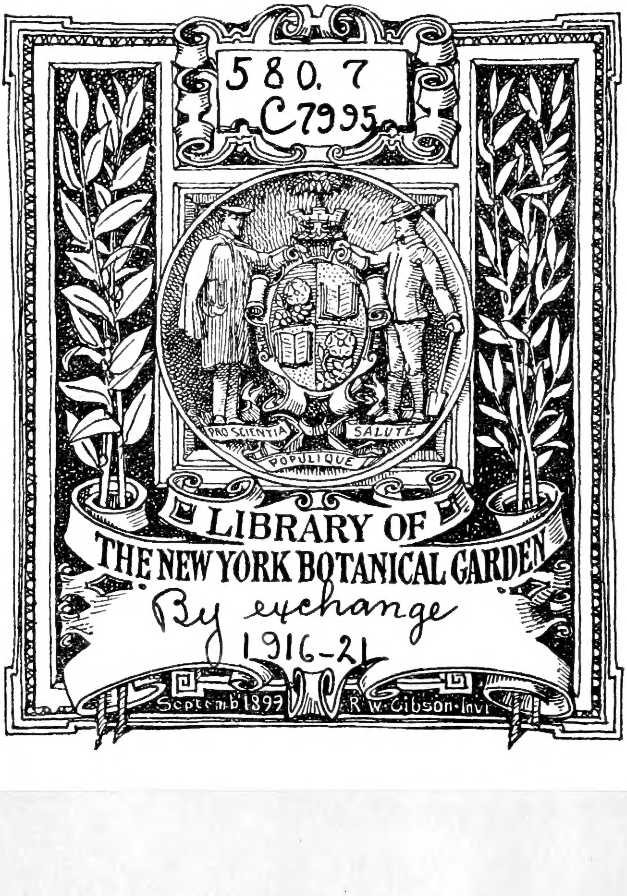

The Structure and Biology of Arctic Flowering Plants.

II. 1.

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Hitherto, the following papers have been published (Vol. XXXVI in "Meddelelser om Grønland"):

8.

Rosaceæ.

By

Knud Jessen.

1913.

In the present paper I have given an account of the growth-forms and of the anatomy of the root, stem and leaf, and also of the flower-biology, of some Arctic and Subarctic *Rosaceæ* in a similar manner to my work on the Arctic *Ranunculaceæ* (vol. 36). — In addition to the alcohol-material in the Bot. Museum in Copenhagen and the herbarium in the same place I have also made use of the literature in order, as far as possible, to collect in one place what is known about these plants.

I wish to convey to Professor Warming my thanks for the readiness with which he has placed at my disposal his notes from his journeys in Arctic Norway and Greenland. Some of the figures are drawn by him and a good many of these have not previously been published. The rest of the figures, with the exception of figs. 8 and 26, have been drawn by myself.

The following species have been investigated: —

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Potentilla palustris (L.) Scop.

Lit. IRMISCH, 1861. LINDMAN, 1884. WARMING, 1884. KNUTH, 1894. KÖLPIN RAVN, 1894. NORMAN, 1895. ASTRID CLEVE, 1901. FREIDENFELT, 1904. SYLVÉN, 1906. WOLF, 1908.

Potentilla palustris is widely distributed over a great part of the northern hemisphere. It lives in Arctic and Subarctic regions and extends southwards as far as 40° N. lat.; and the monographer of the *Potentillas*, TH. WOLF (l. c.), states that it is highly probable that the species is a remnant of the Arctic tertiary flora and that it has doubtless only recently — perhaps during the Glacial period — advanced southwards. It is everywhere confined to boggy and peaty soil and thrives best at the edge of swamps and high-moors among the peat-forming mosses. NORMAN (l. c.) writes that in Arctic Norway it frequently occurs on the strand and he believes that it is in part distributed by ocean-currents.

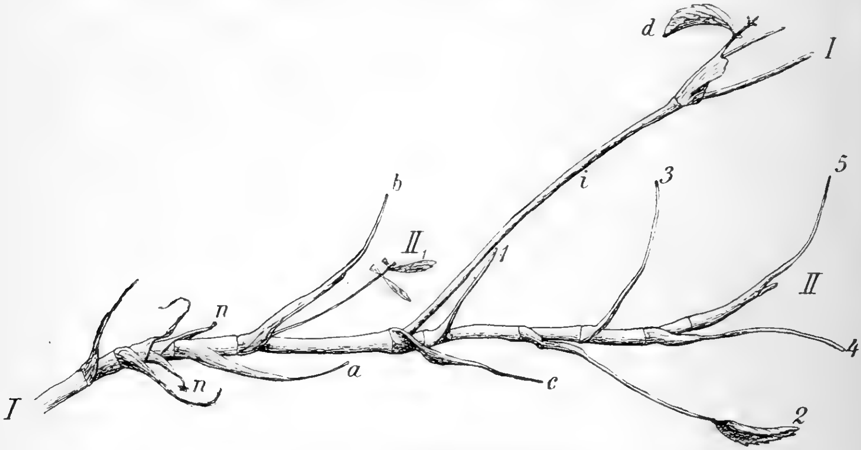

Fig. 1. *Potentilla palustris.*

(Denmark, Oct. 20, 1912; about 1/2). The leaves are dead. *n, n,* Scale-leaves of the winter bud, 1911—1912; its internodes are slightly elongated; *a, b, c, d,* foliage-leaves on axis I unfolded during early summer; *i,* floral axis; *c* subtends the principal shoot II with the leaves 1—5 which have unfolded during summer; *b* subtends a supplemental shoot ("Bereicherungsschuss").

The alcohol material on which the following description is based was collected in Greenland and in Denmark.

The figure given of the structure of the shoots of *Potentilla palust.*, illustrates a common feature as regards the shoot-succession when flowering begins. After the winter-bud, which is shown by the short internodes, the first 2—3 elongated internodes of the floral shoot form a continuation of the older axis, while the following internode constitutes the basal part of the ascending branched floral axis. Often even before flowering begins the principal bud grows out, subtended by the leaf (Fig. 1, c) which is seated at the base of the flower-stalk, and forms a sympodial continuation of the axis. But different specimens from the same locality, at any rate in Denmark, may differ greatly as regards the degree of development reached by the principal shoot during the year in which the parent-shoot flowers, in that the length may vary from 2 cm. to about 10 cm., and this proleptic development is by no means a fixed rule even though it is certainly typical in temperate regions. By comparison of herbarium specimens from Denmark, Iceland and Greenland in the Botanical Museum in Copenhagen, it appears, however, to be the rule that the proleptic development of the principal shoot is rarer in the two latter countries than in Denmark, and rarer in Greenland than in Iceland. It was found to be the rule among the Greenland specimens that the principal bud did not emerge until next spring. In vigorous specimens from Denmark, the leaves *a* and *b* in Fig. 1 also often subtend proleptically developed supplemental shoots ("Bereicherungsschüsse") while such were not found in the Greenland specimens in the herbarium, and in only a few of those from Iceland did the leaf *b* subtend a slightly precocious shoot. This proleptic development may perhaps be regarded, for instance, as a weapon in the struggle against the mosses among which *Potentilla palustris* commonly grows; since if the growth in length of the obliquely placed stem was arrested in the middle of summer by the formation of the floral shoot it might easily be overgrown by the mosses.

Furthermore, a more extensive assimilation is attained by the expansion of the new leaves.

Other leaves also may subtend shoots which, however, usually do not grow out until next summer, and it should be mentioned that such shoots which pass their first winter in bud differ in certain respects from vigorous precocious shoots; the latter begin with a more-or-less elongated internode, and the first leaf is a foliage-leaf, so that they can begin to assimilate immediately, while the other shoots begin with 1—3 short internodes and the first 1—3 leaves are scale-leaves.

After germination — probably in the spring — *Potentilla palustris* begins a stage of vegetative growth which lasts for several years. The first year it may form a rosette, but even then may also have elongated internodes (IRMISCH, SYLVÉN, WARMING).

The primary root is slender, but does not die during the first year (WARMING); afterwards the plant is entirely dependent on its adventitious roots which according to IRMISCH arise upon the epicotyledonary axis even during the first year. So far as I have observed they do not arise upon the proleptically developed shoots until during their second summer. The brown, somewhat compressed stem may attain a considerable length: I have dug up sympodia above two metres in length; they may live for at least seven years. As the stem branches freely, vegetative propagation takes place abundantly.

The two-rowed leaves usually live for one summer only, but SYLVÉN says that a single leaf may pass the winter in a green condition. After the leaves have died the large sheaths persist and those seated at the apex of the year's shoot envelop the winter-bud; in the latter a few scale-leaves may also be developed (see Fig. 1).

In Denmark there is no fixed rule as to the height above the surface of the bog at which the shoot-apex lives through the winter. Some shoot-apices are found raised as much as 10 cm. above the surface, while others are at the surface, and others again are overgrown by the sphagnum of the bog. To judge from specimens in the Copenhagen herbarium it is not a fixed rule for the shoot-apices to die away during winter in Greenland and Iceland, though they no doubt often do so; normally the plant forms a monopodium till flowering begins. In the event of the shoot-apex dying during winter there will always be found a lateral bud upon the stem, situated at the surface of the bog or below it, which can continue the life of the plant.

Irmisch does not understand why this plant is not reckoned among woody plants as much, for instance, as *Vaccinium oxycoccus*, and Warming (1884) very properly calls it a shrub. When *Potentilla palustris* is a chamæphyte it certainly resembles most closely a dwarf shrub, but the case becomes more doubtful when the plant is a hemicryptophyte or helophyte. Sylvén, Th. Wolf and Ascherson and Graebner[1] mention it as an undershrub.

Anatomy. The adventitious roots proceed from the nodes of the stem especially during the second period of vegetation; they branch abundantly, but in each system there is always a well-marked main axis. The anatomy has been treated by Freidenfelt (l. c.). I have, on the whole, found the structure to be the same as that which he describes, but in my material there were no roots with periderm. The epidermis was characterized by being exceedingly small (Fig. 4, *A*); its contents were always brown in colour. In the periphery of the cortex of the adventitious roots of the first order there occur a few layers of cells with slightly thickened walls; intercellular spaces are absent from this part; in the inner part of the cortex the latter are large, and lysigenous lacunæ occur. The endodermis is rather thick-walled. Freidenfelt records that the primary cortex ultimately dies and falls off, a peri-

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[1] Synop. d. mitteleurop. Flora. Bd. VI, 1, p. 663.

derm being formed — the latter contains small intercellular spaces — and a secondary woody part. The most vigorous roots in my Greenland material had just begun the development of these structures, but the cortex was living and contained a large amount of starch especially in the part within the exodermis.

In the cortex of the absorbent roots from Greenland fungal hyphæ occurred; these are also recorded by FREIDENFELT in plants from Sweden.

The creeping stem is distinguished anatomically from the floral shoot, partly by its secondary formations and partly by the fact that normally bast is absent from it.

The epidermis of the year's shoot is rather small-celled, the outer wall is about 4.5 μ thick; and the outermost layer of the cortex is slightly collenchymatous. The cortex, in the middle, consists of especially large cells, some of which die at an early period, forming large lacunæ separated by radiating trabeculæ. The cortex of the floral stem behaves in the same manner. During the first period of vegetation the cortex of the shoot dies, but it is found attached to the shoot even during the third year. The central cylinder is surrounded by an endodermis. In the floral shoot the several-layered pericycle is transformed into bast tissue, and only in one particular case did I find bast in the rest of the shoot also, viz. in a plant which grew among shrubs and whose annual shoots of the three last years protruded about ½ metre vertically above the surface of the bog.

The periderm is formed in the outermost layer of the pericycle, and even in the first period of vegetation it reaches a thickness of several layers. Moreover it appears to be stronger in Arctic specimens, and while in Denmark, at any rate when young, it probably does not contain cork-cells, in the material from Greenland 1—2 layers of phelloid-cells alternated with one layer of cork-cells, and as many as 6 layers of the latter may occur. The periderm contains fairly large intercellular spaces, which however are always absent from the inner side of the cork-layers. On older parts of the stem the periderm peels off as brown concentric flakes.

During the first period of vegetation of the shoot is formed the greatest amount of the total secondary wood, since often the addition during following years is only a few layers thick. The annual rings are, however, fairly distinct. The structure of the wood is regular, one-layered medullary rays being separated by vessels and tracheids in one to a few layers. Some wood-parenchyma is, however, also present.

The pith is heterogeneous. It consists of a broad peripheral part of homogeneous living cells which lasts during the life of the shoot, and in addition of a central part which dies away early. The pith, the medullary rays, the pericambium and the phelloid tissue are the chief depositories of food-material, and during autumn they are filled with starch, but on investigating the shoots in November it will be found that almost all the starch has disappeared and has been replaced by fat the presence of which is indicated by use of Sudan III. In Denmark this change takes place in October.

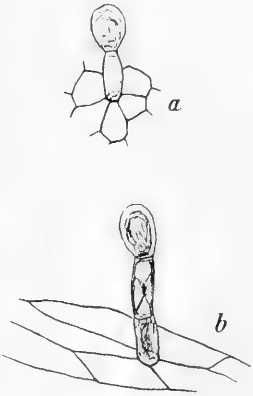

Fig. 2. *Potentilla palustris.* *a* and *b*, Glandular hairs from the lower surface of a leaf from Denmark (Bagsværd); $^{220}/_{1}$.

