Kobresia simplisiuscula (Wahl.) Mack.	72—76	70—75	....	Löve & Löve	1961a
		76	Norway (Dovre Mts.)	Knaben & Engelskjön	1967
Juncaceae					
Juncus biglumis L.	> 100	60	Norway (Troms)	Knaben & Engelskjön	1967
		> 100	Wrangel Is.	Zhukova	1967
		120	....	Löve & Löve	1961a
		130±	Melville Is.	Mosquin & Hayley	1966
Luzula confusa Lind. s.l.	36	36	....	Löve & Löve	1961a
			Alberta (Rocky Mts.)	Packer	1964
			Melville Is.	Mosquin & Hayley	1966
			Wrangel Is.	Zhukova	1967
			Central Norway	Knaben & Engelskjön	1967
		42	....	Löve & Löve	1961a
		48			
Luzula nivalis (Laest.) Beurl.	24	24	Melville Is.	Mosquin & Hayley	1966
Luzula wahlenbergii Rupr.	24	24	....	Löve & Löve	1961a
			Chukchi (Cape Schmidt)	Zhukova	1967
			Baffin Is.	Hedberg	1967
			Southampton Is.		
			Northern Norway	Knaben & Engelskjön	1967
			Alaska (White Mts.)		

Species	Ogotoruk counts (2n)	Previously published counts (2n)	Localities for previously published counts	References	Year
Liliaceae					
Allium schoenoprasum L. var. *sibiricum* (L.) HARTM.	16	16	....	LÖVE & LÖVE	1961a
			Kamchatka	SOKOLOVSKAJA	1963
			Yukon (Richardson Mts.)	PACKER	1964
			Chukchi (Egvekinot)	ZHUKOVA	1966
			British Columbia (Fauqier)	TAYLOR & BROCKMAN	1966
Lloydia serotina (L.) RCHB.		24	....	LÖVE & LÖVE	1961a
			Colorado	WIENS & HALLECK	1962
			Chukchi (Egvekinot)	ZHUKOVA	1966
Tofieldia coccinea RICH.	48 30	30	Kamchatka	SOKOLOVSKAJA	1963
		32	U.S.S.R. (Tiksi Bay)	SOKOLOVSKAJA & STRELKOVA	1960
			Anyuyskyi Mts. (Bilibino)	ZHUKOVA	1967
Tofieldia pusilla (MICHX.) PERS.		c. 28	Finland	SORSA	1963
	30	30	....	LÖVE & LÖVE	1961a
			Southampton Is.	LÖVE & RITCHIE	1966
			Southampton Is.	HEDBERG	1967
			Chukchi Mts.	ZHUKOVA	1967
Zygadenus elegans PURSH.	32	32	N. America	MILLER	1930
			Yukon (Richardson Mts.)	PACKER	1964
Salicaceae					
Salix alaxensis (ANDERSS.) COVILLE	38	38	Chukchi Mts. (R. Kuek'vun)	ZHUKOVA	1967
Salix arbutifolia PALL.	38				
Salix arctica PALL.	76	76	....	LÖVE & LÖVE	1961a
		c. 76	Melville Is.	MOSQUIN & HAYLEY	1966
		c. 120	....	LÖVE & LÖVE	1961a
Salix brachycarpa NUTT. ssp. *niphoclada* (RYD.) ARGUS		40	Manitoba (Churchill)	ARGUS	1965
Salix glauca L. s.l.	c. 38 c. 76	79, 81, 95 102, 115	Manitoba (Churchill)	ARGUS	1965
		152, 176	....	LÖVE & LÖVE	1961a
Salix phlebophylla ANDERS.		38	Wrangel Is.	ZHUKOVA	1967
			Chukchi (Peveek)		
Salix pulchra CHAM.	c. 76 76	76	Chukchi (Peveek)	ZHUKOVA	1967
Salix ovalifolia TRAUTV.	38		....	LÖVE & LÖVE	1961a
Salix rotundifolia TRAUTV.	38	38	Chukchi	ZHUKOVA	1967
Betulaceae					
Betula nana L. ssp. *exilis* SUKATCH.	28 42				
Polygonaceae					
Koenigia islandica L.	28	28	....	LÖVE & LÖVE	1961a
			Chukchi (Providence Bay)	ZHUKOVA	1965
			Wrangel Is.	ZHUKOVA	1967
			Norway (Troms)	KNABEN & ENGELSKJÖN	1967
Oxyria digyna (L.) HILL	14	14	....	LÖVE & LÖVE	1961a
			Finland	SORSA	1963
			Alberta (Rocky Mts.)	PACKER	1964
			Melville Is.	ZHUKOVA	1965
			Chukchi (Lorino)	MOSQUIN & HAYLEY	1966
			Alberta (Rocky Mts.)	TAYLOR & BROCKMAN	1966
		24	Caucasus	SOKOLOVSKAJA & STRELKOVA	1948
Polygonum bistorta L. ssp. *plumosum* (SMALL) HULT. (incl. ssp. *ellipticum*)		50	Wrangel Is.	ZHUKOVA	1967
Polygonum viviparum L.	c. 72 > 100	(83–88)–132	....	LÖVE & LÖVE	1961a
		100 ±	Melville Is.	MOSQUIN & HAYLEY	1966
		100	Wrangel Is.	ZHUKOVA	1967
		120	Alberta, Banff	LÖVE & LÖVE	1964
			Manitoba (Churchill)	LÖVE & RITCHIE	1966
			New Hampshire (Mt. Washington)	LÖVE & LÖVE	1966
Rumex acetosa L. ssp. *alpestris* (SCOP.) LÖVE	14, 15	14, 15	....	LÖVE & LÖVE	1961
				LÖVE & LÖVE	1961a
Rumex arcticus TRAUTV.	c. 170	c. 200 > 150	Chukchi (Providence Bay)	ZHUKOVA	1965
Portulacaceae					
Claytonia acutifolia PALL. s.l.		30—32	Kamchatka	SOKOLOVSKAJA	1963
			Chukchi (Cape Schmidt)	ZHUKOVA	1966
ssp. *graminifolia* HULT. (= *C. eschscholtzii*)		16	Kolymskoe Mts. (Karamken)	ZHUKOVA	1966
Claytonia tuberosa PALL. ex WILLD.	32 16	18	....	LÖVE & LÖVE	1961a
Montia lamprosperma CHAM.	20	20	West Chukchi (Apapel'khino)	ZHUKOVA	1966

Bot. Notiser, vol. 121, 1968

Species	Ogotoruk counts (2n)	Previously published counts (2n)	Localities for previously published counts	References	Year
Caryophyllaceae					
Arenaria chamissonis MAGUIRE	26				
Cerastium beeringianum CHAM. & SCHLECHT.	72	72	Yukon (Dawson)	SÖLLNER	1954
Dianthus repens WILLD.	30				
		60	West Chukchi (Shelagskiy)	ZHUKOVA	1966
Honckenya peploides (L.) EHRH. s.l.	68	68	…	LÖVE & LÖVE	1961a
			Poland (Gastarnia, Gdansk)	SKALINSKA	1964
			Chukchi (Lorino)	ZHUKOVA	1965
			Wrangel Is.	ZHUKOVA	1966
Melandrium affine (J. VAHL) HARTM.		24	U.S.S.R. (Tiksi Bay)	SOKOLOVSKAJA	1960
	48	48	…	LÖVE & LÖVE	1961a
			Chukchi (Lorino)	ZHUKOVA	1965
			Chukchi Mts. (R. Alyarmagtyn)	ZHUKOVA	1967
Melandrium apetalum (L.) FENZL	24	24	…	LÖVE & LÖVE	1961a
			Wrangel Is.	ZHUKOVA	1966
			Southampton Is.	HEDBERG	1967
			Norway (Dovre Mt., Troms)	KNABEN & ENGELSKJÖN	1967
Merckia physodes (DC.) FISCH.		66	Chukchi Mts. (R. Alyarmagtyn)	ZHUKOVA	1967
		72	Chukchi Mts. (R. Kuek'vun)	ZHUKOVA	1966
	100—110				
Minuartia arctica (STEV.) ASCHER.	c. 52				
Minuartia macrocarpa (PURSH) OSTENF.		44	Wrangel Is.	ZHUKOVA	1966
	46	46	Chukchi Mts. (R. Alyarmagtyn)	ZHUKOVA	1967
			Anyuyskiy Mts. (Bilibino)		
Minuartia rossii (R.BR.) GRAEBN. s.l.		30	Yukon (Richardson Mts.)	PACKER	1964
			Alberta (Rocky Mts.)	PACKER	1968
		58	Wrangel Is.	ZHUKOVA	1966
	60				
Minuartia rubella (WG.) HIERN	24	24	…	LÖVE & LÖVE	1961a
			Canada	FAVARGER	1962
			Baffin Is.	HEDBERG	1967
		26	…	LÖVE & LÖVE	1961
			Wrangel Is.	ZHUKOVA	1966
Silene acaulis L. s.l.	24	24	…	LÖVE & LÖVE	1961a
			Colorado (Rocky Mts.)	WIENS & HALLECK	1962
			Finland	SORSA	1963
			Alberta (Rocky Mts.)	PACKER	1964
			Northern Norway	LAANE	1965
			Chukchi (Cape Chaplino)	ZHUKOVA	1965
			Ellesmere Is.	MOSQUIN & HAYLEY	1966
			Poland (Tatra)	SKALINSKA & POGAN	1966
			New Hampshire (Mt. Washington)	LÖVE & LÖVE	1966
			Quebec	HEDBERG	1967
Stellaria humifusa ROTTB.	26	26	…	LÖVE & LÖVE	1961a
			West Chukchi (Apapel'khino)	ZHUKOVA	1966
			Southampton Is.	HEDBERG	1967
		c. 24	Melville Is.	MOSQUIN & HAYLEY	1966
Stellaria monantha HULT.		52	Ellesmere Is.	MOSQUIN & HAYLEY	1966
		76	Melville Is.	MOSQUIN & HAYLEY	1966
	104	104	N.W. Greenland	BÖCHER & LARSEN	1950
			N.W. Greenland	JØRGENSEN et al.	1958
Stellaria longipes GOLDIE		52	…	LÖVE & LÖVE	1961a
	c. 104	104			
		105±	Alaska (Umiat)	HEDBERG	1967
		106±	Quebec (Ft. Chimo)		
Sagina intermedia FENZL	56				
		84, 88	…	LÖVE & LÖVE	1961
Ranunculaceae					
Aconitum delphinifolium DC.		32	Kamchatka	SOKOLOVSKAJA	1963
			Chukchi Mts. (R. Kuek'vun)	ZHUKOVA	1966
spp. *paradoxum* (RCHB.) HULT.	16				
Anemone multiceps (GREENE) STANDLEY	16				
Anemone narcissiflora L. s.l.	14	14	…	LÖVE & LÖVE	1961a
		16	…	LÖVE & LÖVE	1961a
			U.S.S.R. (Tiksi Bay)	SOKOLOVSKAJA	1958
			U.S.S.R. (Tiksi Bay)	SOKOLOVSKAJA & STRELKOVA	1960
			West Chukchi (Peveek)	ZHUKOVA	1966
Anemone parviflora MICHX.		14	Alaska (Arctic slope)	BORMANN & BEATTY	1955
	16	16	Manitoba (Churchill)	HEIMBURGER	1959
			Alberta (Clearwater)		
			Alberta (Rocky Mts.)	PACKER	1964
			Chukchi (Senyavin)	ZHUKOVA	1965
			British Columbia (Yo Ho Nt. Pk.)	TAYLOR & BROCKMAN	1966

Bot. Notiser, vol. 121, 1968

Species	Ogotoruk counts (2n)	Previously published counts (2n)	Localities for previously published counts	References	Year
Anemone richardsonii Hook.	14	14	Alaska (Arctic slope)	Bormann & Beatty	1955
			Alaska (Anchorage)	Heimburger	1959
			Chukchi Mts. (R. Kuek'vun)	Zhukova	1966
Caltha palustris L. s.l.		28	Finland	Sorsa	1962
	32	32	....	Löve & Löve	1961a
			Sakhalin	Sokolovskaja	1960
			Alberta	Packer	1964
			Europe (many localities)	Smit	1967
		48—80	....	Löve & Löve	1961a
	56—70	56	Kamchatka	Sokolovskaja	1963
			Gt. Britain	Kootin-Sanwu	1964
			Norway (Tromsö, Dovre Mts.)	Knaben & Engelskjön	1967
			Europe (many localities)	Smit	1967
		60±	Victoria Is.	Hedberg	1967
		60	Melville Is.	Mosquin & Hayley	1966
		c. 70	Kamchatka	Sokolovskaja	1963
Delphinium brachycentrum Ledeb.	16	16	Kamchatka	Langlet	1932
			Kamchatka	Sokolovskaja	1963
Oxygraphis glacialis (Fisch.) Bunge	16	16	Altai	Sokolovskaja & Strelkova	1948
			U.S.S.R. (Tiksi Bay)	Sokolovskaja	1958
			Wrangel Is.	Zhukova	1966
Ranunculus affine R.Br. s.l.	32	32	....	Löve & Löve	1961a
			Wrangel Is.	Zhukova	1966
			Chukchi Mts. (Umkrynnet)		
		48	....	Löve & Löve	1961a
			Southampton Is.	Hedberg	1967
Ranunculus gmelinii DC.		16	Kamchatka	Sokolovskaja	1963
			Quebec (Ft. Chimo)	Hedberg	1967
			Manitoba (Macbride Lake)	Löve & Ritchie	1966
	32	32	....	Löve & Löve	1961a
			Wrangel Is.	Zhukova	1966
Ranunculus hyperboreus Rottb.	32	32	....	Löve & Löve	1961a
			Kamchatka	Sokolovskaja	1963
			Melville Is.	Mosquin & Hayley	1966
			Chukchi (Cape Schmidt, Apapel'khino)	Zhukova	1966
			Norway (Dovre Mts.)	Knaben & Engelskjön	1967
			Alaska (White Mts.)		
			Cornwallis Is.	Hedberg	1967
Ranunculus lapponicus L.	16	16	....	Löve & Löve	1961a
			Manitoba (Macbride Lake)	Löve & Ritchie	1966
			Anyuyskiy Mts. (Bilibino)	Zhukova	1967
Ranunculus pallasii Schlecht.	32	32	....	Löve & Löve	1961a
			Anyuyskiy Mts. (Bilibino)	Zhukova	1967
Ranunculus pygmaeus Wg.	16	16	....	Löve & Löve	1961a
			Richardson Mts.	Packer	1964
			Wrangel Is.	Zhukova	1965b
			Southampton Is.	Hedberg	1967
			Norway (Dovre Mts.)	Knaben & Engelskjön	1967
Thalictrum alpinum L.	14	14	....	Löve & Löve	1961a
			Finland	Sorsa	1963
			Kamchatka	Sokolovskaja	1963
			Ogotoruk Creek	Johnson & Packer in Mooney & Johnson	1965
			Wrangel Is.	Zhukova	1966
			Norway (Troms, Dovre Mts.)	Knaben & Engelskjön	1967
	21	21	Ogotoruk Creek	Johnson & Packer in Mooney & Johnson	1965
Papaveraceae					
Papaver macounii Greene	28				
Papaver hultenii Knab.	42	42	Alaska (Coppermine River)	Knaben	1959
Fumariaceae					
Corydalis pauciflora (Steph.) Pers. (incl. *C. arctica*)	16	16	U.S.S.R. (Tiksi Bay)	Sokolovskaja & Strelkova	1960
			Chukchi Mts. (R. Kuvet)	Zhukova	1966
Cruciferae					
Arabis lyrata L.		16	....	Löve & Löve	1961a
			Saskatchewan (Prince Albert)	Mulligan	1966
		32	British Columbia (Bella Coola, Vancouver Is.)		
			Yukon (Otter Lake)		
ssp. *kamtschatica* (Fisch.) Hult.	16	16	Alaska (Arctic slope, Kurupa R.)	Rollins	1966
		32	Alaska (Kuskokwim Mts.)		