The imparipinnate leaves are covered on both sides to a greater or less degree with hairs of the usual unicellular form; older leaves are often almost glabrous. IRMISCH (l. c.) writes that in the young plant the leaf-stalk and the margin of the leaves bear stalked glands, and on older plants he found such glands also on the leaves which had developed during spring, while they were absent from the leaves which had unfolded later in the summer. In the neighbourhood of Copenhagen I found in spring numerous glands upon both sides of the leaf (Fig. 2) and upon the leaf-stalk of *Potentilla palustris*, but they were wanting later in the summer, probably they had then fallen off. With the exception of a few specimens, leaf-glands were entirely absent from the Greenland plants which have been investigated.

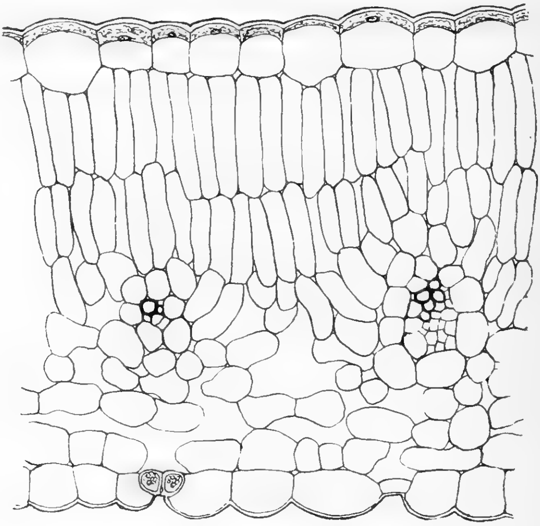

Fig. 3. *Potentilla palustris.*

Transverse section of leaf from Ivigtut in South Greenland ($^{260}/_{1}$). The inner wall of the epidermis of the upper surface is highly mucilaginous.

The under side usually presents a greyish blue colour; this is perhaps due to a thin, granular covering of wax, which must, in addition to the hairs, serve to prevent the under side, which is rich in stomata, from getting wetted.

Stomata may also be found on the upper side; they then occur either singly or in groups (Fig. 4, *C*). The stomata are sunken (Fig. 3). The upper side is slightly reticulated and the outer wall of the stout epidermis is not specially thick, about 2.5 μ; the inner wall is highly mucilaginous (Fig. 3). The palisade parenchyma usually consists of two layers which may be more or less strongly developed; the leaf figured has a relatively compact structure. The spongy parenchyma is rather loose in structure (Fig. 4, *B*), and a slit-like lacuna is often found within the subepidermal layer. No stereom proper is present in the leaf, only along the main bundle some bast occurs.

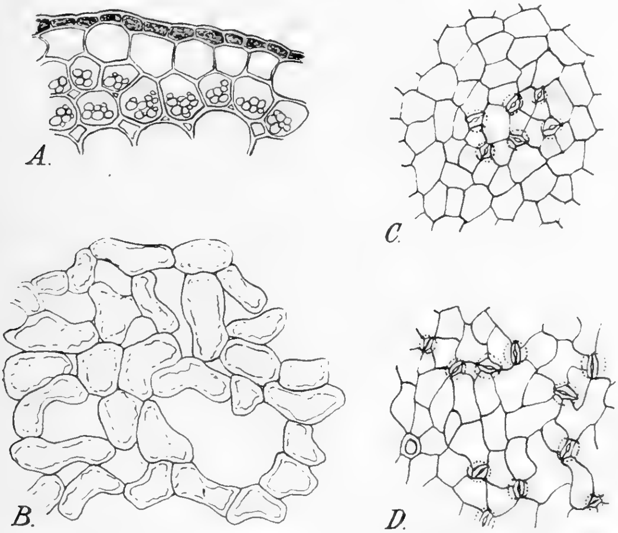

Fig. 4. *Potentilla palustris.* (From Ivigtut in South Greenland). *A,* Epidermis and the outermost layer of cortex of an adventitious root of the first order; the epidermis is about 6.5 μ high. *B,* Section of the spongy parenchyma of the leaf. *C,* Epidermis af the upper and *D* of the lower surface of the leaf. (*A, B,* $^{290}/_{1}$; *C, D,* $^{130}/_{1}$).

At the apex of the leaf-teeth there are hydathodes with water-stomata on the upper side of the teeth.

The dark brown flower is about 25 mm. in diameter (Knuth); the petals are small, about three times as short as the sepals. It is usually stated that the petals persist while the fruits are ripening (e. g. by Irmisch, Lindman, Knuth and Neuman in "Sverige's Flora"), the sepals after pollination closing round the inner parts of the flower, but

TH. WOLF, on the other hand, states that they fall off after flowering. The flower-biology has been exhaustively described by HEINSIUS[1] and KNUTH (l. c.) from Holland and from the North Frisian Islands respectively; unfortunately my Greenland material contained only a very few flowers, but they corresponded with the descriptions of the above authors in being decidedly proterandrous. According to KNUTH *Potentilla palustris* behaves as follows: Shortly after the young flower has expanded, the extrose anthers on the numerous erect stamens open; when the anthers have fallen off the filaments bend outward toward the calyx and the corolla so that room is made for the stigmas which are now furnished with small, yellow stigmatic papillæ. The flowers are eagerly visited by bees. Honey is secreted by a green disk between the carpels and the stamens; this had already been observed by KONRAD SPRENGEL. NORMAN writes that the great amount of honey contained in the flowers attracts numerous insects, flies, butterflies and bees, which continue to visit the flower a long time after fertilization has taken place.

The time of flowering is in Central Europe in June and July; in Arctic Norway it begins about July 20; in the mountains of northern Sweden it is recorded to be in August, in Greenland in July and August. In specimens from Denmark I found young flower-buds in the beginning of May, while such were not found in the middle of March. So the flower-development probably begins at the same time as the closely folded winter-bud begins to open. In some of the northernmost localities of Arctic Norway it may happen that flowers are not developed. Miss CLEVE found no fruit in the mountains of northern Sweden.

The theory advanced by NORMAN that in the coastal districts of Norway *Potentilla palustris* is dispersed by marine currents is borne out by the fact that the fruit is

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[1] Bot. Jaarboek, 1892, Tab. II, figs. 7—9.

certainly able to float. This point has been discussed by Kølpin Ravn (l. c.) among others. He found that the fruits keep afloat even while they are germinating, and anatomical investigation showed that the thick testa consists of several layers of cells, which contain air. The inner part of the pericarp consists of protective stone-cells.

Potentilla tridentata Soland.

Lit. Hartz, 1894; Wolf, 1908.

This plant grows in Greenland, Arctic North America, Labrador, Newfoundland and Canada. It occurs in clefts of rocks, on lichen-heaths and in other dry localities.

The alcohol material was collected in the following localities in Greenland: Christianshaab, Ivigtut, Sukkertoppen and Holstensborg.

Lange and Wolf call *Pot. tridentata* an undershrub, and as is the case in *Potentilla palustris* the lignified axis lives several years. It is a typical wandering plant with a horizontal, richly branched rhizome from which slender adventitious roots arise. Usually the runners, which may be above 30 cm. long, are etiolated and bear scale-leaves, but creeping shoots with elongated internodes, bearing only foliage-leaves, are also met with; such epiterranean shoots may also be ascending. The scale-leaves are distichous. The shoots which arise from the runners and which often grow out from older stems have probably a life-cycle of several years. In the first period of vegetation they are wandering and pass the winter with straight apex, and not until the second period or perhaps even later do they enter the rosette-stage and form foliage-leaves. It appears to be necessary for the young rosettes to pass through a stage of vegetative growth before they attain the flowering stage. The apex of the rosette-shoot is protected during winter by the large, closely folding sheaths of the older leaves; scale-leaves are probably not developed (Fig. 5,A, B ,C). The foliage-leaves probably remain green during winter; when they die the three leaflets fall off separately, and the stalk persists (Fig. *A*). The floral shoot is terminal and the principal bud arises in the axil of the uppermost rosette-leaf; it begins with a small transversly placed scale-leaf, and opens its first foliage-leaf in the year in which the parent-shoot flowers. As other lateral shoots may be developed in the rosette, the plant may form loose tufts. The floral axis bears a few foliage-leaves below the often profuse inflorescence.

Fig. 5. *Potentilla tridendata.*

A, Flowering rosette-shoot; *i*, floral axis; the principal bud II is borne in the axil of the uppermost rosette-leaf, the dead leaf-stalks are seen below the fresh leaves. *B*, Drawn from a herbarium specimen; a scale-leaf upon an older and now flowering shoot subtends a new runner. *C*, Apex of a runner. *D*, Carpel; the ovaries are hidden by long hairs. *A*, *C* are from Ivigtut, 20. 8. 1883; *B* from Ivigtut, 1868; *D* from Præstefjæld (*A*, *B* and *C* about natural size: *D* $^{12}/_{1}$).

ANATOMY. Only older adventitious roots have been investigated. The phelloid of the periderm contains, as in the rhizome, scattered thick-walled wood-cells. The cells of the cork-layers are rather thick-walled. The intercellular spaces are fairly large.

The young runner is protected by a strong epidermis the outer and inner walls of which measured 4.4 μ and 3.5 μ respectively. The outermost layer of the cortex is also fairly strong, but otherwise the thick cortex is rather loose and perishes early. The central cylinder which is surrounded by an endodermis contains only a few primary bundles and a homogeneous pith of long duration. A continuous cambium develops during the first period of vegetation a considerable amount of wood as in *Pot. palustris.* This — the secondary wood — consists, in addition to large vessels, of one-layered medullary rays usually one layer high, and also of about equal quantities of thick-walled stereom-cells and woody parenchyma. Some indistinct annual rings may be distinguished in the older rhizomes which may attain an age of at least about ten years. The periderm is thick and consists of series of layers of usually 3-layered phelloid separated by one layer of cork. The outer tangential wall of the cork-cells is especially very thick. Some of the older phelloid-cells in rhizomes from several localities had very thick walls which were lignified (Fig. 6, H). These strengthening cells form connecting bands between the vigorous cork-cells in the periderm and probably thereby delay the peeling-off of the latter. There are large intercellular spaces in the periderm; these are, however, absent from the inner side of the corky layer.

The often rather tall flowering shoot is stiffened partly by a strong bast cylinder situated outside the sieve-tissue, and partly by the secondary wood formed by a continuous cambium the peripheral part of which consists chiefly of thick-walled tracheids. The tangential walls of the epidermis are strong, the outer one measured $4.5\,\mu$ and the inner $3.3\,\mu$. The outer layers of the cortex are somewhat collenchymatous and as the otherwise loose cortex is rather few-layered, the outer stereom-ring is close to the periphery of the stem. An endodermis is present.

The pith consists of a narrow, small-celled peripheral part formed of living cells only, and a larger central part consisting of larger cells of which a greater or smaller number often dies, but nevertheless the shoot cannot be called hollow.

The leathery leaf, which is 238—270 μ thick, has a decidedly xeromorphic structure in correlation with the fact that the plant grows in dry localities; perhaps it also may live through the winter. It is glabrous upon the upper surface, but upon the lower surface it bears in addition to scattered adpressed hairs of the common type also numerous glandular hairs of two other forms (Fig. 6, E, F.). In the smaller form the apical cell is almost spherical and in the larger ovate to cylindrical. The stalk is often several-celled. These hairs spring from epidermal cells which are smaller than the rest and have a thin outer wall. Perhaps these hairs with their thin-walled and plasma-filled apical cells are able to absorb water which may then be carried into the leaf. Both the upper and lower epidermis have very strong outer walls; thus that of the upper surface measured between 8 and 11 μ and that of the lower about 11 μ. The lower surface of the leaf is moreover highly reticulated. The lower epidermis in particular has a strong cuticle which is somewhat rough. The epidermis of the upper surface is characterized by its tangential walls being mucilaginous to a very high degree, especially the inner; the mucilaginous covering is always wanting above the larger bundles. (Fig. 6, A.). Both leaf-surfaces bear stomata, but upon the upper surface they are very scattered and are surrounded by a group of smaller cells (Fig. 6, B). Upon the lower surface they are placed closely and are not definitely arranged. They are sunk below the level of the surface (Fig. 6, *A*). The radial walls on both the upper and lower surface are only slightly wavy; they are highly perforated on the lower surface (Fig. 6, *C*); on the upper surface the pores occur in larger quantities only near the bundles.

The palisade parenchyma occurs in 2—3 layers of closely

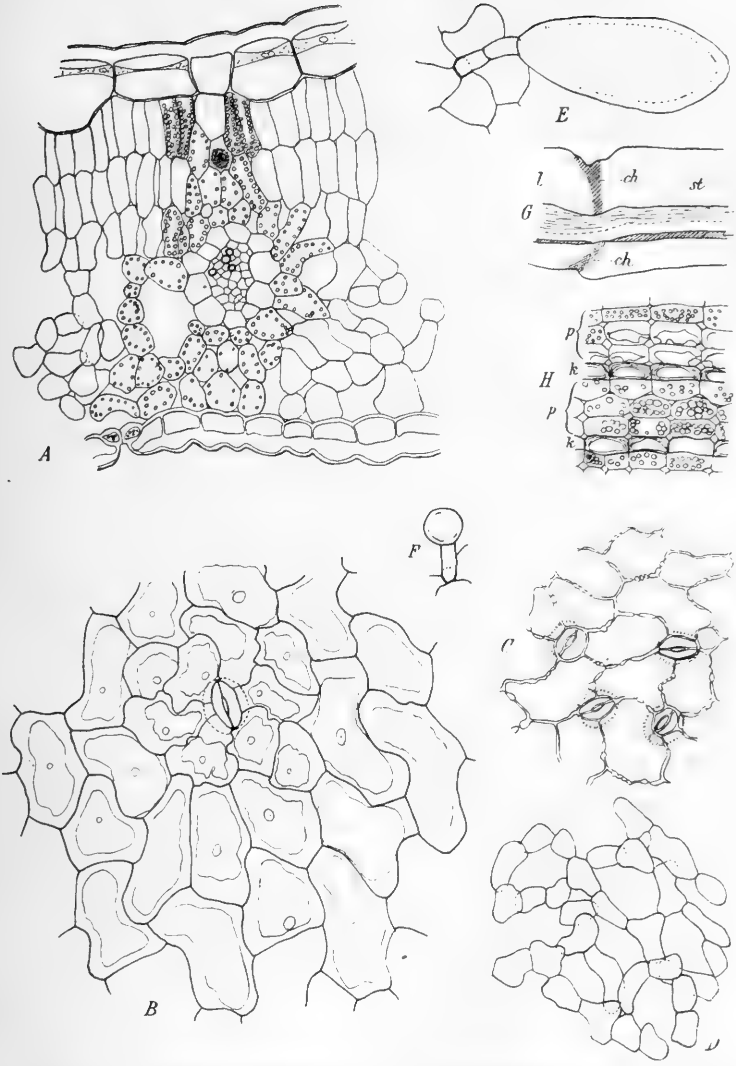

Fig. 6. *Potentilla tridendata* (From Christianshaab in Greenland).

A, Transverse section of leaf; both the tangential walls of the upper epidermis are mucilaginous. *B*, Epidermis of the upper leaf-surface, a stoma is seen surrounded by small cells. *C*, Epidermis of the lower leaf-surface. *D*, Section parallel to the surface of spongy parenchyma from the middle of the leaf between a pair of bundles. *E* and *F*, Two glandular hairs from the lower leaf-surface. *G*, Longitudinal section of leaf-stalk through the zone where the leaf-blade is cast off; *b*, bast; *ch*, collenchyma; *l*, the basal portion of the leaf; *st*, stalk; *x*, xylem. *H*, Fragment of a transverse section through the periderm of a rhizome; *k*, cork-layer, the striation of the walls is not so distinct as shown in the figure; *p*, phelloid-cells; the upper side is the outer. (*A*, *B*, *C*, *D*, *E*. *F* and *H* $^{220}/_{1}$; *G* $^{18}/_{1}$).

placed narrow cells, which to a certain extent are grouped around the bundles. The proportion between the thickness of the leaf and the thickness of the palisade parenchyma is about $\frac{2.4}{1}$. The spongy parenchyma is built in such a manner, that between the bundles in the middle of the leaf areas occur where the intercellular spaces are very large. This structure has this effect that the thick, solid leaf succeeds in getting a well-developed system of larger canals in the respiratory tissue[1]. For the rest the spongy parenchyma consists of rather small cells of simple form (Fig. 6,*D*).

The larger vascular bundles are accompanied by bast both upon the upper and the lower surface. The leaves are very rich in sphaero-crystals which occur especially along the bundles.

When the trifoliolate leaves die, the leaflets fall off separately, as mentioned above, and leave a scar upon the leaf-stalk which persists upon the rhizome for a year or more. Fig. 6, *G* shows a median, longitudinal section through a leaf-stalk just below the blade. The leaf-fall is in several ways prepared for through the anatomical structure. The three bundles of the leaf-stalk divide, so that three enter each leaflet. The bundles of the median leaflet are all of almost the same strength, and lie in almost the same plane; in the lateral leaflets the two lateral bundles are very small. In the zone where the leaflet is to be thrown off there is no bast along the bundles, as is the case both in the leaf-stalk proper and along the main bundles of the blade, and the zone in question is further distinguished by a collenchymatous area which extends straight through the stalk. In the peripheral part of the collenchymatous area the direction of the line of separation is indicated by the longitudinal direction of the cells; thin-walled areas further facilitate the falling process.

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[1] Cf. *Coptis trifolia.* Arct. Flow. Pl., I, 6. *Ranunculaceæ*, by KNUD JESSEN; Fig. 58, B. Meddel. om Grönland, Bd. 36.

The leaf-stalk is also stiffened, in addition to the fibrous tissue of the bundles, by some collenchyma which at the angles attains a thickness of several layers. The outer wall of the epidermis is also strong.

The open, cymose inflorescence is few- to many-flowered. The entire petals are white, and the stamens — 20 in number — have very long reddish filaments. The diameter of the flower is 10—15 mm. (Wolf). The flower is scentless; there is a greenish yellow disk around the base of the stamens; the intensely flesh-coloured anthers appear to dehisce before the stigma is functional (Warming's notes). Investigation of about 10 flowers preserved in spirit and collected from different districts in Greenland showed that the minute stigma of the long styles does not bear papillæ even in flowers which were so old that the anthers had fallen from the filaments. In spite of a close search I found only one pollen-grain upon a stigma; among the crowded long hairs of the gynophore much pollen is usually found in older flowers. The anthers form pollen abundantly, which is, apparently, capable of germination. Warming states in his notes that in some inflorescences from the previous year from different localities in Greenland he found a few fruits which appeared to be ripe. Hartz (1894) found *Pot. tridentata* in flower on Præstefjæld on June 15, 1890; the flowering is continued into September.

Potentilla pulchella R. Br.

Lit. Andersson and Hesselman, 1900. Simmons, 1906. Wolf, 1908. Lundager, 1912.

This is a purely Arctic species; it grows in Spitzbergen, Greenland, Arctic North America and on Wrangel Island off N. E. Siberia. Its habitats are rocky and grassy flats. — The alcohol material I had for investigation was from Snenæs in N. E. Greenland and Tempel Bay in Spitzbergen.

Pot. pulchella has a vigorous multicipital primary root, which may attain a considerable length — about 30 cm. or perhaps more — and probably lives as long as the plant; adventitious roots are probably not developed. The often numerous, rosette-leaved shoots are usually very close-set, and solid tufts of considerable size (about 20 cm. in diameter) may be formed. The new leaves project between the crowded

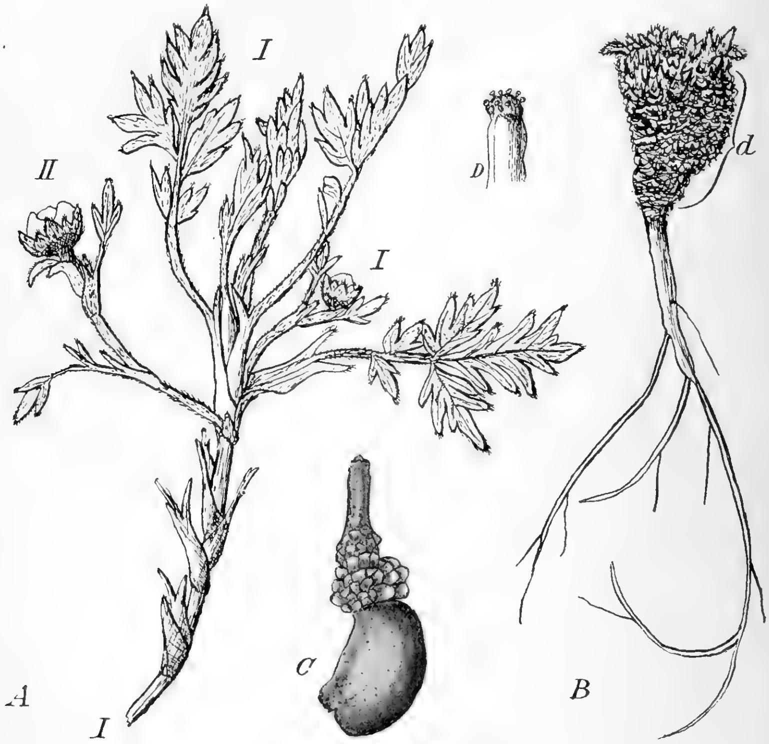

Fig. 7. *Potentilla pulchella* (From Snenæs in Greenland).

A, Shoot with internodes elongated to an unusual degree; *I—I*, the monopodial main axis bearing in its basal part dead fragments of leaves from the previous year; *II*, flowering lateral axes (12. 7. 1908; the upper floral axis is wrongly marked *I*); about natural size. *B*, *f. humilis; d*, closely packed dead fragments of leaves; at the top the living leaves form a layer a few mm. in height (22. 6. 1908); about natural size. *C*, Pistil which has not as yet received any pollen; ${}^{25}/_{1}$. *D*, Fragment of a style with stigma upon which are germinating pollen grains; ${}^{25}/_{1}$.

old leaves and their remains. The older portions of the stems appear ultimately to become bared (WARMING's notes). The prostrate floral shoots (TH. WOLF) are lateral (Fig. 7, *A.*); their subtending leaves are often dead when they flower, so that they arise from the stem below the terminal rosette. The leaf-sheaths are large and closely folded around the young leaves at the apex of the stem. I found no scale-leaves. The much divided leaves are densely hairy especially in LANGE's *f. humilis*, the leaves of which bear long close-set hairs on both sides, while his *f. elatior* is only slightly hairy upon the upper surface. LUNDAGER (l. c. p. 406) writes regarding *f. elatior* that on Lille Snenæs in N. E. Greenland it was found along river banks, and had very long roots which might reach a length of 1.15 metre "and to a great extent were lying so high that a portion of them lay bare." On the other hand, he found *f. humilis* on gravel-banks exposed to the wind and so greatly influenced by the sand-drift that they acquired columnar forms, "pillars," as shown in figures 7, *B* and 8.

Anatomy. The very slender absorbent roots contain fungal hyphæ in the large-celled, few-layered cortex. The epidermis dies early and collapses; the same happens to large portions of the cortex with the exception of the exodermis and the cell-layer outside the strong endodermis. The structure of the exodermis is specially strong, its radial walls, especially on the outside, being highly thickened in the same manner as in *Pot. emarginata.* Secondary growth in thickness begins early in the roots and also the formation of periderm. Usually I found in the lateral roots a continuous woody portion with scattered vessels, but in these roots the woody portion may also be divided into radiating parts separated by broad non-lignified medullary rays. This is what happens in the primary root, and owing to this structure and also on account of its considerable thickness (5—6

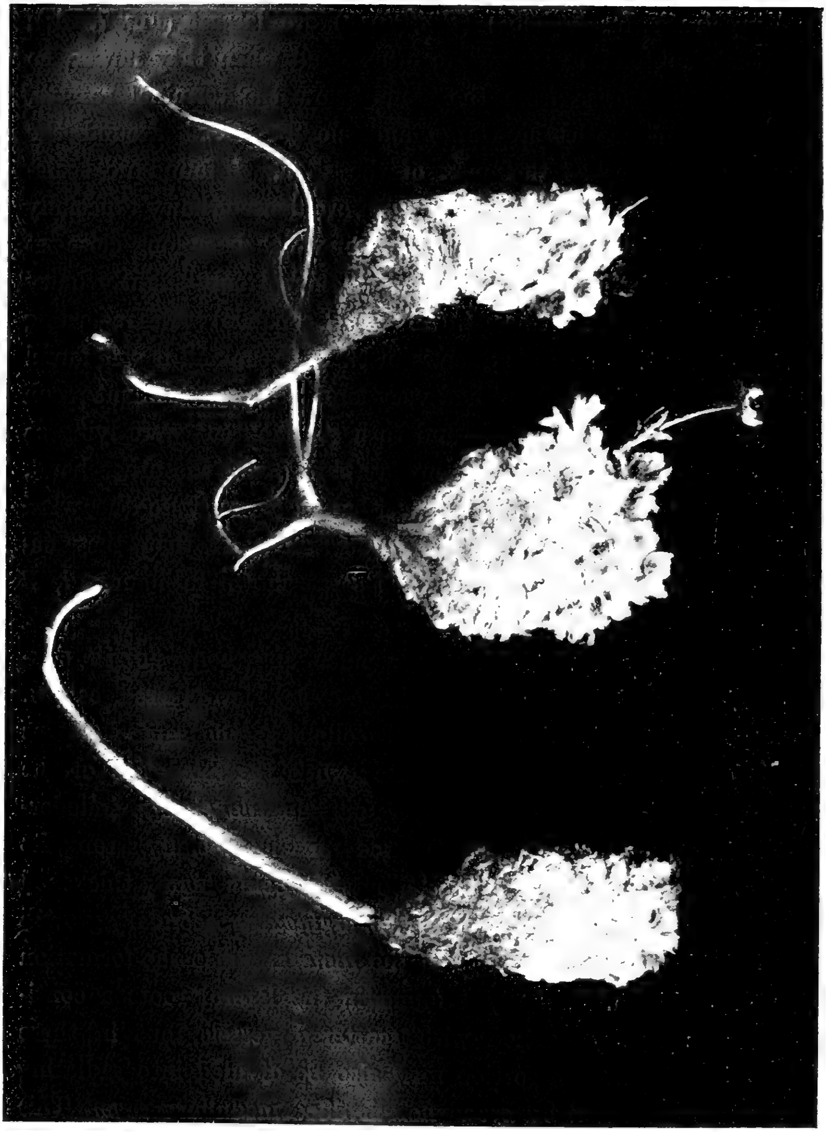

Fig. 8. *Potentilla pulchella*; "pillars" from N. E. Greenland (Nat. size).

(From *C. H. Ostenfeld* and *Andr. Lundager*: List of vascular plants from N. E. Greenland. "Meddel. om Grønland", XLIII, København, 1910).

mm.) it becomes a spacious reservoir of food-material. A plant collected on Snenæs in the middle of June contained in the primary root in addition to some starch large quantities of fat. The walls in the older secondary cortex are collenchymatous and the tissue has the appearance of being highly compressed. — The periderm around the roots does not attain any considerable thickness (about 10 layers) and consists of alternating layers of cork and phelloid. Small intercellular spaces occur between the phelloid-cells, but there are probably none upon the inner side of the cork-layers.