Species	Ogotoruk counts (2n)	Previously published counts (2n)	Localities for previously published counts	References	Year
Braya purpurascens (R.Br.) Bunge	56	56	. . . .	Löve & Löve	1961a
			Ellesmere Is.	Mulligan	1966
			Alaska (Donnelly)		
			British Columbia (Summit Lake)		
			Wrangel Is.	Zhukova	1966
			Spitzbergen, E. & W. Greenland	Böcher	1966
Cardamine bellidifolia L.	16	16	. . . .	Löve & Löve	1961a
			Alberta (Rocky Mts.)	Packer	1964
			Chukchi (Arakamchechen Is.)	Zhukova	1965
			Wrangel Is.	Zhukova	1966
			Ellesmere Is.	Mulligan	1966
			Vancouver Is.		
			New Hampshire (Mt. Washington)	Löve & Löve	1966
Cardamine digitata Rich.	28				
		32	Alaska (Umiat)	Rollins	1966
Cardamine purpurea Cham. & Schlecht.	c. 80				
Cochlearia groenlandica L. s.l.	14	14	. . . .	Löve & Löve	1961a
			Chukchi (Providence Bay)	Zhukova	1965
			Manitoba (Churchill)	Löve & Ritchie	1966
			Melville Is.	Mosquin & Hayley	1966
			Prince Patrick Is.		
			Prince Charles Is.	Rollins	1966
			Cornwallis Is.	Hedberg	1967
Draba hirta L.		64	. . . .	Löve & Löve	1961a
			Wrangel Is.	Zhukova	1967
	c. 80	80	. . . .	Löve & Löve	1961a
			Norway (Dovre Mts.)	Knaben & Engelskjön	1967
Draba nivalis Liljebl.	16	16	. . . .	Löve & Löve	1961a
			Wrangel Is.	Zhukova	1965
			Norway (Jotunheimen Mts.)	Knaben & Engelskjön	1967
Eutrema edwardsii R.Br.		18	Alaska (North slope Brooks Range)	Rollins	1966
	28	28	. . . .	Löve & Löve	1961a
			Ellesmere Is.	Mulligan	1966
			Wrangel Is.	Zhukova	
			Southampton Is.	Hedberg	1967
		42	. . . .	Löve & Löve	1961a
			Baffin Is.	Packer	1964
			Yukon (Richardson Mts.)		
			Axel Heiberg Is.	Mulligan	1966
Parrya nudicaulis (L.) Regel		14	Cornwallis Is.	Hedberg	1967
	28	28	Chukchi (Cape Chaplino)	Zhukova	1965
Smelowskia calycina (Steph.) C.A. Meyer		12	Colorado	Drury & Rollins	1952
			Wyoming		
			Utah		
		22	Alberta (Mountain Pk.)	Packer	1968
var. *integrifolia* (Seem.) Rollins	22				
Parnassiaceae					
Parnassia kotzebuei Cham. & Schlecht.	18	18	Yukon (Richardson Mts.)	Packer	1964
			Chukchi Mts. (R. Kuek'vun)	Zhukova	1966
			Quebec (Ft. Chimo)	Hedberg	1967
		36	Manitoba (Churchill)	Löve & Ritchie	1966
Parnassia palustris L. s.l.	18	18	. . . .	Löve & Löve	1961a
			Finland	Sorsa	1963
			Kamchatka	Sokolovskaja	1963
			Kolymskoe Mts. (Chukchi)	Zhukova	1966
			Sweden (Jämtland)	Hedberg	1964
			Manitoba (Churchill)	Löve & Ritchie	1966
			Holland	Kliphuis et al.	1965
			Norway (Kongsberg)	Knaben & Engelskjön	1967
			Quebec (Ft. Chimo, Gt. Whale River)	Hedberg	1967
		36	. . . .	Löve & Löve	1961a
			Holland	Kliphuis et al.	1965
			Norway (E. Finnmark)	Laane	1967
			Norway (Troms, Norland)	Knaben & Engelskjön	1967
Saxifragaceae					
Boykinia richardsonii Hook.	84				
Chrysosplenium tetrandrum (Lund) Fries	24	24	. . . .	Löve & Löve	1961a
			Western & Arctic N. America (several localities)	Packer	1963
			Wrangel Is.	Zhukova	1965b
			Southampton Is.	Hedberg	1967

Bot. Notiser, vol. 121, 1968

Species	Ogotoruk counts (2n)	Previously published counts (2n)	Localities for previously published counts	References	Year
Chrysosplenium wrightii FRANCH. & SAV.	24	24	Ogotoruk Creek	JOHNSON & PACKER in PACKER	1963
			Wrangel Is.	ZHUKOVA	1965
Saxifraga bronchialis L. ssp. *funstonii* (SMALL) HULT.	100±	c. 104	Yukon (Richardson Mts.)	PACKER	1964
Saxifraga caespitosa L. s.l.		80	....	LÖVE & LÖVE	1961a
	c. 80	c. 80	Melville Is.	MOSQUIN & HAYLEY	1966
Saxifraga cernua L.		36—70	....	LÖVE & LÖVE	1961a
	c. 50	c. 54	Norway (Dovre Mts.)	KNABEN & ENGELSKJÖN	1967
		c. 70	Cornwallis Is.	HEDBERG	1967
		72	Melville Is.	MOSQUIN & HAYLEY	1966
Saxifraga davurica WILLD. ssp. *grandipetala* (ENGL. & IRMSCHER) HULT.	52				
Saxifraga eschscholtzii STERNB.	12	12	Ogotoruk Creek	JOHNSON & PACKER	1967
			Chukchi (Cape Schmidt)	ZHUKOVA	1967
			Anyuyskiy (Bilibino)		
Saxifraga flagellaris WILLD. (=ssp. *flagellaris* sensu PORSILD)	16	16	Yukon (Richardson Mts.)	PACKER	1964
		18 (?16)	Caucasus	SOKOLOVSKAJA & STRELKOVA	1948
Saxifraga foliolosa R.BR.	56	56	....	LÖVE & LÖVE	1961a
			Melville Is.	MOSQUIN & HAYLEY	1966
			Wrangel Is.	ZHUKOVA	1967
			Norway (Nordland)	KNABEN & ENGELSKJÖN	1967
Saxifraga hieracifolia WALDST. & KIT.	> 100	> 100	Wrangel Is.	ZHUKOVA	1965
		> 110, 112	....	LÖVE & LÖVE	1961
		c. 112			
		112	Southern Norway	KNABEN & ENGELSKJÖN	1967
		110—120	Northern Norway		
		> 120	Yukon (Richardson Mts.)	PACKER	1964
Saxifraga hirculus L. s.l.	16	16	....	LÖVE & LÖVE	1961a
			Melville Is.	MOSQUIN & HAYLEY	1966
			Victoria Is.	HEDBERG	1967
			Southampton Is.		
			Cornwallis Is.		
			Alaska (Barter Is., Lake Peters, Barrow)		
		24	Cornwallis Is.		
		32	....	LÖVE & LÖVE	1961a
			Yukon (Richardson Mts.)	PACKER	1964
			Wrangel Is.	ZHUKOVA	1967
Saxifraga hyperborea R.BR.	26	26	....	LÖVE & LÖVE	1961a
			Alberta (Rocky Mts.)	PACKER	1964
			New Hampshire (Mt. Washington)	LÖVE & LÖVE	1966
Saxifraga nelsoniana D. DON (sensu auct. ross.)		28	Yukon (Richardson Mts.)	PACKER	1964
		c. 60	Kamchatka	SOKOLOVSKAJA	1963
		c. 70	U.S.S.R. (Tiksi Bay)	SOKOLOVSKAJA	1958
				SOKOLOVSKAJA & STRELKOVA	1960
	c. 84				
Saxifraga nivalis L.		c. 56	Cornwallis Is.	HEDBERG	1967
		60	....	LÖVE & LÖVE	1961a
			Kamchatka	SOKOLOVSKAJA	1963
			Norway (Nordland, Finnmark)	KNABEN & ENGELSKJÖN	1967
	c. 60	c. 60	Melville Is.	MOSQUIN & HAYLEY	1966
Saxifraga oppositifolia L.		26	....	LÖVE & LÖVE	1961a
			Alberta Rocky Mts.	PACKER	1964
			Melville Is.	MOSQUIN & HAYLEY	1966
			Norway (Dovre Mts., Valdres)	KNABEN & ENGELSKJÖN	1967
		39	N.E. Greenland	JØRGENSEN et al.	1958a
	52	52	....	LÖVE & LÖVE	1961a
		c. 52	Wrangel Is.	ZHUKOVA	1967
			Southampton Is.	HEDBERG	1967
Saxifraga radiata SMALL	52				
Saxifraga reflexa HOOK.	20	20	Yukon (Richardson Mts.)	PACKER	1964
Saxifraga tricuspidata ROTTB.	26	26	N.W. Greenland	BÖCHER & LARSEN	1950
				HARMSEN in JØRGENSEN et al.	1958
			Alberta (Rocky Mts.)	PACKER	1964
			Melville Is.	MOSQUIN & HAYLEY	1966
			Southampton Is.	HEDBERG	1967
Rosaceae					
Comarum palustre L.		28	....	LÖVE & LÖVE	1961a
	42	42	....	LÖVE & LÖVE	1961a
			Kamchatka	SOKOLOVSKAJA	1963
			Manitoba (Churchill)	LÖVE & RITCHIE	1966
			Chukchi (Bilibino)	ZHUKOVA	1967
			Norway (Troms, Oslo, Dovre Mts.)	KNABEN & ENGELSKJÖN	1967
		c. 64	....	LÖVE & LÖVE	1961a

Bot. Notiser, vol. 121, 1968

Species	Ogotoruk counts (2n)	Previously published counts (2n)	Localities for previously published counts	References	Year
Dryas octopetala L. s.l.	18	18	....	Löve & Löve	1961a
			Alberta (Rocky Mts.)	Packer	1964
			Greenland	Elkington	1965
			Chukchi (Providence Bay)	Zhukova	1965a
			Wrangel Is.	Zhukova	1966
			Norway (Langesund, Dovre Mts.)	Knaben & Engelskjön	1967
			Norway (East Finnmark)	Laane	1967
		36	....	Löve & Löve	1961a
Geum glaciale Adams	28	28	U.S.S.R. (Tiksi Bay)	Sokolovskaja & Strelkova	1960
			Chukchi (Cape Schmidt)	Zhukova	1966
			Chukchi (Bilibino)	Zhukova	1967
Potentilla biflora Willd. ex Schlecht.	14				
Potentilla egedii Wormskj. s.l.	28	28	....	Löve & Löve	1961a
			Kamchatka	Sokolovskaja	1963
			West Chukchi (Apapel'khino)	Zhukova	1966
			Manitoba (Churchill)	Löve & Ritchie	1966
Potentilla fruticosa L. s.l.	14	14	....	Löve & Löve	1961a
			Chukchi Mts. (R. Kuek'vun)	Zhukova	1966
		28	....	Löve & Löve	1961a
Potentilla hyparctica Malte	42	42	....	Löve & Löve	1961a
			Chukchi (Providence Bay)	Zhukova	1965a
			Wrangel Is.	Zhukova	1966
			Chukchi (R. Kuek'vun)		
			Melville Is.	Mosquin & Hayley	1966
			Baffin Is.	Hedberg	1967
		49	....	Löve & Löve	1961a
Potentilla hookeriana Lehm.	28				
Rubus arcticus L.	14	14	....	Löve & Löve	1961a
	21				
Rubus chamaemorus L.	56	56	....	Löve & Löve	1961a
			Manitoba (Churchill)	Löve & Ritchie	1966
Sanguisorba officinalis L.		14	Wrangel Is.	Zhukova	1965
	28	28	....	Löve & Löve	1961a
			Western Europe (many localities)	Nordborg	1963
			U.S.S.R. (Kola Peninsula, Vladivostok)		
			Wrangel Is.	Zhukova	1966
		56	Western Europe (many localities)	Nordborg	1963
		c. 70	Kamchatka	Sokolovskaja	1963
Papilionaceae					
Astragalus alpinus L.		16	....	Löve & Löve	1961a
			Finland	Sorsa	1963
			Sweden (Jämtland)	Hedberg	1964
			Norway	Laane	1965
			Norway (Nordland, Dovre Mts.)	Knaben & Engelskjön	1967
	32	32	....	Löve & Löve	1961a
			Switzerland	Favarger	1965
			Kamchatka	Sokolovskaja	1963
			West Chukchi (Apapel'khino)	Zhukova	1966
			Chukchi Mts. (R. Kuek'vun)		
			Wrangel Is.		
			Melville Is.	Mosquin & Hayley	1966
			Prince Patrick Is.		
			Victoria Is.	Hedberg	1967
			Baffin Is.		
			Quebec (Ft. Chimo)		
			Alaska (Umiat)		
Astragalus australis (L.) Lam.		16	Switzerland	Favarger	1965
		32	Switzerland	Favarger	1965
			Alaska (Liberator Lake)	Holmen	1962
			Alaska (Umiat)	Hedberg	1967
		48	Switzerland	Favarger	1965
Astragalus umbellatus Bunge	16	16	U.S.S.R. (Tiksi Bay)	Sokolovskaja & Strelkova	1960
			Alaska (Liberator Lake)	Holmen	1962
			Wrangel Is.	Zhukova	1966
Hedysarum alpinum L. s.l.	14	14	....	Löve & Löve	1961a
			Saskatchewan (Regina, Redvers)	Ledingham	1960
			Alaska (Peter's Lake)	Holmen	1962
			Saskatchewan (Cypress Hills)	Taylor & Brockman	1966
			Quebec (Bic)	Mulligan	1967
			Alberta (Rocky Mts.)	Packer	1968
			Yukon (Richardson Mts.)		
		16	Alaska (Beetles)	Hedberg	
	28				
Hedysarum mackenzii Rich.	16	16	Saskatchewan (Langham)	Ledingham	1960
		17			