The structure of the rhizome is similar to that of the primary root, the vessels being gathered into rays rich in parenchyma and separated by broad non-lignified medullary rays (Fig. 9, *G.*). Distinct annual rings were not observed either in the rhizome or in the primary root. The pith is large and persistent; it contains large intercellular spaces. The secondary cortex becomes compressed by the growth in thickness; the walls are somewhat collenchymatous. In the young rhizome there is an endodermis. The periderm consists of layers of cork and phelloid-cells which alternate; it does not attain any considerable size (about 8 layers). Intercellular spaces occur as in the root. In a rhizome collected on July 12 on Snenæs (N. E. Greenland) in addition to some small-grained starch a considerable amount of fat was found in all the living tissues.

The flower-stalk contains about 10 vascular bundles; no continuous cambium is developed. There is no endodermis proper. In the older stalk the several-layered pericycle is probably transformed into bast; but my material contained young stalks only. The few-layered cortex consists of an inner part with large cells without chlorophyll and an outer part with chlorophyll; in the latter the outermost cell-layer is slightly collenchymatous. The outer wall of the epidermis is about 3 μ thick. The pith is homogeneous.

Fig. 9, *A* shows that the leaf-margins may be revolute, which is especially the case in *f. humilis;* and the tomentose hair-covering of the lower surface is a good protection for the leaf against the danger of excessive transpiration. Both leaf-surfaces have scattered glandular hairs. Upon the upper surface only a few stomata occur which are situated on a level with the leaf-surface; the numerous stomata upon the lower surface are on the other hand usually slightly projecting

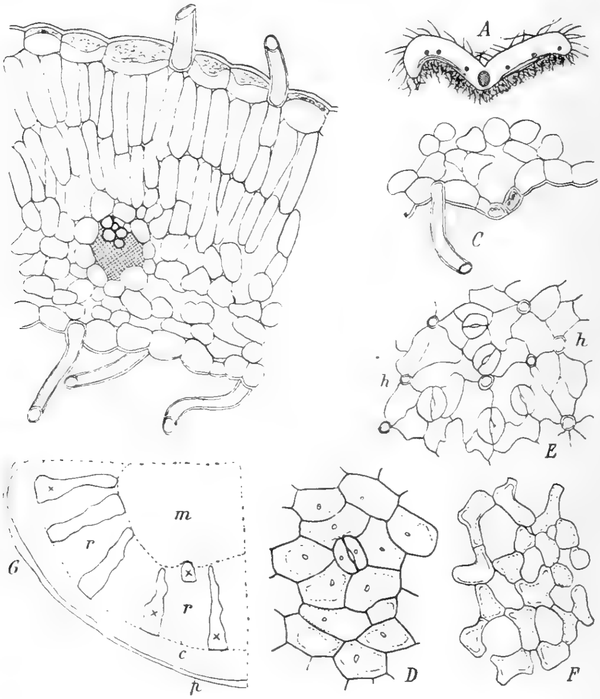

Fig. 9. *Potentilla pulchella.*

A, Transverse section of a leaf-segment. *B*, Fragment of a transverse section of a leaf of *f. elatior*, the inner wall of the upper epidermis is highly mucilaginous. *C*, Stoma from the lower surface of the leaf. *D*, Epidermis of the upper and *E* of the lower surface of the leaf; *h*, the base of a hair. *F*, Section of spongy parenchyma parallel to the surface. *G*, Fragment of transverse section of rhizome; *c*, cambium; *m*, pith; *p*, periderm; *r*, medullary rays. *x*. xylem. A, From Tempel Bay in Spitzbergen: *B*, *C*, *D*, *E*, *F* and *G* from Snenæs in Greenland (*A* and *G* about $^{16}/_{1}$; *B*, *C*, *D*, *E* and *F* $^{190}/_{1}$).

(Fig. 9, *C*.). The outer wall of the upper epidermis in *f. elatior* is 2.5—3.5 μ thick; in *f. humilis* from Lille Snenæs it was found to be about 6.5 μ; the inner wall is mucilaginous (Fig. 9, B); the radial walls are straight (Fig. 9, *D*); in the lower epidermis they are wavy (Fig. 9, *E*). In the palisade parenchyma also a difference was found between the two forms, there being 2 layers in *f. elatior* (Fig. 9, *B*), but 3 layers in *f. humilis* which is on the whole somewhat more xeromorphic. The spongy parenchyma is rather loosely built and consists of somewhat branched cells (Fig. 9, *F*). Bast either does not occur or is slightly developed only along the strongest bundles.

The yellow petals are slightly longer or according to Simmons usually only just as long as the sepals, and the diameter of the flower is about 10 mm. (Wolf); there are 20 stamens with short filaments. According to the alcohol material from Snenæs in Greenland the species appears to be homogamous. In the young flower which was just opening the anthers were found to be closed, and the short, slightly lobed stigma had not as yet received pollen (Fig. 7, *C*). In an older flower some of the stamens were bending with open anthers inwards towards the pistils, and the appearance of the stigmas was as shown in Fig. 7, *D;* they were densely covered with germinating pollen. Spontaneous self-pollination probably occurs. *Pot. pulchella* flowers in July; in Spitzbergen flowering begins at the end of June and is continued into September. Fruit is set regularly and abundantly (*A.* and *H.;* Simmons).

Potentilla nivea L.

Lit. Bonnier, 1894. Hartz, 1894, p. 6; 1895 a, pp. 287, 300; b, p. 322. Norman, 1895. Kruch, 1897. Abromeit, 1899. Andersson and Hesselman, 1900. Cleve, 1901. Sylvén, 1906. Hollstein, 1907. Wolf, 1808.

This species grows on rocks, and on rocky and grassy flats; it avoids well-aerated moist soils (Cleve). It is circumpolar and is found in addition in Alpine regions in the temperate parts of Asia, America and Europe.

The alcohol material is from northern Norway and from Greenland.

Pot. nivea has a multicipital main root, which may attain a considerable length, at least 60 cm. (Warming's notes) and may also become very thick (6 or even 9 mm.). The often numerous shoots are usually short and close-set, so that they form compact tufts which may attain a diameter of at least 20 cm. The shoots are covered by the old, brown leaf-sheaths which, however, disappear in the course of the following years. Sometimes looser tufts are also found; Warming, in his notes, even mentions short, horizontal shoots. In the Botanical Museum in Copenhagen I have measured obliquely ascending shoots which were about 10 cm. in length. Adventitious roots, which are even fairly strong (about 2 mm. in diameter), are frequently found, and it must undoubtedly be presumed, as Warming also is of opinion, that new individuals may be formed by vegetative propagation. The floral shoots are lateral; in a small tuft gathered on Danmarks Ø in East Greenland at the end of the winter the young floral shoots were found to be subtended by dead leaves.

The leaves wither in the autumn, but in favourable localities in southern regions a few small new leaves may protrude a little before the winter owing to the fact that the plant has no real winter-bud with scale-leaves. According to Hartz, in Scoresby Sound in East Greenland it lives through the winter in places free from snow.

Anatomy. The absorbent roots contain fungal hyphæ in balls in the cells of the few-layered, loosely built cortex. The structure of the epidermis and the exodermis is as in *Pot. emarginata;* but the walls of the exodermis are somewhat weaker than in the latter species. In the primary root the secondary woody portion is at first continuous, and not until the roots get somewhat older are the broad non-lignified medullary rays developed. The periderm is not very thick; in it one layer of cork-cells alternates with one layer of phelloid-cells. The older secondary cortex becomes highly compressed and is somewhat collenchymatous.

The rhizome, with the exception of the periderm, has a structure similar to that in *Pot. pulchella.* In the periderm one layer of phelloid-cells alternates with one layer of cork-cells, as in the root. The inner cellulose-layer of the phelloid-cells is fairly strong. An endodermis is present in the young rhizome. The structure of the rhizome from Dauphiné, as described by HOLLSTEIN, is similar to that of the present one. HOLLSTEIN writes that the outermost layers of the phloem is somewhat collenchymatous, and I find this generally to be the case in the greater part of the area between the cambium and the phellogen, but the peculiar appearance cannot be explained solely by this fact; it is no doubt chiefly due to a strong radial pressure.

The rhizome together with the primary root is the chief depository for food-material; and I find the alternation in the abundance of starch and fat according to the season of the year to be the same as is indicated in *Pot. emarginata.* The materials contained in the rhizome in five different months from somewhat different localities in Greenland varied as follows: —

	18. II. 92.	10. IV. 92.	31. V. 08.	1. VIII. 07.	4. XI. 91.
Starch.	a little.	0.	0 to rather much.	much.	0.
Fat.	much.	rather much.	a little.	very little.	rather much.

The plants gathered in November, February and April were from Danmarks Ø in East Greenland, while the plants gathered in May and August were from other localities in East Greenland. The quantity of the starch increases during summer till in August all the tissues are crowded; in November the starch has disappeared entirely; in February a small quantity was, however, present. During summer only a very small amount of fat occurs; during autumn the quantity increases; a maximum is reached about the middle of February, then the amount begins to decrease.

For the structure of the flowering axis the reader is referred to HOLLSTEIN.

The leaves, which are usually tripartite, are covered with a dense felt of white hairs on the lower surface; the upper surface is glabrous or may sometimes be more or less hairy. Fig. 10, *F* shows a glandular hair. Such hairs were found, both on the leaves from Norway, and on leaves of plants in the Herbarium of the Botanical Museum in Copenhagen gathered on Danmarks Ø in East Greenland (HARTZ), at King Point in Arctic America (determined by Dr. OSTENFELD), in the Tyrol (Huter) and in the Altai. The glandular hairs are found on both leaf-surfaces though not in great quantity. There is the more reason for emphasizing this fact as WOLF

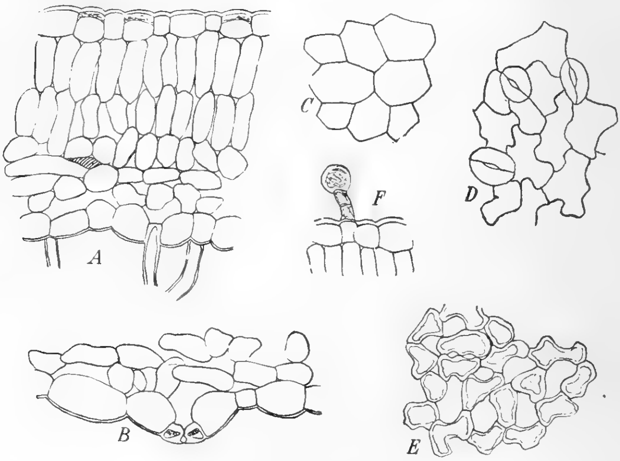

Fig. 10. *Potentilla nivea.*

A, Transverse section of a leaf, a few of the cells of the upper epidermis have mucilaginous inner walls. *B*, Stoma on the lower surface of the leaf; it projects slightly. *C*, Epidermis of the upper surface of the leaf and *D*, epidermis of the lower surface. *E*, Section of the spongy parenchyma of the leaf parallel to the surface. *F*, Stalked gland from the upper surface of the leaf. Kongsvold in Norway. (A, *B*, *C*, *D*, *E*, *F* $^{185}/_{1}$).

(l. c.) in his key of the species in the group *Nivea* states that among others the present species and *P. Vahliana* (see p. 34) are destitute of such hairs. The method for discovering hairs described by Wolf (loc. cit. pp. 32 and 38) cannot be employed with certainty in the case of leaves with a dense layer of felt as in these two species, when the object is to prove the possible presence of glandular hairs; I have demonstrated the hairs in transverse sections.

The leaf-margins are often more or less revolute. The stomata do not occur exclusively upon the lower surface; the few scattered stomata upon the upper surface are situated on a level with the surface, while those upon the lower surface often project slightly (Fig. 10, *B*). The outer wall of the upper epidermis varies in thickness from about 3 to about 4.5 μ, in that of the lower it is about 2.5 μ thick. The radial walls of the epidermis are straight and undulating on the upper and lower surfaces respectively (Fig. 10, *C*, *D*). Several of the cells of the epidermis on the lower surface of the leaf have mucilaginous inner walls (see also Kruch). In the leaves investigated the palisade parenchyma consisted of 2—3 layers of cells. The thickness of the leaf varied between 132 μ (N. E. Greenland) and 192 μ (Norway) and the proportion between the leaf-thickness and the thickness of the palisade parenchyma was $\frac{2}{1}$. In the two upper layers of the palisade parenchyma the cells were well-formed; they inclosed large intercellular spaces. The spongy parenchyma was loose in structure and consisted of slightly branching cells (Fig. 10, *E*). Here reference should be made to Bonnier (l. c.) who in leaves from Spitzbergen found two layers of palisade-cells which were scarcely longer than they were broad. In specimens from the Alps he found 3—5 layers of palisade-tissue: the cells were narrow and well-formed, and intercellular spaces were either wanting or few in number.

Warming says in his notes regarding the flowers from Greenland: "The flowers are highly conspicuous on account of the intensely yellow petals which are either of one colour or have an orange-coloured spot at the base. Honey is secreted abundantly." According to Wolf the diameter of the flower is 10—15 to 18 mm. The flowers in my material from northern Norway and from Greenland were homogamous, and appeared to behave like those of *P. emarginata.* The five innermost stamens which stand before the sepals are longer than the others and rise upwards almost to the level of the pistils. In flowers from Kongsvold and Alten in Norway it could be seen how the somewhat outwardly bent styles touched with their stigmas the open anthers of these stamens. Warming (l. c.) also finds that the anthers and stigmas are developed simultaneously "and the stamens stand so erect and close to the pistils that self-pollination must undoubtedly easily take place (Fig. 11, *A*)." In Scoresby Sound Hartz (l. c. 1895 a) observed *Syrphids* to visit the flowers of *P. nivea.*

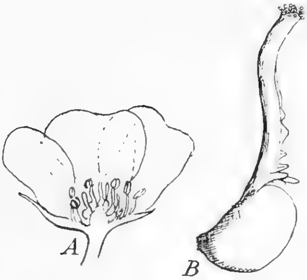

Fig. 11. *Potentilla nivea.*
A, Longitudinal section through a flower from Spitzbergen (about $^{2}/_{1}$). Drawn by Eug. Warming. *B*, Carpel showing the peg-shaped cells at the base of the style (about $^{24}/_{1}$).

Norman records that the flowering period is in the latter half of July and in the first half of August; Cleve: from June 30th to July 10th; Lange: July—August in Greenland where Hartz, however, in 1889, 1890 and 1892 found it flowering in the middle of June. In tke botanical museum of Copenhagen there are flowering specimens from different places in N. Greenland gathered at the end of June.

P. nivea sets fruit abundantly probably everywhere. Fruit-dispersal is as in *P. emarginata.* Greenland specimens gathered on the 4th of February on ground free from snow had ripe fruit enclosed between the contracted sepals, and Warming (notes) found (July 15) fruit from the preceding year hidden in the same manner.

Potentilla Vahliana Lehm.

Lit. Simmons, 1906. Wolf, 1908.

This is an Arctic species which lives in North-West Greenland, Arctic America and adjacent islands (Unalaschka) and perhaps the Rocky Mountains. It occurs in dry localities exposed to the sun, especially when they are gravelly, and extends to the snow-line (Wolf, Lange). The alcohol material was collected near Godhavn on Disco.

Pot. Vahliana is a plant with a tufted growth; it has a strong, long, multicipital primary root. An almost unbranched primary root on a small tuft from Godhavn, which Warming had measured, was 60 cm. long. The numerous shoots are covered, almost for their whole length, with dead leaves and remains of leaves, pressed closely together, and upon the surface of the tuft the living leaves hardly protrude above the old dead ones (Fig. 12, *A*). Adventitious roots, which may be fairly vigorous, may arise from the shoots, but vegetative propagation is undoubtedly only a rare occurrence. The shoot-structure is monopodial. The lateral flowering stems bear 1—2 small leaves and 1—2 large flowers. The whole plant is covered with long, yellow hairs.

Fig. 12. *Potentilla Vahliana* (Godhavn on Disco, July 7).

A. A shoot-complex about 10 years old; about 1/2. Above are seen two flowering stems and one which has finished flowering protruding from among the living leaves; for the rest, the greater part of the shoots are covered with dead masses of leaves, through which the remains of the flowering stems of previous years are protruding. B, Leaf; about 1/2. Drawn by Eug. Warming.

Anatomy. I have not examined the roots.

The structure of the rhizome agrees in its chief points with that of *Pot. pulchella*. The pith is however considerably smaller; the greater part of it was found to be compressed; it contained starch, as did the other depository tissues of the rhizome, and, in addition, large sphaero-crystals. The shoot may attain a considerable age. In the oldest part of the shoot in my material about 15 partially indistinct annual rings could be counted with an average breadth of about 40 μ. Even at this age the rhizome is closely covered with dead fragments of leaves. An endodermis is present.

In the flowering stem there is no distinct endodermis. Outside the vascular bundles, about 10 in number and separated by broad medullary rays, there is a ring of stereom consisting of 3—7 layers of slightly lignified bast. The outer part of the medullary rays also becomes woody. The structure of the cortex is similar to that of *Pot. pulchella.* The epidermis consists of rather small cells; the tangential walls are about 6.5 μ thick. The pith is homogeneous.

The leaf is hairy on both surfaces, but more so upon the lower (Fig. 13, *A*), where there also occurs a fair number of glandular hairs of the type figured (Fig. 13, *E*); the stalk is 2—4 celled. Besides in the alcohol material, fairly large numbers of glandular hairs are shown also on leaves from Ellesmereland (determ. SIMMONS) and from King Point in Arctic America (determ. OSTENFELD), contained in the herbarium of the Botanical Museum in Copenhagen; (see *Pot. nivea* p. 31). The glandular hairs may also occur upon the upper surface of the leaf along the margin.

The outer wall of the upper epidermis is about 2.5 μ thick; the inner wall is not mucilaginous. The radial walls of the upper epidermis are almost straight (Fig. 13, *C*), of the lower undulating. Stomata occur only upon the lower surface, and as seen in the figure, they often project somewhat, a fact which should doubtless be correlated with the dense hairy covering (compare *Pot. pulchella* and *Pot. nivea*). There are two layers of coarse palisade-cells and a rather loose spongy parenchyma the cells of which are slightly branched (Fig. 13, *B*, *D*). The thickness of the leaf was about 140 μ and the proportion between the leaf-thickness and the thickness of the palisade parenchyma was $\frac{2}{1}$. Some weak bast occurs upon the under side of the main bundle of the leaf and also at the leaf-margin when a bundle runs along the latter.

The diameter of the flower is somewhat large, Wolf records 18—20 mm.; the petals are broader than long and yellow in colour, and these large, conspicuous bowls doubtless readily attract insects. Warming states in his notes that honey is secreted abundantly. According to Warming's notes, of the 20 stamens the episepalous are longer than the epipetalous and stand more erect against the pistils. To judge from my alcohol material *Pot. Vahliana* appears to be homogamous, and self-pollination probably takes place.

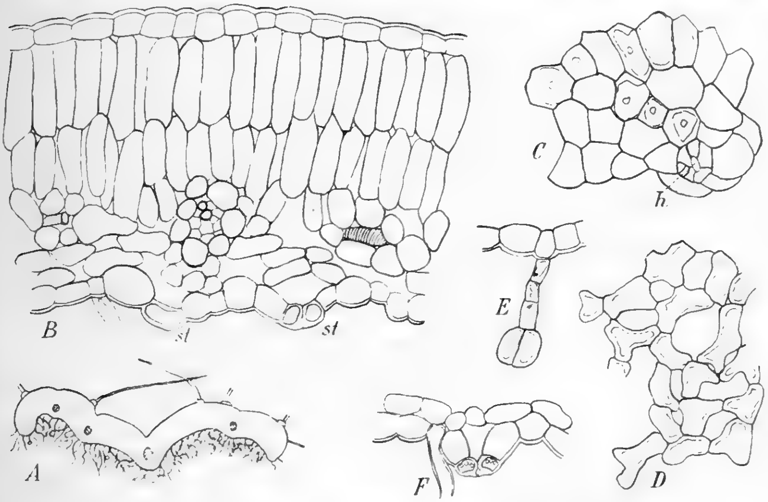

Fig. 13. *Potentilla Vahliana* (Godhavn on Disco).

A, Transverse section of a leaf-lobe, the edges are revolute, the lower surface is tomentose. *B*, Transverse section of leaf; *st.*, stoma. *C*, Epidermis of the upper surface; *h*, cross section of a hair which is standing on a small stalk. *D*, Section of spongy parenchyma parallel to the surface. *E*, Glandular hair from the lower surface of the leaf. *F*, A highly projecting stoma which was found behind the revolute leaf-edge. (*A*, about $^{25}/_{1}$; *B*, *C*, *D*, *E* and *F* $^{245}/_{1}$).

Flowering begins in July; according to Simmons it lasts only a short time. Fruit is set abundantly (Simmons).

Potentilla emarginata Pursh.

Lit. ABROMEIT, 1899. HARTZ, 1894, p. 32; 1895 a., p. 288; 1895 b., p. 322. EKSTAM, 1897. SIMMONS, 1906. WOLF, 1908.

This plant is high northern and circumpolar. In Greenland it lives on rocky and grassy flats; on Nova Zembla it prefers dry slopes exposed to the sun (EKSTAM).[1]

The alcohol material was collected in Greenland in different places.

Pot. emarginata has a strong, multicipital primary root which may attain a length of at least 25 cm. and a thickness of 6 mm. During the first years the seedling is in the form of a rosette without lateral shoots; the specimen figured has just entered on its second- or perhaps its third summer (Fig. 14, *A*). Later on it branches freely and very compact tufts rich in shoots, measuring as much as 20 cm. in diameter, may be formed. Looser tufts are however often found; these plants have probably lived in more favourable localities. The shoots in such tufts are ascending or may at first have a horizontal part several cm. in length. Often adventitious roots, which may even be somewhat vigorous, arise from older shoots, though this is hardly a normal occurrence, and then vegetative propagation may take place or, rarely, even a slight vegetative wandering may occur. The large brown sheaths of the spirally arranged leaves persist for several years, but the shoots may ultimately get rid of them.

The floral shoots are lateral. They usually bear 1—2 leaves and are ascending or the lower portion is prostrate. They are subtended by those leaves which in the autumn occur uppermost in the rosette upon the monopodial main

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[1] EKSTAM (l. c.) records *P. fragiformis* Willd. from Nova Zembla, but as this species, according to WOLF, does not occur on Nova Zembla, he has probably had specimens of *P. emarginata* before him, as these two species are commonly confused (cf. WOLF, p. 510).

shoot. Plants from Kekertak in Greenland collected Sept. 14 had formed flower-buds for the next summer, which had developed so far that the exterior of the stamens was fully formed and in the interior the mother-cells of the pollen-grains could be seen; the carpels were formed, but no indication of the formation of ovules could be observed. In the specimens from Upernivik (May 17) the young flowers were somewhat larger; as yet no pollen was to be seen, but in the carpels the style was formed, and in the ovules the embryo-sac could be seen.

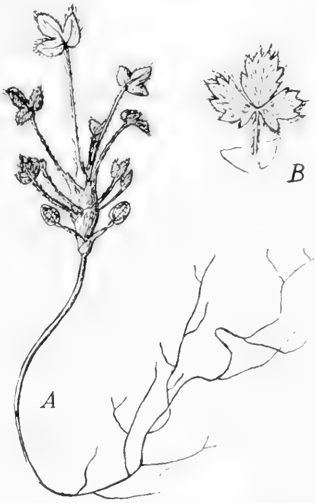

Fig. 14. *Potentilla emarginata.*

A, Seedling from Lille Snenæs in N. E. Greenland (25. 6. 1908; about $^{9}/_{5}$); the cotyledons and the lower darkly shaded leaves were dead and date probably from 1906 and 1907; there are two fresh leaves at the shoot apex; the primordial leaves have a simpler form than the leaves of the full-grown plant. *B*, Leaf of a full-grown plant from Spitzbergen; somewhat reduced. (Drawn by Eug. Warming.)

The plants probably pass the winter with dead leaves; in Kekertak they had withered in the middle of September 1886, and in Upernivik they began to unfold in the beginning of June 1887. The shoot-apices are protected by the leaf-sheaths; scale-leaves are not developed.

Anatomy. The structure of the slender absorbent roots is shown in Fig. 15, *F*. The epidermis is very weak and collapses, on the other hand the structure of the exodermis is very strong especially in its radial walls. The rest of the cortex consists of a few layers of cells in which balls of fungal hyphæ occur; in the intercellular spaces fairly vigorous hyphæ are found. In the secondary woody portion, which begins to develop early, the medullary rays are absent from the slender roots, but in the older roots broad, non-lignified medullary rays are gradually formed, similar to those which are found in the primary root, of which they may constitute the main portion. The rays of wood contain much parenchyma. The periderm consists of alternating layers of cork-cells and phelloid-cells; in the former the walls of the lateral roots are specially strong. The intercellular spaces are fairly large in the periderm; they are absent from the inner side of the cork-layers. The outer part of the secondary cortex becomes gradually compressed owing to growth in thickness. The primary root which, as already mentioned, may attain a thickness of at least 6 mm. is doubtless the chief depository of food-material.

The rhizome is similar in structure to that of *Pot. pulchella.* In the periderm 1—2 layers of phelloid-cells alternate with a layer of cork-cells. The intercellular spaces are rather large; they are absent from the inner side of the cork-layers. The rhizome may attain an age of at least about 15 years.

The material at my disposal allowed an investigation of the amount of the food-materials — starch and fat — contained in the rhizome in the months of May, June, July and September, with the following result:—

	17. V	4. VI	medio. VII	14. IX
Starch.	a little	rather much	much	much
Fat.	much	rather much	a little	a little

(Cf. *Pot. nivea*). Though the rhizomes investigated were collected in different localities and in different years yet the investigation is of some interest particularly as regards this plant which is hardly green during winter. Plants from the second column were collected on June 4, and the leaves were not unfolded; consequently, the very decided increase in the amount of the starch as compared with the plants in the first column cannot be due to new acquisition, but must have been produced by the transformation of other materials which were already present. The simultaneous decrease of the amount of the fat may indicate that some of this material has been used in the starch-formation, though naturally nothing can be stated with certainty on this basis. Besides, there are other materials than fat in herbaceous plants which, like the latter, decrease in quantity during spring.[1]

The vascular bundles in the floral shoot vary greatly in number (7—17) and are surrounded by a sheath of several-layered stereom which is well-developed especially opposite the vascular bundles; the outer part of the woody portion of these bundles is connected with the bast-sheath, so that the groups of sieve-tissue are surrounded by stereom. The cortex is similar to that in *Pot. pulchella.* The outer wall of the epidermis is about 5 μ in thickness. The inner portion of the pith breaks down. An endodermis is not present.