Bot. Notiser, vol. 121, 1968

Species	Ogotoruk counts (2n)	Previously published counts (2n)	Localities for previously published counts	References	Year
Lathyrus japonicus WILLD. var. *aleuticus* (GREENE) FERN.	14	14	Sakhalin	SOKOLOVSKAJA	1960
			Kamchatka	SOKOLOVSKAJA	1963
			Chukchi (Apapel'khino)	ZHUKOVA	1966
Lupinus arcticus S. WATS.	48	48	Alaska (Umiat)	HOLMEN	1962
			Alaska (Anchorage)	HEDBERG	1967
		96	Yukon (Whitehorse)	PORSILD et al.	1967
Oxytropis glutinosa PORS.	c. 48	48	Alaska (Peter's Lake)	HOLMEN	1962
Oxytropis gracilis (A. NELS.) K. SCHUM.	> 60				
Oxytropis maydelliana TRAUTV.	96	96	Alaska (Liberator Lake)	HOLMEN	1962
			West Chukchi	ZHUKOVA	1966
Oxytropis mertensiana TURCZ.	16	16	U.S.S.R. (Tiksi Bay)	SOKOLOVSKAJA & STRELKOVA	1960
			Alaska (Feniak Lake)	HOLMEN	1962
			Chukchi (Senyavin)	ZHUKOVA	1965
Oxytropis nigrescens (PALL.) FISCH.		16	Alaska (Feniak Lake)	HOLMEN	1962
	32	32	Chukchi (Lorino)	ZHUKOVA	1965a
			Wrangel Is.	ZHUKOVA	1965b
Oxytropis pygmaea (PALL.) FERN.	16				
Violaceae					
Viola epipsila LEDEB. ssp. *repens* (TURCZ.) BECKER	24	24	....	LÖVE & LÖVE	1961a
			Chukchi Mts. (Umkrynnet)	ZHUKOVA	1967
Hippuridaceae					
Hippuris vulgaris L.	32	32	....	LÖVE & LÖVE	1961a
			Kamchatka	SOKOLOVSKAJA	1963
			Finland	SORSA	1963
			Manitoba (Churchill)	LÖVE & RITCHIE	1966
			West Chukchi (Apapel'khino)	ZHUKOVA	1966
		48	West Chukchi (Apapel'khino)	ZHUKOVA	1966
Onagraceae					
Epilobium anagallidifolium LAM.	36	36	....	LÖVE & LÖVE	1961a
			Gt. Britain	RAVEN & MOORE	1964
			Alberta (Rocky Mts.)	PACKER	1964
			Poland (Tatra)	SKALINSKA & POGAN	1964
			Norway (Dovre Mts.)	KNABEN & ENGELSKJÖN	1967
Epilobium angustifolium L. s.str.	36	36	....	LÖVE & LÖVE	1961a
			Gt. Britain	RAVEN & MOORE	1964
			Norway	LAANE	1965
			North temperate zone (many localities)	MOSQUIN	1966
		c. 36	Finland	SORSA	1962
Epilobium latifolium L.	36	36	Melville Is.	MOSQUIN & HAYLEY	1966
		54	Melville Is.		
		72	....	LÖVE & LÖVE	1961a
Epilobium palustre L.	36	36	....	LÖVE & LÖVE	1961a
Umbelliferae					
Angelica lucida L.	22				
Bupleurum americanum COULT. & ROSE	14	28—32	Alberta (Waterton Nt. Pk.)	PACKER (unpublished)	
Conioselinum cnidiifolium (TURCZ.) PORS.	22				
Pyrolaceae					
Pyrola grandiflora RAD.	46	46	....	LÖVE & LÖVE	1961a
			Manitoba, Churchill	LÖVE & RITCHIE	1966
			Baffin Is.	HEDBERG	1967
Orthilia secunda (L.) HOUSE	38	38	....	LÖVE & LÖVE	1961a
		c. 38	Finland	SORSA	1962
Ericaceae					
Andromeda polifolia L.		48	....	LÖVE & LÖVE	1961a
	c. 48	c. 48	Finland	SORSA	1963
Arctous alpinus (L.) NIEDENZU	26	26	....	LÖVE & LÖVE	1961a
			New Hampshire (Mt. Washington)	LÖVE & LÖVE	1966
			Kolymskoe Mts. (Karamken)	ZHUKOVA	1966
			Baffin Is.	HEDBERG	1967
Cassiope tetragona (L.) D. DON	26	26	....	LÖVE & LÖVE	1961a
		c. 26	Melville Is.	MOSQUIN & HAYLEY	1966
Ledum palustre L. s.l.	26				
		52	....	LÖVE & LÖVE	1961a
		c. 52	Finland	SORSA	1962
Vaccinium gaultherioides BIGEL.	24	24	....	LÖVE & LÖVE	1961a
			New Hampshire (Mt. Washington)	LÖVE & LÖVE	1966
			Wrangel Is.	ZHUKOVA	1966
			Baffin Is.	HEDBERG	1967

Bot. Notiser, vol. 121, 1968

Species	Ogotoruk counts (2n)	Previously published counts (2n)	Localities for previously published counts	References	Year
Vaccinium vitis-idaea L. ssp. *minus* (LODD.) HULT.	24	24	....	LÖVE & LÖVE	1961a
			Sweden (Jämtland, Lule Lappmark)	HEDBERG & HEDBERG	1964
			Norway	LAANE	1965
			New Hampshire (Mt. Washington)	LÖVE & LÖVE	1966
Empetraceae					
Empetrum eamesii FERN. & WIEG. ssp. *hermaphroditum* (HAGERUP) D. LÖVE	52	52	....	LÖVE & LÖVE	1961a
			Switzerland	FAVARGER	1962
			Sweden (Jämtland, Lule Lappmark)	HEDBERG & HEDBERG	1964
			New Hampshire (Mt. Washington)	LÖVE & LÖVE	1966
Diapensiaceae					
Diapensia lapponica L. ssp. *obovata* (SCHMIDT) HULT.	12				
Primulaceae					
Androsace chamaejasme HOST. ssp. *lehmanniana* (SPRENG.) HULT.	20	20	Alberta (Rocky Mts.)	PACKER	1964
Androsace septentrionalis L.	20	20	....	LÖVE & LÖVE	1961a
			Alberta (Rocky Mts.)	PACKER	1964
			Mackenzie Dist. (Inuvik)		
			West Chukchi	ZHUKOVA	1966
Androsace ochotensis WILLD.	38				
		40	Wrangel Is.	ZHUKOVA	1965
			Chukchi Mts. (Umkrynnet)	ZHUKOVA	1967
			Chukchi (Cape Schmidt)	ZHUKOVA	1967
Dodecatheon frigidum CHAM. & SCHLECHT.	44	44	Alaska (Noluk Lake)	THOMPSON	1953
Primula borealis DUBY		18	Alaska (Pt. Lay)	THOMAS	1951
	36	36	Wrangel Is.	ZHUKOVA	1965
			Chukchi (Apapel'khino)	ZHUKOVA	1966
Primula egaliksensis WORMSKJ.	c. 36	36		LÖVE & LÖVE	1961a
		c. 40	Quebec (Ft. Chimo)	HEDBERG	1967
Primula tschuktschorum KJELLM.		18	Kamchatka	SOKOLOVSKAJA	1963
	22	22	Chukchi (Cape Schmidt)	ZHUKOVA	1966
Plumbaginaceae					
Armeria maritima (MILL.) WILLD. ssp. *sibirica* (TURCZ.) LAWR.	18	18	Kolguev Is.	SOKOLOVSKAJA & STRELKOVA	1960
			Wrangel Is.	ZHUKOVA	1966
			West Chukchi (Peveek)		
Gentianaceae					
Gentiana glauca PALL.	24	24	Kamchatka	SOKOLOVSKAJA	1963
			Alberta (Rocky Mts.)	PACKER	1964
			Chukchi (R. Kuek'vun)	ZHUKOVA	1966
Gentiana prostrata HAENKE		36	Peru	DIERS	1961a
	32—36	c. 36	....	LÖVE & LÖVE	1961
Gentiana tenella ROTTB.	10	10	....	LÖVE & LÖVE	1961
			West Chukchi, Apapel'khino	ZHUKOVA	1966
Polemoniaceae					
Phlox sibirica L.	14+IF	14	Chukchi (Bilibino)	ZHUKOVA	1967
Polemonium acutiflorum WILLD.	18	18	Kolguev Is.	SOKOLOVSKAJA & STRELKOVA	1960
			Finland	SORSA	1963
			Yukon (Richardson Mts.)	PACKER	1964
			Wrangel Is.	ZHUKOVA	1966
			Norway (Torne Lappmark, Finnmark)	KNABEN & ENGELSKJÖN	1967
		16—18	Norway	LAANE	1965
Polemonium boreale ADAMS	18	18	....	LÖVE & LÖVE	1961a
			Wrangel Is.	ZHUKOVA	1965b
			Yukutia (Nyaiba)	ZHUKOVA	1966
			Norway (E. Finnmark)	LAANE	1966
Boraginaceae					
Eritrichum chamissonis DC.	48				
Eritrichum splendens KEARNEY	36				
Mertensia maritima (L.) S. F. GRAY	24	24	....	LÖVE & LÖVE	1961a
			Wrangel Is.	ZHUKOVA	1966
Myosotis alpestris SCHMIDT ssp. *asiatica* VESTERGR.	24	24	Altai	SOKOLOVSKAJA & STRELKOVA	1948
			Wrangel Is.	ZHUKOVA	1966

Species	Ogotoruk counts (2n)	Previously published counts (2n)	Localities for previously published counts	References	Year
Scrophulariaceae					
Castilleja elegans OSTENF. ex MALTE	24	24	Wrangel Is.	ZHUKOVA	1966
Castilleja caudata (PENNELL) JOHNSON & PACKER	96				
Lagotis glauca GAERTN.	22	22	Kamchatka	SOKOLOVSKAJA	1963
Pedicularis capitata ADAMS	16	16	Wrangel Is.	ZHUKOVA	1966
Pedicularis labradorica WIRSING	16	16	Greenland	BÖCHER	1967
Pedicularis lanata CHAM. & SCHLECHT.	16	16	Greenland	BÖCHER	1967
Pedicularis langsdorfii FISCH. ex STEV.	16	16	Wrangel Is.	ZHUKOVA	1966
			Melville Is.	MOSQUIN & HAYLEY	1966
Pedicularis oederi VAHL.	16	16	....	LÖVE & LÖVE	1961a
			Chukchi Mts. (R. Kuvet)	ZHUKOVA	1967
Pedicularis pennellii HULT.	16	16	Chukchi (Cape Schmidt)	ZHUKOVA	1967
Pedicularis sudetica WILLD. ssp. *albolabiata* HULT.	16				
ssp. *interior* HULT.	16				
Pedicularis verticillata L.	12	12	....	LÖVE & LÖVE	1961a
			Wrangel Is.	ZHUKOVA	1966
Rubiaceae					
Galium septentrionale ROEM. & SCHULT.	66	66	....	LÖVE & LÖVE	1954
			Chukchi (Bilibino)	ZHUKOVA	1967
			Saskatchewan (Fleming)	TAYLOR & BROCKMAN	1966
		> 60	Kamchatka	SOKOLOVSKAJA	1963
Adoxaceae					
Adoxa moschatellina L.	36	36	..............*..............	LÖVE & LÖVE	1961a
			Finland	SORSA	1963
			U.S.S.R. (Primorye Territory)	SOKOLOVSKAJA	1966
			Chukchi (Bilibino)	ZHUKOVA	1967
			Alberta (Mountain Pk.)	PACKER	1968
Valerianaceae					
Valeriana capitata PALL. ex LINK		56	....	LÖVE & LÖVE	1961a
			Wrangel Is.	ZHUKOVA	1965b
	c. 60				
		64	....	LÖVE & LÖVE	1961a
Campanulaceae					
Campanula lasiocarpa CHAM.	34	34	Kamchatka	SOKOLOVSKAJA	1963
Campanula uniflora L.	34	34	....	LÖVE & LÖVE	1961a
			Wrangel Is.	ZHUKOVA	1966
Compositae					
Antennaria alaskana MALTE	56+2—3F				
Arnica lessingii GREENE	76	c. 76	Kamchatka	SOKOLOVSKAJA	1963
Arnica louiseana FARR ssp. *frigida* (MEYER) MAGUIRE	c. 76	c. 67	Alberta	ORNDUFF et al.	1967
Artemisia arctica LESS.		18	Chukchi (Providence Bay)	ZHUKOVA	1965a
			U.S.S.R. (Kirovsk B.G.)	KAWATANI & OHNO	1964
	36	36	Kamchatka	SOKOLOVSKAJA	1963
			Japan	KAWATANI & OHNO	1964
ssp. *comata* HULT.	36				
Artemisia borealis PALL.		18	....	LÖVE & LÖVE	1961a
			Kamchatka	SOKOLOVSKAJA	1963
			W. Germany (Rostock B.G.)	KAWATANI & OHNO	1964
			Alberta (Rocky Mts.)	PACKER (unpublished)	
	36	36	W. Germany (Rostock B.G.)	KAWATANI & OHNO	1964
			Chukchi (Providence Bay)	ZHUKOVA	1965a
Artemisia globularia BESS.	18				
		36	U.S.S.R. (Leningrad B.G.)	KAWATANI & OHNO	1964
			Chukchi (Providence Bay)	ZHUKOVA	1965
Artemisia glomerata LEDEB.	18	18	Chukchi (Lorino)	ZHUKOVA	1965a
		36	U.S.S.R. (Leningrad B.G.)	KAWATANI & OHNO	1964
		54	Japan, U.S.S.R. (Leningrad B.G.)	KAWATANI & OHNO	1964
Artemisia tilesii LEDEB.		18	U.S.S.R. (Tiksi Bay)	SOKOLOVSKAJA & STRELKOVA	1960
			U.S.S.R. (Kirovsk B.G.)	KAWATANI & OHNO	1964
			Chukchi (Providence Bay)	ZHUKOVA	1965a
			Wrangel Is.	ZHUKOVA	1965b
			Anyuyskiy Mts. (Bilibino)	ZHUKOVA	1967
		54	Alaska	CLAUSEN et al.	1940
ssp. *elatior* TORR. & GRAY	18				
Artemisia trifurcata STEPH. ex SPRENG.		18	Japan	KAWATANI & OHNO	1964
		36	Japan, U.S.S.R. (Kirovsk B.G.)		
		54	Japan		