The leaf of *Pot. emarginata* is most nearly mesophilous; the thickness is about 170 μ. Along the margin and along the bundles of the leaf a fair number of long hairs occur; upon the surface of the blades these hairs are fewer, but short-stalked glands are rather numerous especially upon the lower surface (Fig. 15, *A B*), a fact which has also been observed by Abromeit (l. c.). The outer walls of both upper and lower epidermis are about 2 μ in thickness; the inner walls of the upper epidermis are not mucilaginous. As regards the radial walls of the upper and lower epidermis the reader is referred to figure 15, *C* and *D*. Stomata occur on both surfaces, but they are more numerous upon the lower surface where they may project slightly; upon the upper side they are on a level with the surface. The coarse, somewhat barrel-shaped palisade-cells occur in 2—3 layers. The proportion between the leaf-thickness and the thickness of the palisade parenchyma is found varying from $\frac{2}{1}$ to $\frac{2.5}{1}$.

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[1] Ernst Michel, Zur Kenntniss der Jahresperiode unserer Stauden. Inaug. Dissertat. Göttingen, 1909.

The spongy parenchyma consists of shortly branched cells and has a loose structure (Fig. 15, *A*, *E*). Slit-like lacunæ are often found upon the dorsal side of the leaf. Stereom is absent.

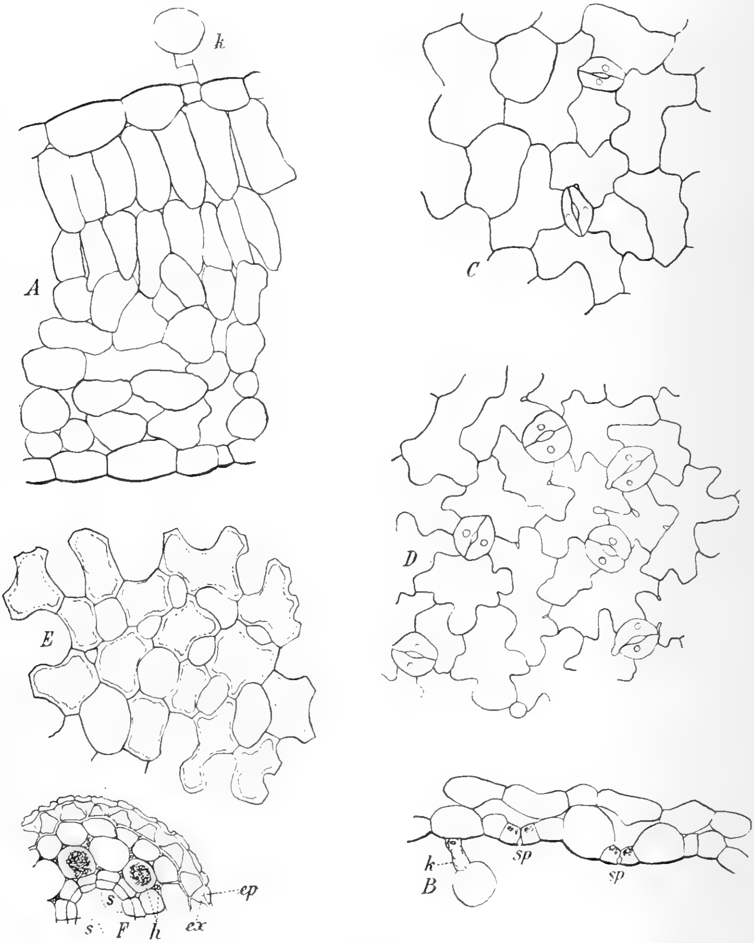

Fig. 15. *Potentilla emarginata.*

A, Fragment of a transverse section of a leaf; *k*, a glandular hair. *B*, Epidermis from the lower leaf-surface with 2 stomata and a glandular hair *k*. *C* Epidermis of the upper leaf-surface. *D*, Epidermis of the lower leaf-surface. *E*, Section of the spongy parenchyma of the leaf. *F*, Transverse section of an absorbent root; *ep*, the collapsed epidermis; *ex*, exodermis; *h*, fungal hyphæ, which partly forms balls in the cortical cells and partly fills out the intercellular spaces; *s*, the leptome-groups of the central cylinder. *A*, From Lille Snenæs; *B*, *C*, *D*, *E* and *F* from Upernivik (*A*, *B*, *C*, *D*, *E* and *F* about $^{220}/_{1}$).

According to LANGE the flowering period in Greenland is in July—August, and on Nova Zembla the plant flowers in the middle of summer and late in autumn (EKSTAM)[1]; but HARTZ found it in flower on Præstefjæld in Greenland on June 15, and at Scoresby Sound on June 19; in Ellesmereland the flowering begins in the middle of June and is continued into August (SIMMONS). In my alcohol material there were numerous flowers from Upernivik gathered on June 21. *Pot. fragiformis* Willd. *f. parviflora* Trautw., which is perhaps a synonym of *Pot. emarginata* (cf. WOLF, p. 533), according to ANDERSSON and HESSELMAN (l. c.), is a spring plant in Spitzbergen; it flowers in the middle of June and in the beginning of July. *Pot. emarginata* sets fruit abundantly (EKSTAM, SIMMONS).

The large, pale yellow flowers occur either singly or 2—3 together on the floral shoot. WOLF states the diameter to be 15—18 (—20) mm., EKSTAM records 20 mm. from Nova Zembla, while *Pot. fragiformis f. parviflora* from Spitzbergen has flowers only 10—14 mm. broad (A. and H.). EKSTAM found no scent, but he found honey which is secreted between the stamens and on the base of the filaments. He was of opinion that homogamy and self-pollination were possible as the stamens were bending over the stigmas. Of the stamens the 5 innermost are the longest and in the spirit-material they were only very slightly separated from the stigmas. WARMING writes in his notes regarding specimens from Spitzbergen that these 5 antesepalous stamens which he also found to be the longest, are without doubt easily able to shed pollen upon the stigmas. They open later than do the others. I also find that *Pot. emarginata* is homogamous (Upernivik and Lille Snenæs), perhaps with a short proterogynous stage. In case pollination fails for some reason or other, the 5 innermost

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[1] See note, p. 36.

and longest stamens remain as a reserve which ensures self-pollination (Fig. 16).

Of a large collection of flowers preserved in spirit and gathered at Upernivik on June 21, 1887, a great number were found with more or less abortive stamens. All transitions from normal to purely female flowers were found. The abortive stamens were shorter than the head of pistils and the anthers were small and shrunken, even in quite young flowers; they contained no pollen. The carpels were apparently normal though the styles were somewhat short, but no pollen was found on the stigmas which were furnished with large papillæ, and no fertilization had taken place in the older flowers.

Fig. 16. *Potentilla emarginata.*
A, Longitudinal section through a flower; 4/1. *B*, Pistil with hairs at the base; stigma with many small conical protuberances; 18/1. Spitzbergen. (Drawn by Eug. Warming.)

According to EKSTAM on Nova Zembla "*Pot. fragiformis Willd.*" is visited by flies and other diptera.

As is usual in the *Potentillas* the calyx is persistent and closes around the fruits, whereby their dispersal is regulated. The fruit-dispersal is anemophilous (EKSTAM).

P. maculata E. M. vix Pour.

Syn. *Potentilla alpestris* Hall f.

Lit. HARTZ, 1894, p. 4; 1895 a., p. 288. NORMAN, 1895. ABROMEIT, 1899. ANDERSSON and HESSELMAN, 1900. CLEVE, 1901. SYLVÉN, 1906. WOLF, 1908.

The alcohol material is from Spitzbergen and Greenland

Wolf is of opinion that, judging from its present distribution, this plant is an old species which was probably originally circumpolar and has only recently advanced southwards to about 40° N. lat. In Arctic and Subarctic regions it is found both in the mountains and near the sea, in southern regions (Europe and western Asia) only in Alpine and Subalpine mountain regions.

It grows on rocks, on heaths on grassy slopes and in copses.

The shoot-structure is monopodial and caespitose, but the tuft is rather loose in form, and ascending or almost horizontal branches, 10—15 cm. in length, commonly occur. There is some individualization of the older branches. The branches are for many years covered with the remains of brown leaf-sheaths.

Sylvén writes that in Sweden *Pot. maculata* is evergreen even in mountainous regions and in the Copenhagen herbarium there are specimens with green leaves from Disco in Greenland gathered in September and in the beginning of April. In a garden in Copenhagen it remains green through the winter.

Anatomy. My material of *Pot. maculata* was extremely poor with regard to roots; but it appeared that the exodermis of the absorbent roots has thin walls very much as in *Pot. Anserina.* The epidermis of the absorbent roots proved to have collapsed. No mycorrhiza was seen.

The structure of the rhizome resembles in its main points that of *Pot. pulchella* (see Fig. 9, *G*), the medullary rays are however fewer in number—about 4. Fairly distinct annual rings were seen in the wood. A shoot, 7 cm. long, was about 6 years old, and another which measured about 3 cm. was of the same age. The pith in these shoots was still alive. The secondary cortex had somewhat thickened walls and its outermost part was found to be somewhat compressed. The periderm is thick, there are about 6 layers of cork each separated from the other by a layer of phelloid. In this species also, intercellular spaces are absent from the inner side of the cork-layers.

Fig. 17 shows a portion of the transverse section of a floral shoot which may serve as an example of the stem-structure of the monopodial *Potentillas* mentioned in the present work. The vascular bundles may vary somewhat in number in the different species. The primary groups of vessels always remain distinct: the function of the cambium is slight. The pericycle is transformed into a rather strong bast-ring, about 3—6 layers thick. No distinct endodermis is present. The structure of the cortex is similar to that described for *Pot. pulchella.*

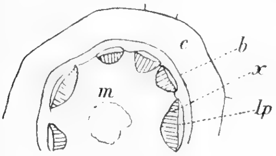

Fig. 17. *Potentilla maculata.* Portion of a transverse section of a floral shoot (about $^{17}/_{1}$); *b*, bast; *c*, cortex; *lp*, leptome; *m*, pith, in its centre the cells are somewhat disorganized; *x*, xylem.

The leaves are almost glabrous or slightly hairy upon the upper surface, and upon the lower surface the hairs are sparsely scattered. The hairs are projecting. LANGE maintains that *Pot. Frieseana* Lge. is distinguished from *Pot. maculata* Pour. among other things by the fact of the leaves being glandular, but Abromeit states that in Sweden he has found numerous yellow glands upon the lower surface of the leaves of the latter species. In the key given by WOLF of the determination of the forms of *Pot. maculata*, among the northern forms leaf-glands are assigned only to *Pot. Frieseana* (found only on Disco). I have, however, usually found numerous short-stalked glands on both leaf-surfaces of *Pot. maculata* from the majority of the localities represented in the Arctic herbarium in Copenhagen. The glandular hairs occur in unequal quantities in different plants and on the different leaves of the same plant; upon the upper surface they often occur especially in the furrows above the larger bundles. The form of the glands is shown in Fig. 18, *D.*

The outer wall of the epidermis of both leaf-surfaces was 3—4 μ thick. In the epidermis of the upper surface a mucilaginous inner wall was found in a great many of the cells, and in specimens from a single locality in Greenland (Kangerdlugsuatsiak) a few cells in the lower epidermis had also mucilaginous inner walls. Such cells were often larger than the other cortical cells (Fig. 18, *A*, *B*, *C*; cf. p. 57). The stomata are far more numerous upon the lower than upon the upper surface; they are situated on a level with the surface.

The palisade parenchyma consist of 2—3 layers of cells and contains large intercellular spaces. The spongy parenchyma is often composed of short, stellately branched cells and is more or less loose in structure. In the subepidermal layer of the present species more branched cells occur than in the other *Potentillas* mentioned in this work.

As may be seen in the two figures of the transverse section of the leaf, this varies considerably in thickness, from 160 μ to 240 μ. In the thick leaf from Spitzbergen Fig. 18, *A*, which was somewhat fleshy and almost smooth there were three layers of well-marked palisade-cells, and the proportion between the leaf-thickness and the thickness of the palisade parenchyma was about $\frac{2.1}{1}$. The spongy parenchyma was specially loose in structure owing to its large intercellular spaces. In Fig. 18, *B* are shown 2 layers of less well-marked palisade-cells and the proportion mentioned above was in this leaf about $\frac{2.9}{1}$; here the spongy parenchyma was somewhat more compact. Unfortunately nothing is known with regard to the conditions in which the different plants were living. It is however of some interest that this difference in the leaf-structure in a single species is also found, though in a more marked degree, in other Arctic plants, viz. among the land-species of *Ranunculus*. The thin leaf of *Pot. maculata* (Fig. 18, *B*) resembles in the structure of the mesophyll the type exhibited by the majority of the land-species of *Ranunculus*, while a further development in the direction indicated in Fig. 18, *A* would lead to a leaf of the *R. glacialis* type[1].

The diameter of the flower varies greatly; WOLF records from 10 to 25 mm. I measured flowers from Greenland which were about 15 mm. in diameter. The petals are usually golden yellow in colour, sometimes they are of one colour, sometimes there is a saffron coloured spot at the base (WOLF).

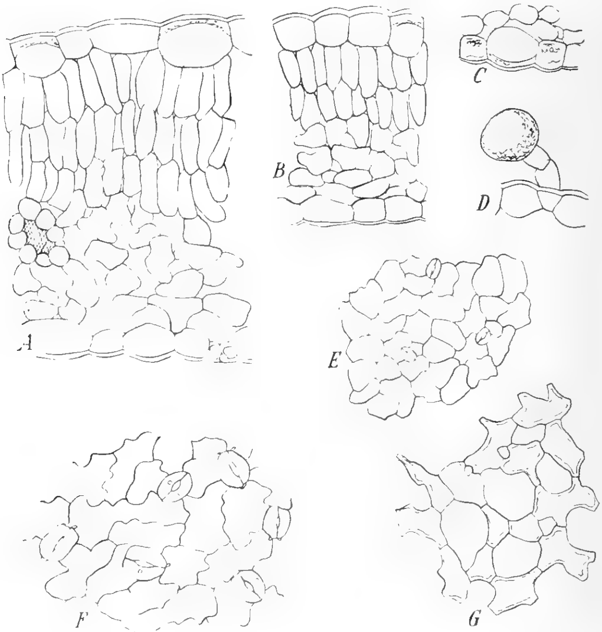

Fig. 18. *Potentilla. maculata.*

A, Transverse section of leaf. *B*, Transverse section of leaf. *C*, Cortical cell with mucilaginous inner wall from the lower surface of the leaf. *D*, Stalked gland from the upper leaf-surface. *E*, Epidermis of the upper leaf-surface. *F*, Epidermis of the lower leaf-surface. *G*, Section of the outermost layer of the spongy parenchyma. *A* and *G* are of leaves from Spitzbergen, the others are of leaves from Greenland (*A*, *B* *C*, *D*, *E* and *G* about $^{175}/_{1}$; *E*, about $^{60}/_{1}$).

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[1] *Ranunculaceæ* by KNUD JESSEN: Arctic Flow. Pl. I. 6. Meddel. om Grönland, Bd. 36.

The flowering period is June-September. Flowers from Bosekop (Arct. Norway) were found to be distinctly proterandrous; the next stage is homogamous, and it is probable that self-pollination takes place in the latter, as the outermost of the somewhat outwardly directed stigmas are either in direct contact with the inner erect or slightly inwardly bent anthers, or they are only slightly separated from these inner anthers which occur either at the same level as the stigmas or at a somewhat higher one. *Herman Müller* investigated a *Pot. verna* L[1] in the Alps in which he found the anthers developed simultaneously with the stigmas. He writes that as the flowers in inclement weather remain half-closed and during the night entirely closed, self-pollination is ensured if cross-pollination fails.

The fruit does not ripen in the mountains of northern Sweden (Cleve).

Potentilla anserina L.

Lit. Warming, 1884. Knuth, 1894. Norman, 1895. Coville, 1896. Porsild, 1902. Poppius, 1903. Sylvén, 1906. Wolf, 1908.

As regards the distribution of this species in Arctic Norway Norman writes that the strand and the fore-shore were most likely its original habitats and as the result of civilization it has been brought inland where it occurs especially along road-sides and near houses. This supposition is no doubt true for other regions also; thus Coville (l. c.) records that in Yakutat-bay in Alaska where *Pot. anserina* is common it is confined to the beaches. On Disco Porsild found var. *Egedii* in such places only, where it would be washed by the sea. Both Norman and Wolf think that *P. anserina* is dispersed by the agency of the sea, and the latter author writes that the fruit or even whole shoots ("ganze Stöcke")

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[1] It is uncertain whether this was a *P. maculata* or a *P. minor* Gil.

can withstand being carried a long distance in salt water without getting damaged. Fig. 21, *F* shows a transverse section through a ripe fruit. In the wall, within a few layers of cells which keep alive a long time, there occurs a considerable area of dead cells containing air. The shaded part is sclerenchymatous. I have found no difference in the degree of development of this floating tissue in the fruit of var. *Egedii* which Porsild gathered on the strand on Disco and in the fruit of a specimen of the typical form which had been growing in Denmark at a distance from the sea.

Pot. anserina is almost cosmopolitan; for further notes regarding its distribution the reader is referred to Wolf.

The alcohol material is from Greenland and Denmark.

Sylvén has observed the germination during spring in nature. During the second year the slightly branched primary root was found to be about 3 mm. thick and spindle-shaped; sometimes, however, it is rather weak and then an adventitious root takes on its function. In older plants the primary root is absent.

The short, vertical rhizome is monopodial and the annual growth-increment hardly lives more than one year; the leaves die away every autumn and the shoot-apices are protected by scale-leaves. The rosette-leaves subtend from one to several runners, which may attain a length of about one metre; but the longest runner I have seen from Greenland was only about ½ metre long. According to Warming, who mentions *Pot. anserina* in his paper of 1884, these sympodial runners are to be compared with the lateral floral-shoots in *Pot. erecta* (L.) Dalla Torre. The single shoot-generations consist normally of a long and a quite short internode, after which they terminate in a flower. At the base of the flower-stalk are two small connate bracts of which the lower subtends an assimilatory shoot which has leaves in a rosette and as a rule soon produces 1—2 strong adventitious roots, while the upper bract subtends a new runner of the same appearance as the parent-shoot. "The leaf-shoots lie alternately to the right and left on the runner-sympodium, from which it is evident that the branching is as in a true scorpioid cyme" (WARMING l. c.). From the new adventive plants new runners may arise even during the first summer (WOLF).

As every runner may produce several new rosettes, when circumstances are favourable, a parent-rosette of this plant may give rise to a considerable number of new individuals all around it. The runners die during autumn and by this means the young shoots become independent. On the other hand, in less favourable localities, where the runners are short, the number of off-shoots is considerably reduced, and it is especially those shoots which are nearest to the parent-plant which succeed in striking root and becoming independent. It appears, especially in dry soil, to be a critical moment for the young shoot when its roots emerge, because these easily get dried up before they succeed in penetrating deep enough into the soil. Further, it is only the inner shoots or only the innermost one of the shoot-generations of the runners which attain the flowering stage in unfavourable localities. In cases where the flower is not immediately visible, an extremely small dead flower-bud may often be found hidden among the bracts.

Besides these creeping floral shoots the leaves of the parent-rosette may also subtend new rosette-shoots which may sooner or later become independent.

As already mentioned the young adventive shoots are provided with 1—2 strong adventitious roots. The latter die in the course of the following summer while new ones are developed. In older plants these one-year-old roots often take the character of a food-storing root as shown in Fig. 19. They are usually spindle- or club-shaped and may become about 8 mm. thick and about 10 cm. long; they do not branch, but bear thin absorbent roots. During winter they are found crowded with starch which appears to be transformed to fat only in a very slight degree.

Pot. anserina, like many other plants, has the power of keeping its growing point on a level with the surface of the ground, at any rate if the shoot-apex has been covered with a layer of earth and in such a case the fresh food-storing roots are in the autumn often found to be raised as much as 2 cm. above the remains of the shoot-base of the previous year upon a portion of the axis with elongated internodes.

Fig. 19. *Potentilla anserina* (Denmark; 28. 9. 1912.).

Autumn stage; the runners dead or dying; *l*, the leaf-bases; *d*, the dead food-storing root of 1911—12; *f*, two fresh food-storing roots which have been developed in the summer of 1912 (somewhat reduced).

Anatomy. In the slender absorbent roots of the first and second order considerable quantities of strong fungal hyphæ occur which form balls in the cells of the loosely built cortex. The epidermis, especially of the absorbent roots of the second order, is very small-celled, very much as in *Potentilla palustris*, but the outer wall is thinner, and the skin is collapsed; nor are the dark contents found in *Pot. palustris* present here.

Fig. 20, *A* shows the structure of the fully developed food-storing root. On the outside is seen the thin cork with a few fragments of the primary cortex, then follows the thick secondary cortex and lastly a few groups of vessels around the small pith. Not until during the beginning of summer is a continuous woody part developed in the middle of the root. The secondary cortex consists chiefly of parenchyma. It shows concentric layers which result from circles of sieve-tube-groups, the cambium for each circle of such groups producing about 10 layers of parenchyma. Fig. 20, *B* shows a group of sieve-tubes just outside the cambium, while Fig. 20, *C* illustrates two such tubes from about the middle of the cortex.

In the rhizome, as in the food-storing root, a continuous cambium develops chiefly parenchyma. The periderm in correlation with the short duration of life is not very thick. An endodermis is present.

The horizontal portions of the floral shoots are somewhat flattened. The activity of the cambium is slight, and the few groups of vessels always remain separated by primary medullary rays. The two-layered pericycle is transformed to bast which becomes somewhat stronger in the peduncle than in the horizontal part. An endodermis-like layer is present[1]. Within the epidermis there is a layer of weak collenchyma. The stomata project above the level of the surface.

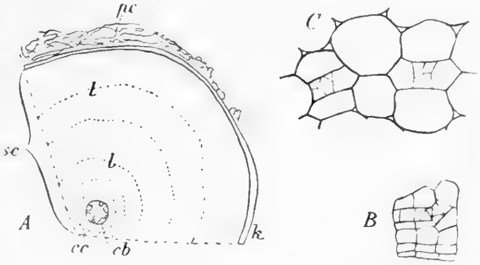

Fig. 20. *Potentilla anserina.*

A, Fragment of a transverse section of a food-storing root taken in the autumn ($^{16}/_{1}$); *cc*, central cylinder with groups of vessels; *cb*, cambium; *sc*, secondary cortex; *pc*, fragments of the dead primary cortex; *k*. cork; *l*, concentric circles in the secondary cortex with groups of sieve-tubes. *B*, A group of sieve-tubes just outside the cambium. *C*, Groups of sieve-tubes from about the middle of the secondary cortex. *B*, *C* about $^{210}/_{1}$.

The leaf varies considerably in size being from about one-third of a metre (*f. grandis* Lehm.) to 3—4 cm. in length, the hair-covering is also very different; in *f. sericea* Hayne,

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[1] Cf. Edmund Orth: Beitr. z. Anatomie d. Gattung. *Potentilla*. Dissert. Hamburg. 1893, p. 27.

which occurs especially in dry localities, both surfaces of the leaf are white with silky hairs, in the typical form this is the case only on the lower surface, and in the Arctic and Subarctic var. *Egedii* Torr. and Gr. and var. *grønlandica* Tratt. the leaves are entirely glabrous or somewhat hairy, on the lower surface only, respectively. Fig. 21, *D* shows a stalked gland; such occur scattered along the bundles and are more common on the lower surface.

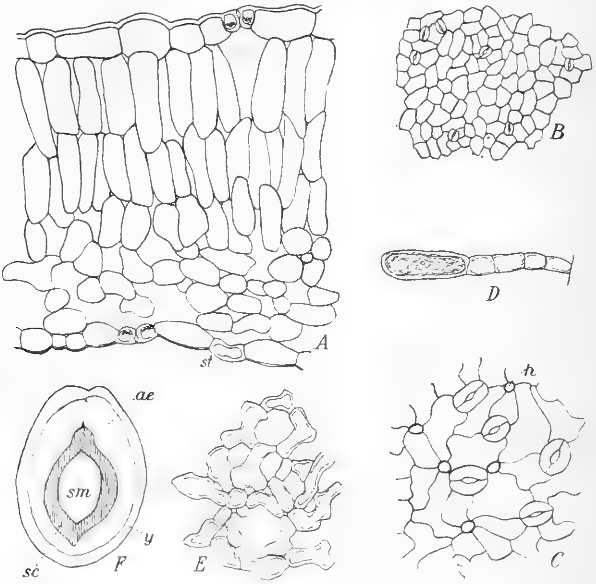

Fig. 21. *Potentilla anserina* (Greenland).

A, Transverse section of leaf. *B*, Surface view of the upper epidermis of the leaf. *C*, Surface view of the lower epidermis of the leaf; *h*, a hair-bearing cell. *D*, Stalked gland from the lower surface of the leaf. E, Surface view of spongy parenchyma. *F*, Transverse section of an almost ripe pistil; *sm*, the seed cavity; *y*, outer layer of the fruit-wall; *ae*, floating tissue; *sc*, sclerenchyma (*A*, *C*, *D*, *E* about $^{185}/_1$; *B* about $^{65}/_1$; *F* about $^{15}/_1$).

The anatomical structure of the leaf, which only lives through one summer, is mesomorphic. The outer wall in the epidermis of the upper surface is about 2.5 μ thick; the radial walls are straight or almost straight (Fig. 21, *B*), but in that of the lower surface somewhat undulating (Fig. 21, *C*).

The palisade parenchyma consists of 2—3 layers of cells, of which the two upper layers are fairly well-marked. The proportion between the thickness of the leaves from Greenland and the thickness of the palisade parenchyma is about $\frac{1.7}{1}$. The spongy parenchyma is rather loose and consists of slightly branching cells (Fig. 21, *A*, *E*).

It is normal for the yellow flowers to occur singly on the often long flower-stalks. Wolf records the diameter of the flower as 18—20 mm., and Knuth as 20 mm.

The flowering period occurs in Arctic Norway between June 25 and Sept. 21 (Norman), Lange records as regards Greenland July—August; in Central Europe the flowering begins in May.

My material contained flowers from different localities in Greenland, and those which had not entered the homogamous stage showed a somewhat considerable degree of proterogyny. Anthers in fully expanded young flowers were still closed while the stigmas were found to be highly papillose even before the petals had opened. It was, however, impossible to find a single pollen-grain on these highly papillose stigmas, but, as soon as the anthers had opened the stigmas were found to be densely covered with pollen. This fact does not seem to indicate that insect-invisitors have been frequent. The stamens are longer than the styles: they are erect or somewhat bent inwards when the anthers are open. Self-pollination is consequently possible, which opinion is also maintained by Knuth. In the Friesian Islands he found *Pot. anserina* to be purely homogamous, and he writes that spontaneous self-pollination must take place as soon as the pollen-grains no longer adhere to the drying pollen-sac; he found that there was a possibility for insect-pollination in the fact that at first the pollen was rather firmly attached to the open pollen sacs. According to Knuth in inclement weather the flowers are half-closed during the day and entirely closed at night, and this makes self-pollination possible. POPPIUS found the flowers to be slightly protandrous at Esbo in Finland; they were very sparsely visited by insects.

Concerning the fruits see p. 48.

Sibbaldia procumbens L.

Lit. WARMING, 1886, *a.* LINDMAN, 1887. HARTZ, 1895, *a.* NORMAN, 1895. A. CLEVE, 1901. KJELLMAN, 1901. SYLVÉN, 1906. HOLLSTEIN, 1907.