Bot. Notiser, vol. 121, 1968

Species	Ogotoruk counts (2n)	Pre-viously published counts (2n)	Localities for previously published counts	References	Year
Aster sibiricus L.	18	18	Chukchi (R. Kuek'vun)	ZHUKOVA	1966
			Alaska (Wild Lake)	HEDBERG	1967
Crepis nana RICH.	14	14	Alaska	BABCOCK	1938
			Wrangel Is.	ZHUKOVA	1966
			Alberta (Rocky Mts.)	TAYLOR & BROCKMAN	1966
			Alaska (Umiat)	HEDBERG	1967
Leucanthemum integrifolium (RICH.) DC.	18	18	Chukchi (Providence Bay)	ZHUKOVA	1965a
			British Columbia (Summit Lake)	PACKER	1968
Leucanthemum hultenii LÖVE & LÖVE	18	18	....	LÖVE & LÖVE	1961a
=*Chrysanthemum arcticum* L. ssp. *polaris* HULT.			West Chukchi (Apapel'khino)	ZHUKOVA	1966
Erigeron humilis GRAH.	36	36	....	LÖVE & LÖVE	1961a
			Yukon (Richardson Mts.)	PACKER	1964
			Chukchi (Providence Bay)	ZHUKOVA	1965
			Chukchi (R. Alyarmagtyn)	ZHUKOVA	1967
			Southampton Is.	HEDBERG	1967
Erigeron hyperboreus GREENE	18				
Matricaria ambigua (LEDEB.) KRYLOV	18	18	....	LÖVE & LÖVE	1961a
Petasites frigidus (L.) FRIES	60	60	....	LÖVE & LÖVE	1961a
			Washington, King Co.	ORNDUFF et al.	1963
			Wrangel Is.	ZHUKOVA	1965b
			British Columbia (Yo Ho Nt. Pk.)	TAYLOR & BROCKMAN	1966
		c. 60	Arakamchechen Is.	ZHUKOVA	1966
			Melville Is.	MOSQUIN & HAYLEY	1966
Saussurea angustifolia (WILLD.) DC.	26				
		52	Yukon (Richardson Mts.)	PACKER	1964
Senecio atropurpureus (LEDEB.) FEDTSCH.		28	Chukchi (Lorino)	ZHUKOVA	1965
	48	c. 48	Tiksi Bay	SOKOLOVSKAJA & STRELKOVA	1960
Senecio congestus (R.BR.) DC.	48	48	....	LÖVE & LÖVE	1961a
			West Chukchi (Apapel'khino)	ZHUKOVA	1966
			Melville Is.	MOSQUIN & HAYLEY	1966
			Alberta	ORNDUFF et al.	1967
			Southampton Is.	HEDBERG	1967
Senecio conterminus GREENM.	46	> 160	Alberta (Waterton Nt. Pk.)	PACKER (unpublished)	
Senecio fuscatus HAYER	46—48	46	Wyoming	ORNDUFF et al.	1967
Senecio integrifolius (L.) CLAIRV.	48	48	....	LÖVE & LÖVE	1961a
Senecio lugens RICH.		76±	Alaska (Peters Lake)	HEDBERG	1967
	c. 80	c. 80	Alberta Rocky Mts.	PACKER (unpublished)	
Senecio pseudoarnica LESS.		38—40	Kamchatka	SOKOLOVSKAJA	1963
		c. 40	Sakhalin	SOKOLOVSKAJA	1960
	40	40	Quebec	ORNDUFF et al.	1967
Senecio residifolius LESS.		46	Altai	SOKOLOVSKAJA & STRELKOVA	1938
	92				
Solidago multiradiata AIT. (incl. *S. compacta*)		18	California	CLAUSEN et al.	1940
			Quebec (Mont Albert)	BEAUDRY	1963
	36	36	Chukchi (Providence Bay)	ZHUKOVA	1965
			British Columbia (Yo Ho Nt. Pk.)	TAYLOR & BROCKMAN	1967
			Alberta (Rocky Mts.)	PACKER	1968
Taraxacum ceratophorum (LEDEB.) DC.	24	24	....	LÖVE & LÖVE	1961a
		32			
Taraxacum phymatocarpum V. VAHL	24	24	Pearyland	HOLMEN	1952
			Ellesmere Is.	MOSQUIN & HAYLEY	1966
		32	Melville Is.	MOSQUIN & HAYLEY	1966
		48	Melville Is.	MOSQUIN & HAYLEY	1966

combination, *Arenaria dicranoides* (CHAM. & SCHLECHT.) HULTÉN, based on the original description under *Cherleria*. Apart from HULTÉN, this combination has been used by a number of authors, ANDERSON (1946), WIGGINS and THOMAS (1962), but unfortunately this name is invalid, being a later homonym previously used for a South American species. As a species of *Arenaria* this taxon must bear the epithet of MAGUIRE (1951).

As HULTÉN (l.c.) has observed the floral structure of this species is very similar to that of *Minuartia sedoides*, in that both are apetalous and have a comparable development of bilobed glands and the similarity in floral structure extends also to the habit and habitats of the two species. It is hardly surprising that they have at times been placed together in the genus *Cherleria*. This would seem to be another case of close parallelism between species of *Minuartia* and *Arenaria* referred to by MAGUIRE (l.c.).

Curiously enough the parallels between *M. sedoides* and *A. chamissonis* extend also to chromosome number. Two chromosome numbers occur in the former species, 2n=26, and 2n=51—52, FAVARGER (1962) the second of these counts being a correction of the 2n=48, published for Scottish material by BLACKBURN and MORTON (1957). In *A. chamissonis* a count of 2n=26 was obtained for our material from Ogotoruk Creek. The occurrence of a basic number of x=13 is rather unusual in *Arenaria* and to our knowledge the only other case is in *A. modesta* also with 2n=26, FAVARGER (l.c.).

Minuartia macrocarpa (PURSH) OSTENF.

In a recent paper FAVARGER (1962) remarks that cytological data generally supports MATTFELD's (1922) classification of the genus *Minuartia*, though he states that in some sections revisions seem to be indicated. Data included in the present paper confirm the view that the relationships of certain species require further investigation.

M. macrocarpa is classified by MATTFELD (l.c.) in the subsection *Laricinae* of the section *Spectabiles*. Cytological data is now available for representatives of four of the five subsections of this section. With the exception of the *Laricinae* (in which *M. macrocarpa* is the only species so far counted) all have a basic number of x=13, FAVARGER (1962), LÖVE and LÖVE (1961 A); in fact only *M. arctica*, found in the present investigation to have a chromosome number of 2n=c. 52, deviates from 2n=26. The chromosome numbers of the 2n=44 and 2n=46 reported for *M. macrocarpa* occur in species of only one other section, *Sabulina*, BLACKBURN and MORTON (1957), FAVARGER (l.c.). They are evidently polyploid derivatives of taxa with x=11 and x=12, basic numbers which occur in the section. On the basis of the known cytological data *M. macrocarpa* is clearly separated from other members of the section *Spectabiles* and it would be most interesting to obtain counts for species such as *M. laricina* and *M. imbricata* which are related to *M. macrocarpa* or at least classified by MATTFELD (l.c.) in the same subsection.

Minuartia rossii (R. BR.) GRAEBN. s.l.

M. rossii is classified by MATTFELD (1922) in the section *Alsinanthe*, the only other species in this section being *M. stricta*. The basic chromosome number of *M. rossii* was found by PACKER (1964) to be x=15 and this has been confirmed in the present investigation. This number occurs consistently in species of two sections of the genus, *Eumінuartia* and *Tryphane*, FAVARGER (1962) but it differs from the reported basic numbers of *M. stricta*, namely x=11 and x=13, cf. LÖVE and LÖVE (1961 A).

With regard to the chromosome numbers in *M. rossii* the count from Ogotoruk Creek material, 2n=60, differs from the earlier count of 2n=30 determined in material from the Richardson Mountains, PACKER (1964). The material is however similar morphologically and both are referable to the subspecies *elegans*, of MAGUIRE (1958), who treats this species under *Arenaria*. ZHUKOVA (1966) has counted 2n=58 in material of *M. rossii* from Wrangel Is., which she claims to be *M. rossii* s. str. The identification of this material with *M. rossii* s. str. is open to doubt for according to MAGUIRE (l.c.) this taxon has an eastern distribution in the N. American Arctic, while ssp. *elegans* is western in its distribution, the type locality being St. Lawrence Bay, Chukchi. It is evident that two chromosome races occur in this subspecies, 2n=30 and 2n=58—60 and further investigation is required to clarify its taxonomy. Material of the third subspecies recognised by MAGUIRE (l.c.), ssp. *columbiana*, collected in the Rocky Mountains of Alberta has been found to have a chromosome number of 2n=30 (PACKER 1968).

Caltha palustris L. s.l.

Caltha palustris in Alaska is divided into two subspecies by HULTÉN (1944), ssp. *arctica* and ssp. *asarifolia*. HULTÉN (l.c.) distinguishes between the two on morphological and geographical grounds, and in most recent treatments, WIGGINS and THOMAS (1962), the distinction is maintained. According to HULTÉN (l.c.) ssp. *asarifolia* occurs only along the south coast of Alaska and all northern material is referred to ssp. *arctica*. However, material referrable to both subspecies occurs at Ogotoruk Creek and the morphological differences are accompanied by differences in chromosome number and ecology.

In a paper on the cytology of *C. palustris*, REESE (1954) divided populations in western Europe into tetraploids (2n=32) and higher ploids, mostly seven-ploid (2n=56). At least in some respects the two chromosome races can be related to the two subspecies recognised by HULTÉN (l.c.). The most obvious difference between the chromosome races is the marked radicant tendency of the higher ploids, absent in the tetraploids; a difference found also in the Ogotoruk Creek populations. HULTÉN uses this morphological characteristic as one of the criteria by which he separates the two subspecies in Alaska.

Apart from this difference, the tetraploid in the Ogotoruk Creek Valley occupies moist gravelly habitats, especially in the uplands, whereas the higher ploids, in this case 2n=56—70, are abundant in the wet tundra bottomlands. SMIT (1967) reports a comparable situation in Dutch populations, where the higher ploid (2n=56) is found in disturbed boggy substrates and the tetraploid in more stable habitats. The results of a study of the physiological ecology of the two chromosome races of *C. palustris* in the Ogotoruk Creek Valley have been presented elsewhere, JOHNSON (1967).

A thorough study of *C. palustris* needs to be undertaken. When it is, the species will most probably be divided into two or more species, corresponding, at least in part to the distinctions made above.

Oxygraphis glacialis (FISCH.) BUNGE

This is a comparatively recent addition to the flora of N. America and is not included in the work of WIGGINS and THOMAS published as recently as 1962. *O. glacialis* was first discovered in N. America by HULTÉN in the Barrow area of Alaska. The 1962 collection from Ogotoruk Creek, where it is extremely rare, would seem to be the second recorded for this continent but further records are to be expected. From a consideration of the habitat of this species and the large size of the achenes we are definitely of the opinion that at least in the Ogotoruk Creek area, this species is not a recent introduction from across the Bering Strait, but a relict of a probably much larger population that became established at a time when a Beringian land bridge existed.

Eutrema edwardsii R. BR.

Until recently only chromosome numbers of 2n=28 and 2n=42 have been found in this species. It will be seen from Fig. 1 that so far significant differences in the geographical distribution of these two races are not apparent. Nor have morphological characteristics been found that allow the two races to be distinguished though it must be admitted that no exhaustive study has yet been made.

An attempt to distinguish the chromosome races of *E. edwardsii* by chromatographic methods, using the technique of ALSTON and TURNER (1961), was made in an early phase of the work on the Ogotoruk Creek flora. This demonstrated the absence of any single chromatographic pattern characteristic of the species or either chromosome race. Usually each population varied from the rest. In one case identical chromatograms were obtained for two populations; the Ogotoruk Creek material proved to be identical with that from Tiksi Bay on the arctic coast of eastern Siberia. The chromatograms were not subjected to critical analysis but from observations made there could be said to exist geographical correlations in the varying chromatographic patterns. Chromatography seems destined to become a technique of vital importance to the phytogeographer. It should be possible, at least in certain cases, to ascertain the direction of migration, specify more precisely from which refugia northern plants have colonised glaciated areas, and allow investigation of cases where a polytopic origin of polyploids is suspected.

The recent count of 2n=18 for *E. edwardsii* published by ROLLINS (1966) has to quote ROLLINS (l.c.) 'introduced a complication that is not at present open to resolution.' It is to be hoped that confirmation of this unexpected number will soon be obtained.

Parrya nudicaulis (L.) REGEL

Until recently published reports of chromosome numbers for species in the genus *Parrya* were non-existent. In the past two years however three papers have appeared that include counts for *Parrya* species. MOSQUIN and HAYLEY (1966) found 2n=14 and 2n=21 in *P. arctica* from Prince Patrick Is. in the Canadian Arctic Archipelago. In the case of *P. nudicaulis*, ZHUKOVA (1965) reported a count of 2n=28 in material from Wrangel Is., while HEDBERG (1967) in material from Cornwallis Is. found 2n=14. We are, however, a little suspicious regarding the identification of the material from which this latter count was obtained. In the Canadian Arctic Archipelago *P. nudicaulis* is known from one locality only; the south coast of Victoria Is., PORSILD (1964). If it is present on Cornwallis Is. it would represent a considerable extension of range. It is to be noted that *P. arctica* occurs on Cornwallis Is. and HEDBERG's count of 2n=14 is that which MOSQUIN and HALEY obtained for this species.

Mention might be made of count of 2n=42 (PACKER, unpublished) from seed of *P. nudicaulis* collected in the Richardson Mts., and unreported for the reason that it was based on a single cell and could not be confirmed. This count suggests the existence of a hexaploid taxon in addition to the tetraploid and possible diploid. As HULTÉN (1945) has remarked, *P. nudicaulis* is a highly variable species and it is quite evidently in need of a critical analysis.

Smelowskia calycina (STEPHAN) C. A. MEYER var. **integrifolia** (SEEM.) ROLLINS

While *S. calycina* var. *integrifolia* is restricted to northern and northwestern Alaska the species itself, in which a total of five varieties are recognised by DRURY and ROLLINS (1952) has an amphi-beringian distribution. It occurs in Siberia from eastern Turkestan to the Altai Mts., in Beringia (though the precise distribution in the Chukchi area is uncertain) and in the mountains of western N. America from southern Colorado, Utah, to central Alberta and British Columbia. There is a considerable gap between these latter localities and those in Alaska and on the basis of the present distributional data a survival of *Smelowskia calycina* in the Rocky Mts. south of the glaciations and in unglaciated Alaska seems highly probable. The morphological differences existing between these disjunct populations support such a view. Thus we concur with DRURY and ROLLINS (l.c.) in their suggestion that the occurrence of *S. calycina* could very well be indicative of a refugial area.

DRURY and ROLLINS (l.c.) also suggest that the genus *Smelowskia* originated in the mountains of the northern Cordilleran region of N. America. In our opinion the evidence is insufficient to justify this observation. Phytogeographers and taxonomists have in the past and often still do assign centers of origin for taxa with little regard to the dubious nature of the criteria employed to establish these centers. Frequently a criterion is selected that best supports their preconceived views. It should be added that in regard to *Smelowskia* DRURY and ROLLINS (l.c.) show more restraint than many in their discussion of the center of origin.

The chromosome number of *S. calycina* var. *integrifolia* was found to be 2n=22 in the Ogotoruk Creek material. This was somewhat surprising in view of the fact that var. *americana* had previously been reported by DRURY and ROLLINS (l.c.) to have a chromosome number of 2n=12. In order to clarify the situation Alberta material of var. *americana* was examined and proved to have a chromosome number of 2n=22. The count of 2n=12 has however been confirmed in Colorado material (PACKER, unpublished), and the species is under further investigations.

Saxifraga eschscholtzii STERNB.

S. eschscholtzii is an amphi-beringian species of restricted distribution, occurring only in the Anadyr and Chukchi regions of N.E. Asia and the Alaska-Yukon area of N. America. These regions were largely unglaciated and we would agree with HULTÉN (1937) that *S. eschscholtzii* must have spread into the Beringian area prior to the maximum glaciation.

The chromosome number of 2n=12 found to occur in *S. eschscholtzii*, confirmed by ZHUKOVA (1967) is interesting in that it indicates a basic number of x=6 not previously known in the genus. This basic number has previously been postulated for *Saxifraga*, since it is reasonable to assume that many of the species of *Saxifraga* with x=13 are ancient polyploids that arose from crosses between taxa with x=6 and x=7. It might be mentioned that the latter basic number is still unknown in the genus, though it is presumed to have existed from the frequent occurrence of 2n=26 and 2n=28 in species of *Saxifraga*, LÖVE and LÖVE (1961). It is not improbable that this number is still extant in some *Saxifraga* species of central Asia.

ENGLER and IRMSCHER (1916) classify *S. eschscholtzii* in the series *Hemisphaerica* of the section *Hirculus*. The only other species in this series is *S. hemisphaerica* which closely resembles *S. eschscholtzii* and which is known from the subalpine and alpine zones of the Himalayas, e.g. Sikkim, between 16—19000′, ENGLER and IRMSCHER (l.c.). The taxonomic position of these two species should be carefully considered in any future revision of the genus for their relationship to other members of the section *Hirculus* seems to us rather tenuous. The discovery of a chromosome number of 2n=12 and the fact that the chromosomes are smaller than those found in some other species of the section (the chromosomes of *S. hirculus* being in our experience the largest occurring in any species of *Saxifraga*) we regard as evidence supporting this view.

The fact that a new, low basic number in a species, confined mostly to the stable, upland environments of an unglaciated area of arctic Alaska is most significant in our opinion, JOHNSON and PACKER (1965, 1967). It is tempting to speculate with the information we have at our disposal, that *S. eschscholtzii* or some ancestral form arose in the mountains of central Asia (where *S. hemisphaerica* still occurs) and that it subsequently migrated into the Arctic, perhaps in the later Tertiary.

In a recent note, CHAMBERS (1964) has commented on certain morphological and ecological aspects of *S. eschscholtzii*. Regarding the latter an explanation is advanced to account for the fact that *S. eschscholtzii* occurs at sea level at Point Hope in N.W. Alaska. To accommodate the view expressed by PORSILD (1939), HULTÉN (1945) and WIGGINS and THOMAS (1962) that this species is found only at higher elevations, CHAMBERS (l.c.) postulates that prolonged human occupancy of a site on the coast may create edaphic conditions suitable for certain calciphilous species, not adapted to the surrounding tundra. No such explanation is required. The simple answer to this problem is that the earlier reports are incorrect. *S. eschscholtzii* grows within 100′ of sea level in the Ogotoruk Creek area on what may be called with precision, stable uplands. It has to be borne in mind that such a description is relative to the other terrain in the area. Further, this species is not limited to limestone substrates for in the Ogotoruk Creek area it is found quite commonly on the acid shales of the Televeruk Hills bordering the eastern side of the valley.

The material of *S. eschscholtzii* from Ogotoruk Creek exhibits the floral dimorphism discussed by CHAMBERS (l.c.) illustrated by ENGLER and IRMSCHER (l.c.) and commented on by POLUNIN (1950). Very frequently, but apparently nor invariably the sexes appear to be on separate plants. Also noted in our material was the curious fact that the anthers of male flowers very often dehisce before the flowers open. Petal color in this material was invariably hyaline to roseate which contrasts with the yellow mentioned by CHAMBERS (l.c.). The dimensions of the seeds given by WIGGINS and THOMAS (l.c.) namely 0.8—1.0 mm, are somewhat exaggerated and we suspect that this may be a misprint.

Saxifraga flagellaris WILLD. (=ssp. **flagellaris** sensu PORSILD)

Taken in the widest sense *S. flagellaris* is a circumpolar arctic-montane species in which the montane populations are disjunct from those in the Arctic. Variation in the species has been variously treated by taxonomists, some recognising a number of species, TOLMATCHEV (1959), others, PORSILD (1954, 1955), recognising a somewhat lower number of subspecies. We are in no position to judge the overall merit of TOLMATCHEV's treatment but we concur with him in the recognition of *S. flagellaris* and *S. platysepala* as distinct species. Not only are these taxa morphologically and geographically distinct, PORSILD (l.c.) but there is a sound cytological basis for their recognition as species, *S. flagellaris* has a chromosome number of 2n=16, *S. platysepala* has 2n=32.

In commenting on the cytological aspects of *S. flagellaris* PACKER (1964) made the observation that material of *S. flagellaris* from the Caucasus (the type area) had not yet been investigated cytologically. This is incorrect. The count of 2n=18 by SOKOLOVSKAJA and STRELKOVA (1948) was overlooked as it seems to have been in most other discussions of these species. Though this count is not exact and consequently some doubt must remain it would appear that at the eastern and western extremes of its distribution, *S. flagellaris* has a chromosome number of 2n=16. Also referred to by PACKER (l.c.) was the count of 2n=14 by WIENS and HALLECK (1962) for Colorado material of *S. flagellaris* s.l. This number is somewhat unexpected and may represent 2n=16 as suggested by TAYLOR and BROCKMAN (1966). However in Colorado material of this species recently examined, PACKER (unpublished) has found 2n=32. Interesting in this connection is the fact that PORSILD (l.c.) includes the Colorado populations in his subspecies *platysepala* for which this number has invariably been recorded. Whether or not two chromosome numbers occur in the Colorado populations remains to be seen.

Saxifraga hirculus L. s.l.

Saxifraga hirculus is a circumpolar, arctic-montane species in which several intraspecific taxa have been recognised, ENGLER and IRMSCHER (1916). Three chromosome numbers are known to occur in this species, 2n=16, 2n=24 and 2n=32. The count of 2n=16 for Ogotoruk Creek material is in conformity with counts by HEDBERG (1967) and MOSQUIN and HAYLEY (1966) for collections from the Canadian Arctic and Alaska. Significantly however the diploid is known also from the Pamirs, SOKOLOVSKAJA in LÖVE and LÖVE (1961 A) and from the Rocky Mountains in Colorado. The count of 2n=32 has invariably been found in collections from the North Atlantic area, Greenland, Spitzbergen, Iceland and Kolguev, but this number has been recorded also in material from Wrangel Is., ZHUKOVA (1967) and the Richardson Mountains, PACKER (1964). With regard to this latter count, while the author has no reason to doubt its accuracy, the fact that it is the only recorded tetraploid from continental N. America suggests that confirmation of this count as typical for populations of the area would be desirable.

At the present moment this extremely interesting species is the subject of a taxonomic investigation by HEDBERG, cf. HEDBERG (1967). His findings are awaited with anticipation, not only because they will no doubt show whether or not there is a close correlation between the different chromosome numbers and the previously described infraspecific taxa, but because significant advances in the elucidation of the evolution of the arctic flora can only be expected when detailed distributional data for chromosome races is available from the total range of the species or species complex.

Saxifraga nelsoniana D. DON (sensu auct. ross.)

In a recent note WEBB (1964) has drawn attention to an earlier observation that the Linnaean type of *Saxifraga punctata* bears little resemblence to specimens to which this name has customarily been applied. In view of this WEBB (l.c.) proposed *S. nelsoniana* as the earliest valid name for the species and *S. aestivalis* is taken to be a subspecies. In so doing WEBB is adopting an extremely broad view of the species. Apart from the western *S. aestivalis* also submerged in this species (actually in the ssp. *nelsoniana*) are the amphiberingian *S. nelsoniana*, a species that Soviet botanists have recognised for years though for taxonomic rather than nomenclatural reasons and the E. Asiatic—N. American entity previously known as *S. punctata*, of which *S. nelsoniana* is a segregate.

It is unfortunate that CALDER and SAVILE (1960) omitted to check the Linnaean material. If it is not *S. punctata* they would most certainly have dealt with this additional problem in their revision. As it is the names of the several N. American subspecies of *S. punctata* recognised by HULTÉN (1945) and CALDER and SAVILE (l.c.) remain to be validated. In a case like this however, with the species especially in the Asiatic part of its range so evidently in need of revision, taxonomists may be reluctant to risk adding to the literature new combinations that could become redundant almost immediately. It might have been better if WEBB (l.c.) had merely drawn attention to the problem and accepted *S. aestivalis* as a species for the purposes of 'Flora

Europaea.' A seemingly invalid name has been used unwittingly for many years and the calculated continuation of the practice for a few more, pending a revision, would do no harm.

In this paper we have adopted the view of Soviet taxonomists in recognising *S. nelsoniana* as a species distinct from *S. punctata*. It is to be noted that when this is done the taxon currently referred to by Soviet taxonomists as *S. punctata* is still without a valid name; that remains to be established. In the absence of this information we shall follow current practice and call this entity *S. punctata*. The taxonomic confusion that exists in this complex is well illustrated by the several different chromosome numbers that have been determined in both *S. nelsoniana* and *S. punctata*. Those found in *S. nelsoniana* are listed in Table 1; in *S. punctata* the following chromosome numbers have been determined from the localities indicated.

2n=28	Altai	Sokolovskaja & Strelkova	1937
2n=28	Tiksi	Sokolovskaja	1958
2n=c. 72	Alberta	Moore in Calder & Savile	1960
2n=c. 76	Kamtchatka	Sokolovskaja	1963

As previously stated a taxonomic investigation of this whole complex is badly needed and a nomenclatural change that necessitates all the above chromosome numbers being referred to one subspecies, that ranges over much of Asia and N. America, is not regarded as particularly helpful contribution.

Saxifraga oppositifolia L.

As more chromosome counts of this species are published the more intriguing it becomes, both taxonomically and phytogeographically. The map of these counts, Fig. 1, reveals no obvious correlations; certainly none linking diploids with the unglaciated areas of the northern land masses or tetraploids with higher latitudes.

Two forms of this species have been recognised, *reptans* and *pulvinata*, Andersson and Hesselman (1900), and they may possibly coincide with the two chromosome races as was first suggested by Löve (1951). The Ogotoruk Creek material is of the 'pulvinata' form and the count of 2n=52 accords with other counts of this form mentioned by Löve (l.c.). However, Holmen (1957), in material from Peary Land reports both forms to have 2n=26. The two forms may well occur in both chromosome races, either as genotypic modification or as Warming (1909) suggests 'modifications occasioned by circumstances pertaining to locality.' This species is in need of a complete revision covering the whole of its distribution.

Rubus arcticus L.

This species is rare in the Ogotoruk Creek Valley; several scattered populations occur, usually associated with small stream drainages. *Rubus arcticus* is interesting cytologically because both diploid and triploid populations occur in the Ogotoruk Creek flora. The diploid population is fertile and matures fruits, but the triploid is sterile and reproduces only vegetatively. Only one population of the triploid is known, and its origin is obscure. Whether it arose directly from diploid *R. arcticus* or is a relict hybrid population formed between *R. arcticus* and a now locally extinct tetraploid *Rubus* species is not known. Hybrid populations between various *Rubus* species are well known in Alaska as elsewhere, and a hybrid origin for the triploid at Ogotoruk Creek cannot be discounted.

Astragalus alpinus L. s.l.

This widely distributed species is obviously in need of a thorough revision. The distribution of the two chromosome races, 2n=16 and 2n=32, Fig. 1, presents an interesting picture. The diploid appears to occur at lower latitudes in N. America and at various latitudes in Europe while the tetraploid, absent from Europe, occupies more northerly latitudes in N. America. The distribution of the diploid and tetraploid correspond in no way with the subspecies *alpinus* and *arcticus* that have been recognised in this species, which is perhaps not surprising since BARNEBY (1964) gives ample evidence for suspecting their validity.

The complete absence of *A. alpinus* from the more westerly parts of Europe, Iceland and Greenland may indicate a migration of the ancestral diploid both east and west from a center in Asia. Superimposed on this ancient pattern is the tetraploid. This may have originated in Asia and might now be following the path of the diploid, or it may have originated in N. America in which case it is retracing the original route of the diploid migration back into Asia. A third possibility is that the tetraploids are polytopic in origin. It should be possible using the tools of modern taxonomic practice to learn much more about the history of this species and which, if any, of the suggestions made above is most probable.

Hedysarum alpinum L.

To date all reports of the chromosome number in *H. alpinum* have been 2n=14. Counts of populations sampled at Ogotoruk Creek have confirmed this number but have also revealed the existence of a tetraploid, with 2n=28. The tetraploid is widespread at Ogotoruk Creek, occurring on gravel bars and benches and on frost scars at the upper edge of the wet meadow habitat. Diploid *H. alpinum* occurs only on the well-drained upland soils around the valley, either on limestone or on sandstone soils, but especially the former. The two chromosome races can be separated morphoolgically by the consistent occurrence of emarginate leaflets in the tetraploid. Herbarium specimens of *H. alpinum* taken from a wide area of northern N. America failed to reveal any populations with emarginate leaves. We therefore conclude that tetraploid *H. alpinum* is very local, possibly restricted to the Cape Thompson area. It seems probable that this entity is to be regarded as a distinct species, though further investigation is required.

Meiosis in the tetraploid is somewhat irregular in that unequal segregation is seen in about 50 percent of all first divisions in PMCs. Pollen fertility is also about 50 percent, but the effect of this on seed production is not known. In any event the tetraploid reproduces most efficiently by rhizomes.

Bupleurum americanum Coult. & Rose

This is the only species of a largely temperate genus of some 150 species that occurs in N. America. It would seem reasonable to suppose that *Bupleurum* is Old World in origin and that its advent into N. America is fairly recent. No fossil material of the genus has been found in N. America (G. Rouse in litt.). However, the entry of the genus certainly predates the last glaciation, for the distribution, like that of *Smelowskia calycina*, suggests survival both north and south of the last ice sheet.

The chromosome number for *B. americanum*, determined from Ogotoruk Creek material differs from that found in material from Alberta, 2n=14 and 2n=28—32 respectively. When more cytological data are available or a taxonomic revision published it will be interesting to see if the present geographical relationships of these numbers is maintained. The diploid being found in the Beringian area where migrants first entered N. America with the tetraploid farthest from this point and being possibly the more active coloniser or migrant.

Ledum palustre L.

Löve and Löve (1965) in a recent consideration of the taxonomy of *Ledum* have concluded that two species only should be recognised in the genus. These are *L. groenlandicum*, a diploid with two subspecies, *groenlandicum* and *glandulosum* and *L. palustre*, a tetraploid with three subspecies, *palustre*, *decumbens* and *diversipilosum*. It would seem to us however, that whatever the merit of this taxonimic treatment it is too early as yet to be certain of the cytological aspects of these taxa. In their paper, Löve and Löve (l.c.) report an unconfirmed count of 2n=52 for *L. groenlandicum* ssp. *groenlandicum* from Mt. Washington which is at variance with the prevailing diploid condition in this taxon and which they are inclined to regard as atypical. This certainly may be the case in view of their subsequent discovery of variation in chromosome number in individual plants, Löve and Löve (1966). In the Ogotoruk Creek material of *L. palustre* the possibility of such variation was not explored, but the prevailing number was 2n=26. It is evident that a detailed investigation of *Ledum* would be a worthwhile undertaking.

Eritrichum splendens Kearney

When Hultén (1949) prepared his account of this species it was known from only five localities occupying mid-latitudes in Alaska from the Bering Strait to the Alaska—Yukon border. The discovery of *E. splendens* at Ogotoruk Creek represents a northward extension of range in Beringia of some 150 miles. It also has been found in the Richardson Mts. on the Yukon—N.W.T. border, Packer (unpublished), which is a considerable northeasterly extension of its range.

There is an interesting aspect to the karyology of this species. The chromosomes fall into two size classes, about 18 large chromosomes and about 18 small chromosomes approximately one-tenth the size of the larger. This size difference is not found in the other species of *Eritrichum* investigated, in which all the chromosomes are small.

Castilleja elegans Ostenf. ex Malte and **Castilleja caudata** (Pennell) Johnson & Packer

Castilleja pallida, taken in the broad sense of Pennell (1934) has a very wide distribution in northern Asia and northern N. America, extending from the Kola Peninsula to Hudson's Bay. To a considerable degree its distribution covers areas that were unglaciated during the Pleistocene and there has been only moderate post-glacial penetration of glaciated territory, Pennell (l.c.) However in species of northern latitudes the influence of the glaciations must be anticipated and the opportunity to study in apparently related taxa, the effects of the changing conditions during the Quaternary, especially with regard to polyploidy and distribution, makes this a particularly interesting assemblage.

C. elegans and *C. caudata* are both treated as subspecies of *C. pallida* by Pennell (l.c.) who recognises a total of seven. Each subspecies has a distinctive distribution with *saccata* and *dahurica* strictly Asiatic, and subspecies *pallida* (Pennell's *typica*) largely so. The subspecies *caudata, auricoma* and *mexiae* are N. American, with *elegans* essentially so but reaching northeast Asia. Also of this group is *C. arctica*, not treated by Pennell (l.c.) which occurs in an area from the Kola Peninsula to the lower River Ob, Hultén (1948).

Cytological data have been published for three of these taxa, all from Russian sources. Material of *C. arctica* from Kolguev Island was found by Sokolovskaja and Strelkova (1960) to have a chromosome number of 2n=48. Recently Sokolovskaja (1963) has published a count of 2n=46—48 for material of *C. pallida* from Kamtchatka, which is most likely to be subspecies *saccata*, the only one occurring in that area, Pennell (l.c.). Zhukova (1967) has published a count of 2n=24 in *C. elegans* from Wrangel Is.

The flora of Ogotoruk Creek includes two of Pennell's subspecies both of which we prefer to regard as species. *C. elegans* has previously been accorded species status but ssp. *caudata* has not, we therefore propose the following change.

Castilleja caudata (Pennell) Johnson & Packer stat. nov.
based on **Castilleja pallida** (L.) Spreng. ssp. **caudata** Pennell,
Proc. Acad. Nat. Sci. Phil. 86: 524. 1934

C. caudata is, as stated by Porsild (1955), a rather distinctive element in the *C. pallida* complex, endemic to Alaska and Yukon. Not only does it differ in morphology and geographical distribution but it also differs in chromosome number from all other members of this assemblage so far investigated. As regards *C. elegans* and *C. caudata* in the Ogotoruk Creek area they differ markedly in their ecology, *C. elegans* generally being found in *Dryas* fell-field, though never abundantly, while *C. caudata* is found in somewhat moister habitats, on gravel bars etc. and when it does occur in ecotonal *Dryas* areas it is as a snow-bed plant.

Saussurea angustifolia (Willd.) DC.

Like *Bupleurum*, *Saussurea* is a genus overwhelmingly Eurasiatic in its distribution; over one hundred species are represented in the 'Flora of the U.S.S.R.' while in N. America only a handful of species occur. *S. angustifolia* is one of two amphi-beringian species and according to Hultén (1950) it extends in Asia from the Alden River to the Chukchi Peninsula and Wrangel Is. while its distribution in N. America, recently mapped by Porsild (1966), covers Alaska, Yukon and Coronation Gulf, central Keewatin south to Great Slave Lake. Prior to the count of 2n=26 in Ogotoruk Creek material the only previously reported chromosome number for this species was 2n=52 in material from the Richardson Mts., Packer (1964). It will be interesting to observe, when more information is available, whether or not the present geographical relationship between the diploid and tetraploid is maintained. At the moment, as is the case in *Bupleurum americanum*, the diploid is found in Beringia, assumed to be the entry point of these taxa into N. America while the tetraploid occurs some distance from the assumed area of entry. Additional information for this species and *Bupleurum americanum* could be significant in shedding light on the relative abilities of diploids and tetraploids to migrate and colonise new areas.

Senecio residifolius Less. and **Senecio conterminus** Greenm.

Considerable confusion exists regarding the taxonomy of both these species and their relationship to *Senecio hyperborealis* Greenm., *Senecio cymbalarioides* Buek (*S. subnudus* DC. of American authors, cf. Barkley, 1962) and *Senecio ovinus*. Greenman (1916) recognises all five species; he himself being responsible for describing two of them, *S. conterminus* and *S. hyperborealis*. Both Hultén (1950) and Porsild (1951, 1955, 1966) follow Greenman (l.c.) in recognising *S. residifolius*, *S. conterminus* and *S. hyperborealis* but Hultén (l.c.) has some reservations regarding the relationship of the Alaskan material of *S. conterminus* to that from the southern Canadian Rocky Mts., not shared by Porsild (l.c.). Moss (1959) recognises *S. residifolius* and *S. cymbalarioides*, but includes both *S. conterminus* and *S. ovinus* in *S. residifolius*. Barkley (1962) on the other hand, while he recognises the two species dealt with by Moss (l.c.) and agrees with his disposition of *S. ovinus*, includes *S. conterminus* with *S. hyperborealis*. Regarding the relationship between *S. residifolius* and *S. cymbalarioides*, Barkley (l.c.) remarks that while these species are ecologically distinct they may well be confused in the herbarium for there are 'virtually no consistent morphological characters for separating the two species.' Various other views regarding these species have been published but the foregoing is sufficient indication of their confused taxonomy.

One of us (J.G.P.) is engaged in an investigation of these arctic and alpine *Senecio* species. Preliminary studies indicate that at least some of the Alaskan material treated as *S. conterminus* is different from that in the Rocky Mts. of Alberta (the type locality); whether this applies totally remains to be seen. Our material of *S. conterminus* from the Ogotoruk Creek area was found to have a chromosome number of 2n=46. In the Alberta material no exact count has yet been made but in the several populations investigated a chromosome number of 2n=> 160 has been obtained. These could in fact be octoploids on the base number x=23, i.e. 2n=184, some counts having come close to this figure.

With regard to *S. residifolius* the count of 2n=46, SOKOLOVSKAJA (1938), in material from the Altai region of central Asia is of interest because this number is not in accord with the counts of 2n=92 for the Ogotoruk Creek material. It is however the same as that found in several Alberta populations of the closely similar *S. cymbalarioides*. *S. ovinus* also has 2n=46 and should undoubtedly be included in *S. cymbalarioides*. A full report of the current investigations will be published in due course.

ACKNOWLEDGEMENTS

The authors wish to acknowledge financial assistance and support for this work from U.S.A.E.C., under contract Nos. AT (04-3)-310 and AT (11-4)-34, the National Research Council of Canada and the Boreal Institute, The University of Alberta, Edmonton, Canada. The authors wish to thank, respectively, Dr. H. LEWIS, Chairman, Department of Botany, University of California, Los Angeles, and Dr. Á. LÖVE, Chairman, Department of Biology, University of Colorado, Boulder, for facilities provided in the course of this study and while this paper was prepared for publication.

LITERATURE CITED

ALLEN, P. W. & WEEDFALL, R. O. 1966. Weather and climate. In Environment of the Cape Thompson region, Alaska, pp. 9—44. Ed. N. J. WILLIMOVSKY. U.S.A.E.C. Division of Technical Information Extension.

ALSTON, R. G. & TURNER, B. L. 1962. New techniques in analysis of complex natural hybridisation. — Proc. Natl. Acad. Sci. 48: 130—137.

ANDERSON, J. P. 1946. Flora of Alaska and adjacent parts of Canada. IV. — Iowa St. Coll. Journ. Sci. 20: 213—257.

ANDERSSON, G. & HESSELMAN, H. 1900. Bidrag till kännedomen om Spetsbergens och Beeren Eilands kärlväxtflora. — Bih. K. Sv. Vetensk. Akad. Handl. 26: 1—88.

ARGUS, G. W. 1965. The taxonomy of the Salix glauca complex in North America. — Contrib. Gray Herb. Harvard Univ. 1961: 1—142.

BABCOCK, E. B. & STEBBINS, G. L. 1938. The American species of Crepis. — Carn. Inst. Wash. Publ. 504. 1—199.

BARKLEY, T. M. 1962. A revision of Senecio aureus Linn. and allied species. — Trans. Kan. Acad. Sci. 65: 318—408.

BARNEBY, R. C. 1964. Atlas of North American Astragalus. I. — Mem. New York Bot. Gard. 13. 596 pp.

BEAUDRY, J. R. 1963. Studies in Solidago L. VI. Additional chromosome numbers of taxa of the genus Solidago. — Canad. Journ. Genet. Cytol. 5: 150—174.

BERG, R. Y. 1965. A study of Calamagrostis lapponica in south Norway, with special reference to ecology and phytogeography. — Nytt Mag. Bot. 12: 79—122.

BLACKBURN, K. B. & MORTON, J. K. 1956. The incidence of polyploidy in the Caryophyllaceae of Britain and Portugal. — New Phytol. 56: 344—351.

Böcher, T. W. 1938. Zur Zytologie einiger arktischen und borealen Blütenpflanzen. — Sv. Bot. Tidskr. 32: 346—361.

— 1966. Experimental and cytological studies on plant species. IX. Some arctic and montane crucifers. — Biol. Skr. Dan. Vid. Selsk. 14: 1—74.

— 1967. IOPB Chromosome number reports. — Taxon 11: 215—222.

— & Larsen, K. 1950. Chromosome numbers in some arctic and boreal flowering plants. — Medd. Grønl. 147: 1—32.

Bormann, F. H. & Beatty, A. V. 1955. Chromosome studies of plants from the arctic slope of Alaska. — Bull. Tor. Bot. Club 82: 118—120.

Bowden, W. M. 1960. Chromosome numbers and taxonomic notes on northern grasses, III. Twenty-five genera. — Canad. Journ. Bot. 38: 541—557.

Calder, J. A. & Savile, D. B. O. 1960. Studies in Saxifragaceae. III. Saxifraga odontolma and lyalli and North American subspecies of S. punctata. — Canad. Journ. Bot. 38: 409—435.

Chambers, K. L. 1964. Saxifraga eschscholtzii Sternb. — Madroño 17: 203—204.

Clausen, J., Keck, D. & Hiesey, W. M. 1940. Experimental studies on the nature of species, I. The effects of varied environments on western North American plants. — Carnegie Inst. Wash. Publ. 520. 1—452.

Diers, L. 1961. Der Anteil an Polyploiden in den Vegetationsgürteln der West-Kordillere Perus. — Zeitschr. Bot. 49: 347—488.

Drury, W. H. & Rollins, R. C. 1952. The North American representatives of Smelowskia (Cruciferae) — Rhodora 54: 85—119.

Elkington, T. T. 1965. Studies on the variation of the genus Dryas in Greenland. — Medd. Grønl. 178: 1—56.

Elliot, F. C. 1949. The cytology and fertility relations of Bromus inermis and some of its relatives. — Agron. Journ. 41: 298—303.

Engler, A. & Irmscher, E. 1916. Saxifragaceae-Saxifraga. In Engler, A. Das Pflanzenreich IV. 117(1). Leipzig.

Favarger, C. 1961. Sur l'emploi des nombres de chromosomes en geographie botanique historique. — Ber. Geobot. Inst. Eidgenoess. Techn. Hochschule Stift. Rübel 32: 119—146.

— 1962. Contribution à l'étude cytologique des genres Minuartia et Arenaria. — Bull. Soc. Neuchât. Sci. Nat. 85: 53—81.

— 1965. Notes de carylogie alpine. IV. — Bull. Soc. Neuchât. Sci. Nat. 88: 5—60.

Greenman, J. M. 1916. Monograph of the North and Central American species of the genus Senecio. II. — Ann. Missouri Bot. Gard. 3: 85—188.

Hedberg, O. 1958. Cytotaxonomic studies in Scottish mountain plants, notably Deschampsia caespitosa (L.) PB., s. lat. — Sv. Bot. Tidskr. 52: 37—46.

— 1967. Chromosome numbers of vascular plants from arctic and subarctic North America. — Ark. Bot. (Stockholm) 6: 309—326.

Hedberg, I. & Hedberg, O. 1964. Documented chromosome numbers of Swedish plants. — Sv. Bot. Tidskr. 58: 125—128.

Heimburger, M. 1959. Cytotaxonomic studies in the genus Anemone. — Canad. Journ. Bot. 37: 587—612.

Holmen, K. 1952. Cytological studies in the flora of Peary Land, North Greenland. — Medd. Grønl. 128: 1—40.

— 1957. The vascular plants of Peary Land, North Greenland. — Medd. Grønl. 124: 1—149.

HOLMEN, K. 1962. Chromosome studies in some arctic Alaskan Leguminosae. — Bot. Notiser 115: 87—92.

— 1964. Cytotaxonomical studies in the arctic Alaskan flora. The genus Festuca. — Bot. Notiser 117: 109—118.

HOLOWAYCHUK, N., PETRO, J. H., FINNEY, H. R., FARNHAM, R. S. & GERSPER, P. L. 1966. Soils of the Ogotoruk Creek watershed. In Environment of the Cape Thompson region, Alaska, pp. 221—276. Ed. N. J. WILLIMOVSKY. U.S.A.E.C. Division of Technical Information Extension.

HULTÉN, E. 1937. Outline of the history of arctic and boreal biota during the Quarternary period. Bokförlags-Aktiebolaget Thule. Stockholm.

— 1941—50. Flora of Alaska and Yukon. I—X. — Acta Univ. Lund. N.F. Avd. 2. 37—46. 1902 pp.

JOHNSON, A. W. 1967. Comparative distribution, cytology, and physiological ecology of chromosome races of Caltha palustris at Cape Thompson, Alaska. — Bull. Ecol. Soc. America 48. 76.

— & PACKER, J. G. 1963. Cytotaxonomic investigations of the Ogotoruk Creek—Cape Thompson vascular flora. — U.S.A. Atomic Energy Commission Report, Contract No. AT(04-3)-310, unpublished manuscript.

— & — 1965. Polyploidy and environment in arctic Alaska. — Science 148: 237—239.

— & — 1967. Distribution, ecology, and cytology of the Ogotoruk Creek flora and the history of Beringia. In The Bering Land Bridge. pp. 245—265. Ed. D. M. HOPKINS. Stanford University Press.

— & REESE, G. 1965. Polyploidy, distribution and environment. In The Quarternary of the United States, pp. 497—507. Ed. H. E. WRIGHT, Jr. & D. G. FREY. Princeton University Press.

JOHNSON, A. L., VIERECK, L. A., JOHNSON, R. E. & MELCHIOR, H. 1966. Vegetation and flora of the Cape Thompson—Ogotoruk Creek Area, Alaska. In Environment of the Cape Thompson region, Alaska, pp. 277—354. Ed. N. J. WILLIMOVSKY. U.S.A.E.C. Division of Technical Information Extension.

JORGENSEN, C. A., SØRENSEN, T. & WESTERGAARD, M. 1958. The flowering plants of Greenland. A taxonomical and cytological survey. — Biol. Skr. Dan. Vid. Selsk. 9: 1—172.

KAWANO, S. 1964. Cytogeography and evolution of the Deschampsia caespitosa complex. — Canad. Journ. Bot. 41: 719—742.

KAWATANI, T. & OHNO, T. 1964. Chromosome numbers in Artemisia. — Bull. Nat. Inst. Hyg. Sci. 82: 183—193.

KLIPHUIS, E., GADELLA, T. W. J. & DORRAT-HAAKSMA, E. P. 1965. Chromosome numbers of Parnassia palustris L. in the Netherlands. — Acta Bot. Neerl. 14: 242—244.

KNABEN, G. 1959. On the evolution of the Radicatum group of the Scapiflora Papavers as studied in 70 and 56 chromosome species. — Opera Botanica 2(3): 1—74. 3(3): 1—96.

— & ENGELSKJÖN, T. 1967. Chromosome numbers of Scandinavian arctic-alpine plant species. II. — Acta Borealia. A. Scientia 21: 1—57.

KOOTIN-SANWU, M. 1964. Cytology and distribution of Caltha. — Proc. Bot. Soc. Brit. Isles 5: 377—378.

LAANE, M. M. 1965. Chromosome numbers in some Norwegian plant species. — Blyttia 23: 169—189.

— 1966. Chromosome numbers in the flora of east Finnmark. I. — Blyttia 24: 270—276.

— 1967. Chromosome numbers in the flora of east Finnmark. II. — Blyttia 25: 45—54.

LANGLET, O. F. J. 1932. Über Chromosomenverhältnisse und Systematik der Ranunculaceae. — Sv. Bot. Tidskr. 26: 381—400.

LEDINGHAM, G. F. 1960. Chromosome numbers in Astragalus and Oxytropis. — Canad. Journ. Genet. Cytol. 2: 119—128.

LÖVE, Á. & LÖVE, D. 1951. Studies on the origin of the Icelandic flora. II. Saxifragaceae. — Sv. Bot. Tidskr. 45: 368—399.

— & — 1961 a. Chromosome numbers of central and northwest European plant species. — Opera Botanica 5: 1—581.

— & — 1961 b. Some nomenclatural changes in the European flora. I. Species and supraspecific categories. — Bot. Notiser 114: 33—47.

— & — 1965. Taxonomic remarks on some American alpine plants. — Univ. Colorado Studies. Ser. Biol. 17: 1—43.

— & — 1966. Cytotaxonomy of the alpine vascular plants of Mount Washington. — Univ. Colorado Studies. Ser. Biol. 24: 1—74.

LÖVE, Á. & RITCHIE, J. C. 1966. Chromosome numbers from central northern Canada. — Canad. Journ. Bot. 44: 429—439.

LÖVE, D. 1960. The red fruited crowberries in North America. — Rhodora 62: 265—292.

LÖVE, D. & BOSCAIU, N. 1966. Vaccinium gaultherioides Bigel. An arctic-alpine species. — Rev. Roum. Biol. Ser. Bot. 11: 295—305.

MAGUIRE, B. 1951. Studies in the Caryophyllaceae. V. Arenaria in America north of Mexico. A conspectus. — Am. Midl. Nat. 46: 493—511.

— 1958. Arenaria rossii and some of its relatives in America. — Rhodora 60: 44—53.

MALTE, M. O. 1934. Notes on Canadian Arctic plants. — Rhodora 36: 101—117, 172—193.

MATTFELD, J. 1922. Geographisch-genetische Untersuchungen über die Gattung Minuartia (L.) Hiern. — Feddes Rep. Spec. Nov. Reg. Beih. 15: 1—228.

MILLER, E. W. 1930. A preliminary note on the cytology of the Melanoideae section of the Liliaceae. — Proc. Univ. Durham Phil. Soc. 8: 267—271.

MITCHELL, W. M. 1967. Taxonomic synopsis of Bromus section Bromopsis (Gramineae) in Alaska. — Canad. Journ. Bot. 45: 1309—1313.

MOONEY, H. A. & JOHNSON, A. W. 1965. Comparative physiological ecology of an arctic and alpine population of Thalictrum alpinum L. — Ecology 46: 721—727.

MOORE, R. J. & CALDER, J. A. 1964. Some chromosome numbers of Carex species of Canada and Alaska. — Canad. Journ. Bot. 42: 1387—1391.

MOSQUIN, T. 1966. A new taxonomy of Epilobium angustifolium L. (Onagraceae). — Brittonia 18: 167—188.

— & HAYLEY, D. E. 1966. Chromosome numbers and taxonomy of some Canadian plants. — Canad. Journ. Bot. 44: 1209—1217.

MOSS, E. A. 1959. Flora of Alberta. University of Toronto Press.

MULLIGAN, G. 1966. Chromosome numbers of the family Cruciferae. III. — Canad. Journ. Bot. 44: 304—319.

NORDBORG, G. 1963. Studies in Sanguisorba officinalis L. — Bot. Notiser 116: 267—288.

NYGREN, A. 1954. Investigations on North American Calamagrostis. — Hereditas 40: 377—397.

ORNDUFF, R., RAVEN, P. H., KYHOS, D. W. & KRUCKEBERG, A. R. 1963. Chromosome numbers in Compositae. III. Senecioneae. — Am. Journ. Bot. 50: 131—139.

—, MOSQUIN, T., KYHOS, D. W. & RAVEN, P. H. 1967. Chromosome numbers in Compositae. VI. Senecioneae II. — Am. Journ. Bot. 54: 205—213.

PACKER, J. G. 1963. The taxonomy of some North American species of Chrysosplenium L., section Alternifolia Franchet. — Canad. Journ. Bot. 41: 85—103.

— 1964. Chromosome numbers and taxonomic notes on western Canadian and arctic plants. — Canad. Journ. Bot. 42: 473—494.

— 1968. IOPB Chromosome number reports XVII. — Taxon 17: 285—288.

PENNELL, F. W. 1934. Castilleja in Alaska and northwestern Canada. — Proc. Acad. Nat. Sci. Phil. 86: 517—540.

POLUNIN, N. 1959. Circumpolar arctic flora. Oxford University Press.

PORSILD, A. E. 1939. Contributions to the flora of Alaska. — Rhodora 41: 141—183, 183—254, 262—301.

— 1951. Botany of the southeastern Yukon adjacent to the Canol Road. — Nat. Mus. Can. Bull. 121.

— 1954. The North American races of Saxifraga flagellaris Willd. — Bot. Tidsskr. 51: 292—299.

— 1955. The vascular plants of the western Canadian Arctic Archipelago. — Nat. Mus. Can. Bull. 135.

— 1964. Illustrated flora of the Canadian Arctic Archipelago. Ed. 2. — Nat. Mus. Can. Bull. 146.

— 1966. Contributions to the flora of southwestern Yukon Territory. — Nat. Mus. Can. Bull. 216.

— & MULLIGAN, G. & HARRINGTON, C. R. 1967. Lupinus arcticus Wats. grown from seeds of the Pleistocene age. — Science 158: 113—114.

RAVEN, P. H. & MOORE, D. M. 1964. Chromosome numbers in Epilobium in Britain. — Watsonia 6: 36—38.

REESE, G. 1954. Euploidie, Aneuploidie und B-Chromosomen bei Caltha palustris L. — Planta 44: 203—268.

ROLLINS, R. 1966. Chromosome numbers of Cruciferae. — Contrib. Gray Herb. Harvard Univ. 197: 43—65.

SKALINSKA et al. 1964. Additions to chromosome numbers of Polish angiosperms. Fifth contribution. — Acta Soc. Bot. Polon. 33: 45—76.

SKALINSKA, M. & POGAN, E. 1966. Further studies in chromosome numbers of Polish angiosperms. Sixth contribution. — Acta Biol. Cracov. 9: 31—58.

SMIT, P. G. 1967. Taxonomic and ecological studies in Caltha palustris L. — Koninkl. Nederl. Akad. Wetensch., Ser. C. 70: 500—510.

SOKOLOVSKAJA, A. P. 1958. Sootnoschenie mechdo chislom kromosom i velichinoye pyl'tsevych o arkticheskikh vidov Ranunculaceae i Saxifragaceae. — Bot. Zh. 43: 1146—1155.

— 1960. Geograficheskoye raspostraneny poliploidnich vidov rasteny (Isseldovanie flory o. Sakhalina). — Vestnik Leningr. Univ. Ser. Biol. 21: 42—58.

— 1963. Geograficheskoye rasprostraneny poliploidnich vidov rasteny (Issledovanie flory poluostreva Kamchatki). — Vestnik Leningr. Univ. Ser. Biol. 15: 38—52.

— 1966. Geograficheskoye rasprostraney poliploidnich vidov rasteny (Issledovanie flory Primoreskiy). — Vestnik Leningr. Univ. Ser. Biol. 3: 92—106.

— & STRELKOVA, O. S. 1938. Polyploidy in the high mountain regions of Pamir and Altai. — Doklady 21: 68—71.

— & — 1948. Geograficheskoye raspredelenie poliploidov. II. Issledovanie flory Altaya. — Uchenye Zapiski LGU. 66: 179—193.

— & — 1948. Geograficheskoye raspredelenie poliploidov. III. Issledovanie flory al'piyskoj oblasti tsentral'nova kavkazskova chrebta. — Uchenye Zapiski LGU. 66: 195—216.

— & — 1960. Geographical distribution of the polyploid species of plants in the Eurasiatic Arctic. — Bot. Zh. 45: 369—381.

SÖLLNER, R. 1954. Reserches cytotaxonomiques sur le genre Cerastium. — Ber. Schweiz. Bot. Ges. 64: 221—354.

SØRENSEN, T. 1953. A revision of the Greenland species of Puccinellia Parl. — Medd. Grønl. 136: 1—179.

SORSA, V. 1962. Chromosomenzahlen finnischer Kormophyten. I. — Ann. Acad. Sci. Fenn. A. IV. Biol. 58: 1—14.

— 1963. Chromosomenzahlen finnischer Kormophyten. II. — Ann. Acad. Sci. Fenn. A. IV. Biol. 68: 1—14.

TATEOKA, T. 1967. IOPB Chromosome number reports XIV. — Taxon 16: 552—577.

TAYLOR, R. L. & BROCKMAN, R. P. 1966. Chromosome numbers of some western Canadian plants. — Canad. Journ. Bot. 44: 1093—1103.

THOMAS, H. J. 1951. A collection of plants from Point Lay, Alaska. — Contr. Dudley Herb. 4: 53—86.

THOMPSON, H. J. 1953. Biosystematics of Dodecatheon. — Contr. Dudley Herb. 4: 73—154.

TJIO, J. H. & LEVAN, A. 1950. The use of oxyquinoline in chromosome analysis. — Anal. Aula Dei 2: 21—64.

TOLMATCHEV, A. I. 1959. De Saxifraga flagellaris Willd. et speciebus affinibus. — Bot. Mat. Herb. Bot. Inst. Komarov Acad. Sci. U.R.S.S. 19: 156—187.

WARMING, E. 1909. The structure and biology of arctic flowering plants. IV. Saxifragaceae. — Medd. Grønl. 36: 171—236.

WEBB, D. A. 1964. Saxifragaceae. In Notulae systematicae ad Floram Europaeam spectantes. IV. Ed. V. H. HEYWOOD. — Feddes Rep. Spec. Nov. Reg. Veg. 69: 142—154.

WEICHOLD, B. 1962. Bioenvironmental features of the Ogotoruk Creek area, Cape Thompson, Alaska. — U.S.A.E.C. Rept. TID-17726. Washington.

WIENS, D. & HALLECK, D. K. 1962. Chromosome numbers in Rocky Mountain plants. I. — Bot. Notiser 115: 455—464.

WIGGINS, I. & THOMAS, J. 1962. A flora of the Arctic Alaska slope. University of Toronto Press.

WILTON, A. C. 1965. Phylogenetic relationships of an unknown tetraploid Bromus, section Bromopsis. — Canad. Journ. Bot. 43: 723—730.

ZHUKOVA, P. G. 1965 a. Kariologicheskaja kharakteristika nekotorikh rasteniy Chukotskogo poluostrova. — Bot. Zh. 50: 1001—1004.

— 1965 b. Kariologicheskaja kharakteristika nekotorikh vidov rasteniy ostrova Vrangelja. — Bot. Zh. 50: 1320—1322.

— 1966. Chromosome numbers in some species of plants of the northeastern part of the U.S.S.R. I. — Bot. Zh. 51: 1511—1516.

— 1967. Chromosome numbers in some species of plants of the northeastern part of the U.S.S.R. II. — Bot. Zh. 52: 983—987.

Meddelanden

Korresponderande ledamöter i Lunds Botaniska Förening

För förtjänstfull verksamhet för Lunds Botaniska Förening och den svenska botaniken har följande botanister vid sammanträde den 16 februari 1968 enhälligt valts till korresponderande ledamöter i föreningen: Professor HANS LUTHER, Helsingfors, Professor K. H. RECHINGER, Wien, och Professor VIVI TÄCKHOLM, Kairo.

Hedersledamot i Lunds Botaniska Förening

Vid sammanträde med Lunds Botaniska Förening den 16 februari 1968 har professor ARNE MÜNTZING, Lund, valts till hedersledamot i föreningen.

Genetikprofessuren i Lund

Professor ÅKE GUSTAFSSON har av Kungl. Maj:t utnämnts att f.o.m. den 1 juli 1968 vara professor i genetik vid Lunds Universitet.

Disputationer

I Lund

4.5 1968: INGEMAR BJÖRKQVIST: »Studies in Alisma L. Distribution, Variation, Germination, Chromosome Studies, Crossing Experiments and Taxonomy.»

9.5 1968: ANDERS JOHNSSON: »Undersökningar av tidsfaktorer i geotropiska och fototropiska reaktioner hos växter.»

31.5 1968: BERTIL NORDENSTAM: »The Genus Euryops. Morphology, Cytology and Taxonomy.»

I Uppsala

2.12 1967: LENA JONSELL: »Studies on Erysiphaceae with Special Regard to the Swedish Species.»

15.12 1967: KERSTIN GEZELIUS: »Studies in the Ultrastructure, Growth and Biochemical Differentiation of Dictyostelium discoideum Raper.»

18.12 1967: OLLE BJÖRKMAN: Comparative Studies on Photosynthetic Properties of Species and Races of Higher Plants from Ecologically Diverse Habitats.»

3.4 1968: BENGT JONSELL: »Studies in the North-West European Species of Rorippa s. str.»

3.5 1968: JAN PERSSON: »Biological Testing of Chemical Humus Analysis.»

17.5 1968: ERIK SKYE: »Lichens and Air Pollution.»

24.5 1968: JIM LUNDQVIST: »Plant Cover and Environment of Steep Hillsides in Pite Lappmark.»

I Göteborg

27.5 1968: HANS EDSBAGGE: »Zur Ökologie der marinen angehefteten Diatomeen.»

Botanisk Litteratur

(Botanical Literature)

JERMY, A. C. & TUTIN, T. G.: British Sedges. A handbook to the species of Carex found growing in the British Isles. — Botanical Society of the British Isles (BSBI), London, April 1968. 199 pp. 9+60 figs. Paperback. Price 17/6.

The large genus *Carex* contains about 220 species in Europe. The species often present identification problems to the non-specialist. But even for the more skilled botanists problems may arise when trying to identify, e.g. vegetative material or members of the critical groups. The reason for these difficulties may be partly that the *Carex* species are so numerous and partly that one does not always know the best distinguishing characters. Some species are also very variable and in some groups hybrids occur frequently.

This illustrated handbook of British sedges will certainly be of great help particularly to amateur botanists and ecologists. But also specialists will find new information within it. The practical size and shape of the book makes it very suitable in field work.

The book contains descriptions of 73 British *Carex* species. All but four of these occur in Scandinavia. In one of the introductory chapters (p. 11) the *Carex* plant is described with particular attention to the diagnostically important structures. In this account as well as in the descriptions the vegetative structures are stressed. This valuable information is chiefly based on field observations made by one of the authors, A. C. JERMY. A key founded on vegetative characters of the *Carex* species and other sedge-like species (p. 42) is presented. Last summer I have been able to test this key several times and it worked surprisingly reliably. I think that this key, one of the few published of this type, will be of much help to ecologists which often have to face the problem of determing non-fruiting material. A key to fruiting specimens is also presented (p. 30).

The descriptions are concise but nevertheless give much information on the variation of the species. The descriptions are all built up according to a common scheme which makes comparisons easy. The same conformity is also found in the illustrations. In the descriptions one misses information on the chromosome numbers. The ecology of the different species is given, often in detail. The distribution of the species on the British Isles is presented. Information on their distribution outside this area is lacking, however. In connection with the descriptions there is in many cases a brief discussion of species which can be confused with the species in question. The hybrids are also mentioned but not described.

The drawings accompanying the descriptions are usually good. In particular the detail drawings are skilfully made. However, in some cases they are somewhat over-simplified which is especially true of those of stem and leaf transections and the nutlets. When two species are illustrated in the same figure one has to consult the text in order to distinguish the partial figures.

The Latin names used sometimes deviate from those in use among Scandinavian taxonomists (cf. HYLANDER, Nordisk kärlväxtflora II, 1966). The synonyms (mainly from English floras) are found in the index of Latin names (p. 195) and in the contents. No synonyms are given in connection with the descriptions.

The classification of the genus has been treated only briefly, probably because it falls outside the scope of this book. Two subgenera are recognised, *Carex* and *Vignea*. The former recognised subgenus *Primocarex*, comprising species with a terminal spike, is entirely placed in subgenus *Carex* although the *Primocarex* is a heterogeneous group. Thus one finds *C. dioica* in subgenus *Carex* but *C. curta* (*C. canescens*) in *Vignea*. But these two species often form hybrids which may indicate a closer relationship (cf. HYLANDER 1966, p. 43).

This book is said to be the first in a series of handbooks and it is my hope that the subsequent ones will be equally useful and keep the same high standard.

ÖRJAN NILSSON

VAN DER PIJL, L. & DODSON, C. H.: Orchid Flowers. Their Pollination and Evolution. — University of Miami Press, Coral Gables, Florida, November 1967. X+214 pp. 48 full-colour illustrations. 121 figs. Clothbound. Price $ 12.50.

Orchids, pollination, evolution — there can hardly exist a more fascinating subject to deal with for a pollination ecologist. This book gives full evidence that the two authors have been as suitable for the task as they have enjoyed it. Their joint publication also gives the reader great satisfaction in following the thrilling and often intricate diversity of the orchid flowers and the mutual adaptions between the flowers and their pollinators. The exquisite layout of the book, the narrative illustrations, and the descriptions of the very complex and interesting phenomena in orchid pollination are kept in a style appealing to amateurs, orchid hobbyists and naturalists as well as to professional biologists and botanists.

Professor emeritus VAN DER PIJL has his main interest and activity directed to pollination ecology and reproduction of tropical flowering plants. From 1948 to 1954 he was Professor of Botany at the University of Java. Professor DODSON has mainly worked on pollination ecology, evolution, and taxonomy of orchids in Tropical America. He is now Associate Professor of Botany at the University of Miami and Curator of Orchids at the Fairchild Tropical Garden.

The first four chapters in the book present the morhology of the orchid flower with particular attention to its function in the pollination system. The next chapter presents the pollinators and gives a general classification of flower types adapted to different pollination agents. The interesting "pollinator-flower bonds" are also presented in this account. In the following six chapters the cooperation between orchid flower and different groups of pollinators, e.g., bees, butterflies, birds, and flies, is described with many interesting examples. In these chapters one gets glimpses of the enormous diversity in floral structures adapted to different pollinators which constitutes the background in the subsequent discussion on evolution and speciation of the orchids. One faces the question — what is the flower to the plant which bears it, and what is it to its pollinator. In chapter 11 the phenomenon of pseudocopulation is described. The last chapters deal with evolution and speciation in orchids and the functions of their flowers. Among the orchids the barriers to gene exchange between different taxa are in general the same as in other plant groups but the importance of biological barriers is perhaps more pronounced here. In speciation hybridisation probably plays a major rôle. The lack of endosperm in the seeds may be an important factor in allowing interspecific crosses. In the discussion on evolution one often meets the statement that "orchids and insects have wandered the paths of evolution hand in hand". The authors of this book stress a somewhat diverging opinion, viz., "that orchids have been quite facile at adapting to advantageous characteristics already present in existing pollinators". They mean that the evolution in orchids is rapid and of rather recent origin and that the pollinators of the orchids of today may have reached their particular characteristics "as adaptions to other much older plant groups".

In an appendix there is a presentation of the taxonomy of the orchid family and a list of orchids and their known pollinators. A glossary to used terms is given as well as a useful bibliography.

No other plant family exhibits such an enormous diversity in floral organisation as the orchids. Since long it has been known that this diversity is intimately connected with their pollination. The classic work of CHARLES DARWIN on this subject was published about one hundred years ago. The authors intend with their book to honor the Centenary of DARWIN's book, which has been a source of inspiration ever since it was published. I wish to express that their intentions have been carried through in an excellent manner.

ÖRJAN NILSSON

PIERRE BOURRELLY: Les Algues d'eau douce. Initiation à la Systématique. Tome II: Les Algues jaunes et brunes. — Éditions N. Boubée & Cie, Paris 1968. 438 pp. 114 planches. Prix 110 F.

Although Dr. BOURRELLY is wellknown as a productive phycologist with a large number of important publications, his effectiveness is still surprising. The green volume of his "Les algues d'eau douce", published in 1966, has already been followed by the yellow volume. Of course, in both cases there have been some previous preparatory publications. For the green volume, there was "Initiation pratique à la systématique des algues d'eau douce 1—8", and for the yellow one, the "Recherches sur les Chrysophycées". The final result foreshadowed in these preparatory publications, and now seen in the volumes published so far of "Les algues d'eau douce" is of high quality.

The latest volume is devoted to yellow and brown algae. The classes *Chrysophyceae*, *Diatomophyceae*, *Xanthophyceae*, and *Phaeophyceae* have been grouped together into the phylum *Chromophyta* s. str. Thus BOURRELLY has only accepted the ideas expressed e.g. by CHADEFAUD (1960) and CHRISTENSEN (1962) to some extent. He considers *Pyrrhophyta*, *Euglenophyta*, and *Raphidophyta* as phyla of their own, an opinion which seems to be well-founded. However, it would have been much better to replace the name *Chromophyta*, a very bad one, by something more appropriate. Even *Chrysophyta* s. ampl. would have been better.

The treatment of *Chromophyta* has been carried out according to the same pattern as that already used for *Chlorophyta* in the first volume. It is characterized by high quality and clarity. The author has managed to be as up-to-date as possible in the text, so there must have been good co-operation with the editor. In the description of each genus the approximate number of species has been indicated, and this is a valuable guide, especially as most of the handbooks available for identification are rather incomplete. E.g. it is always essential to know that there are at least 120 species of *Chromulina* to choose between in making an identification. PASCHER (1913) has 18, HUBER-PESTALOZZI (1941) has 54, MATVIENKO (1965) has 56, and STARMACH (1968) has 70.

There are at least 3500 freshwater species of *Chromophyta*, apportioned to 350 genera. The largest group is, of course, diatoms, with about 2000 freshwater species grouped into 66—67 genera. The descriptions of genera are followed by a large number of illustrations on 114 plates, and there are also many figures in the text. They are all of high quality, the only exception being two photomicrographs of diatoms, which have somewhat fuzzy details. The yellow pages at the end of the volume contain a useful key for the determination of the genera of the freshwater *Chromophyta*.

This volume, like the first, is indispensable for every serious phycologist.

KUNO THOMASSON

OPERA BOTANICA

is edited by the Lund Botanical Society in cooperation with the Institute of Systematic Botany, University of Lund. It consists of larger treatises issued at indefinite times. After vol. 12 the series is published in separate numbers, each with an individual price. The *reduced prices* for members of the Lund Botanical Society are indicated.

Vol. 1. N. Hylander, I. Jørstad and J. A. Nannfeldt: Enumeratio Uredinearum Scandinavicarum. 1953. 102 pp. — H. Horn af Rantzien: Middle Triassic Charophyta of South Sweden. 1954. 83 pp. — H. Hjelmqvist: Die älteste Geschichte der Kulturpflanzen in Schweden. The Oldest History of Cultivated Plants in Sweden. 1955. 186 pp. — Sw. kr. 15.

Vol. 2. H. Runemark: Studies in Rhizocarpon. I. Taxonomy of the Yellow Species in Europe. 1956. 152 pp. — H. Runemark: Studies in Rhizocarpon. II. Distribution and Ecology of the Yellow Species in Europe. 1956. 150 pp. — G. Knaben: On the Evolution of the Radicatum-Group of the Scapiflora Papavers as Studied in 70 and 56 Chromosome Species. A. Cytotaxonomical Aspects. 1959. 76 pp. — Sw. kr. 15.

Vol. 3. A. Gustavsson: Studies in Nordic Peronosporas. I. Taxonomic Revision. 1959. 271 pp. — A. Gustavsson: Studies in Nordic Peronosporas. II. General Account. 1959. 61 pp. — G. Knaben: On the Evolution of the Radicatum-Group of the Scapiflora Papavers as Studied in 70 and 56 Chromosome Species. B. Experimental Studies. 1959. 96 pp. — Sw. kr. 15.

Vol. 4. R. Dahlgren: Revision of the Genus Aspalathus. I. The Species with Flat Leaflets. 1960. 393 pp. — Sw. kr. 15.

Vol. 5. Áskell and Doris Löve: Chromosome Numbers of Central and Northwest European Plant Species. 1961. 581 pp. — Sw. kr. 20 (bound Sw. kr. 28).

Vol. 6. Å. Persson: Mire and Spring Vegetation in an Area North of Lake Torneträsk, Torne Lappmark, Sweden. I. Description of the Vegetation. 1961. 187 pp. — R. Dahlgren: Revision of the Genus Aspalathus. II. The Species with Ericoid and Pinoid Leaflets. 1—2. 1961. 120 pp. — Å. Persson: Mire and Spring Vegetation in an Area North of Lake Torneträsk, Torne Lappmark, Sweden. II. Habitat Conditions. 1962. 100 pp. — Sw. kr. 20.

Vol. 7. N. Malmer: Studies on Mire Vegetation in the Archaean Area of Southwestern Götaland (South Sweden). I. Vegetation and Habitat Conditions on the Åkhult Mire. 1962. 322 pp. — II. Distribution and Seasonal Variation in Elementary Constituents on Some Mire Sites. 1962. 67 pp. — Sw. kr. 20.