This species grows in grassy and often somewhat damp localities, not, however, in bogs (CLEVE). It is circumpolar, and occurs also in Great Britain, Iceland, the Færöes and the Alps.

The alcohol material was collected in Spitzbergen and in Greenland, in different places.

According to SYLVÉN the seedling has a slender, slightly branched main root which together with the hypocotyl quickly becomes woody. From the leaf-axils of the first young rosette monopodial lateral shoots are developed sooner or later, which in the course of time may attain a considerable length; they become prostrate and have a somewhat upwardly turned apex. The primary root may live for a long time, and in the museum of the Botanic Garden in Copenhagen tufts are found, 20—30 cm. in diameter, the numerous, closely placed shoots of which are still in connection with the vigorous main root. KJELLMAN (l. c.) writes that *Sibbaldia* either does not develop adventitious roots or does so only very slightly; but this statement does not quite agree with the specimens I have seen in the herbarium mentioned above; to judge from the latter, adventitious roots — even vigorous ones — may be fairly often developed from older branches, and the plant is certainly not dependent on its primary root, but has some power of vegetative propagation. The shoots are more or less covered by the dead shoot- and leaf-masses of the tuft; they branch freely and often have a characteristic appearance on account of the lateral shoots often arising almost at right angles. The internodes are usually short, and KJELLMAN refers *Sibbaldia procumbens* to one of the characteristic types of rosette-plants; in vigorous specimens from the Botanic Garden in Copenhagen the internodes are, however, as much as about one cm. long. The leaf-arrangement is two-rowed. The dead parts of the leaves persist for a long time on the shoot and may impart to the latter a peculiarly scaly appearance especially in its older parts; or the shoot becomes quite smooth owing to formation of periderm.

The floral shoots with the compact inflorescence are found during summer subtended by dead leaves which are seated below the living terminal rosette. Often 2—3 floral shoots are developed on the same branch. As is the case with the vegetative shoots, they vary greatly in size according to the nature of the habitat; in much exposed places they attain a length of 1—2 cm. only. — Plants which HARTZ collected at Scoresby Sound in the autumn had vegetative lateral shoots of the same year in which a small foliage-leaf had unfolded; in the Botanic Garden in Copenhagen this proleptic development is more pronounced. The new shoots begin either with a scale-leaf or with a weak foliage-leaf. Afterwards no scale-leaves are developed, and the shoot-apices are protected by the older, closely folding leaf-sheaths. The leaves wither in the autumn — at least in the Botanic Garden in Copenhagen.

Anatomy. The primary structure of the adventitious roots of the first and second order is practically the same, with the exception of the central cylinder which in the former is triarch-tetrarch and in the latter diarch. But the outer walls of the epidermis of the lateral roots are somewhat stronger than those in the roots of the first order. The lateral roots have endotrophic mychorrhiza. The older roots are surrounded by a periderm which is formed in the outermost layer of the pericycle. The phelloid-cells occur in a few layers, and each series is separated by a layer of cork. Large intercellular spaces occur between the phelloid-cells themselves and between the latter and the next inner layer of cork.

In the rhizome there is formed during the first period of vegetation a complete ring of cambium which, however, does not produce a particularly large amount of secondary wood during the first year. With increasing age the latter reaches a considerable thickness and the continuous woody portion is very large; the annual rings in older rhizomes are not distinct. When older the rhizome becomes highly hyponastic. An endodermis is present. Periderm is formed during the first or second period of vegetation, after which the primary bark with epidermis dies and falls off. In the periderm one layer of cork alternates with about three layers of phelloid-cells. Specimens investigated from the Botanic Garden in Copenhagen had a smaller amount of cork in the periderm than the specimens from the other localities. Large intercellular spaces occur which are distributed as in the root. The outer, dead portion of the periderm persists as a very thick protective layer. Normally, no bast is produced in the rhizome, only in very vigorous specimens from the Botanic Garden in Copenhagen did I observe scattered groups of bast-cells. The pith is large and lives for a long time; it is, together with the periderm and the medullary rays, the chief depository of food-material. The starch collected during summer disappears, at any rate partially, during winter and is replaced by fat (Bot. Gard. in Copenhagen, January).

HOLLSTEIN has described the floral stem from material from the Dauphiné Alps. There occurred in the stems from these regions considerably more stereom than in the stems from Spitzbergen and Greenland investigated by me. Within the epidermis, which had fairly strong outer walls, I found 1—2 layers of weak collenchyma; this was practically similar in the floral region and the rest of the stem, but the degree of development reached by the stereom in these two parts was different. In the floral region there were a great number of primary bundles within a common endodermis; secondary formations were of slight thickness only, as no interfasicular cambium occurred. The whole of the pericycle was transformed into bast of medium strength or weaker. In the rest of the stem a complete cambium had formed a considerable amount of secondary wood consisting chiefly of stereom, and in the pericycle isolated bundles of bast occurred. Here, also, there was a common endodermis.

Both leaf-surfaces are slightly hairy with compressed, unicellular, thick-walled hairs. Moreover, there occurred on both sides, but in greater abundance on the under side, small stalked glandular hairs of the form shown in figure 22, *B*. Stomata occur on both surfaces of the leaf in almost equal number; they are sunk below the level of the surface (Fig. 22, *A*). The outer wall of the upper epidermis is 3.3 to about 4 μ thick and that of the lower about 3 μ. The cuticle is uneven. The surface views of both the upper and lower epidermis have almost the same appearance, the radial walls are slightly undulating (Fig. 22, *E*, *F*). The inner wall of the epidermis of the upper surface is sometimes mucilaginous (Fig. 22, *C*). Cells with such mucilaginous walls are often larger than the surrounding cells (this fact is also mentioned by WARMING in his "Halofyt Studier")[1] and they appear to occur in varying quantities in the different localities; in the leaves from the Botanic Garden in Copenhagen more epidermal cells were found with than without mucilaginous walls.

The thickness of the leaves showed some variation:

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[1] See p. 59.

123 μ (Nunatsuk in Greenland), 154 μ (Gaaseland in Spitzbergen) and 174 μ (Botanic Garden in Copenhagen), and the proportion between the thickness of the leaf and the thickness of the palisade tissue was $\frac{2.2}{1}$, $\frac{2}{1}$ and $\frac{2.6}{1}$ respectively. The palisade parenchyma consists of 2—3 layers of cells.

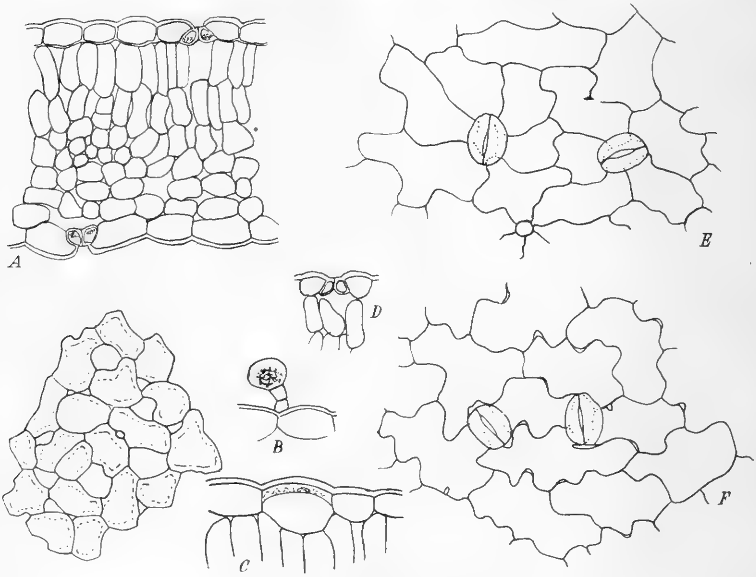

Fig. 22. *Sibbaldia procumbens.*

A, Transverse section of leaf; *B*, glandular hair from the upper surface of a leaf; *C*, epidermal cell from the upper surface of the leaf with mucilaginous inner wall; *D*, air-cavity below a stoma upon the upper surface of the leaf produced in part by the formation of a "Trichtercelle" (cf. text). *E*, Epidermis of the upper surface of the leaf; *F*, epidermis of the lower surface of the leaf, and *G*, section of spongy parenchyma. *A*, *B*, *C*, *D*, *E*, *F* and *G* $^{275}/_{1}$. *A*, *D* from Nunatsuk in Greenland, *C* from Godhavn in Greenland, *D*, *E*, *F*, *G* Gaaseland in Spitzbergen.

Below the stomata there is a large air-cavity which is formed either by the surrounding palisade-cells separating from each other at their upper ends, or by the adjacent cells tapering in the form of a funnel to the outside (Fig. 22, *D*). *Sibbaldia procumbens* may consequently be placed side by side with those specimens which RYWOSCH[1] mentions in support of his

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[1] Beitr. zur Anat. d. Chlorophyllgewebes, Zeitschr. f. Bot., 1912.

theory as against HABERLANDT'S, as regards the signification of the so-called "Trichtercellen" in the foliage-leaves; a theory which should more properly be called the WARMING-RYWOSCH'S theory, as it corresponds with the views of the former investigator[1]) (see also *Alchimilla vulgaris* p. 108).

The polygonal or slightly branching cells of the spongy parenchyma are arranged in about four layers and include intercellular spaces which are usually smaller than the adjacent cells (Fig. 22, *A*, *G*). The bundles are not accompanied by stereom; the smaller branches are surrounded with a sheath while the larger ones are in addition accompanied by the usual vein-parenchyma, which compensates for the assimilatory tissue, up to both the upper and lower epidermis. In fresh leaves from the Botanic Garden in Copenhagen tannic acid occurred especially in the tissue of the veins and in both the upper and lower epidermis.

The insignificant flowers are collected in 6—12—flowered heads which consist of several small cymes. The petals are pale yellow and smaller than the inner sepals. The flowers are 7—8 mm. in diameter (WARMING'S notes). The flowering period begins in July; NORMAN records July 9 for Arctic Norway, and at Scoresby Sound HARTZ observed the first flower on July 7. It no doubt usually sets ripe fruit. MÜLLER is of opinion that it has lost the power of spontaneous self-fertilization (Alpenbl., p. 222); WARMING, on the other hand, writes in 1886, that this cannot apply to the Greenland specimens because he found the anthers placed so close to the stigmas that self-pollination must no doubt easily take place (Fig. 23, *B*), and in his notes he remarks that the species is homogamous and that he has seen the anthers in contact with the stigmas. Similar observations are recorded by LINDMAN (1887) who investigated the species on Dovre

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[1] Halofyt-Studier. Kgl. Danske Vidensk. Selsk. Skr., 6. Række, naturvidensk. og math. Afd. VIII, 4, p. 245. 1897.

(Scandinavia). He writes that the anthers are introrse and the filaments are bent inwards so that the anthers are separated by only ½ mm. or even less from the stigmas, and stand at a somewhat higher level than the latter; therefore he thinks it is probable that self-pollination takes place. Lindman says that the flower agrees with Müller's Fig. 87. As Fig. 23, *A* shows, there is a disk that curves towards the petals.

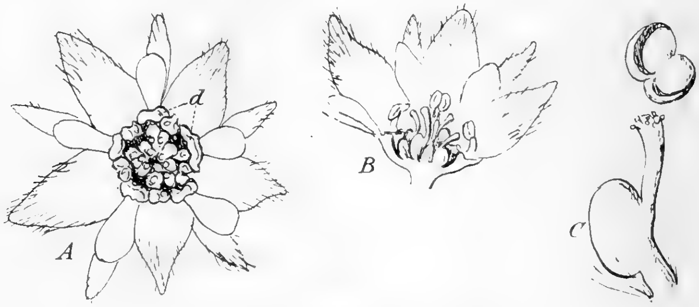

Fig. 23. *Sibbaldia procumbens.*

A, Flower seen from above. The disk (*d*) curves outwards between the stamens towards the petals (about ${}^{5}/_{1}$). *B*, Longitudinal section of a flower; the anthers are almost in contact with the stigmas (${}^{6}/_{1}$). *C*, Carpel with germinating pollen and an anther with open pollen-sacs from flower from Kongsvold in Norway (about ${}^{20}/_{1}$). Drawn by Eug. Warming.

Dryas octopetala L. and **D. integrifolia** Vahl.

Lit. Buchenau and Focke, 1872. Holm, 1885. Warming, 1886, a; 1887. Lindman, 1887. Kihlman, 1890, p. 229. Wagner, 1892. Hartz, 1894, p. 48; 1895, a, pp. 288, 300 and 311; 1895, b. Jónsson, 1895. Norman, 1895. Ekstam, 1897 and 1898. Kruch, 1897. Abromeit, 1899. Andersson and Hesselman, 1900. Hesselman, 1900. A. Cleve, 1901, p. 45. Dusén, 1901. Knothe, 1902. Schrøter, 1904. Haglund, 1905. Simmons, 1906. Sylvén, 1906. Hollstein, 1907.

These two species are treated here jointly for brevity's sake, as they only differ in a few morphological and anatomical points. As regards their mutual systematic relation the reader is referred to DRUDE[1], ABROMEIT (l. c.) and SIMMONS (l. c.)[2].

Dryas octopetala is circumpolar and is moreover found on the mountains of the temperate regions of Europe, in Asia and North America, in Iceland and the Færöes. *D. integrifolia* is found in Greenland, in Arctic America, where it has extended somewhat southwards, and in N. E. Siberia (cf. SIMMONS, where the distribution of both the forms is exhaustively discussed).

D. octopetala and *D. integrifolia* occur chiefly in dry localities, and NORMAN and A. CLEVE emphasize the fact that *D. octopetala* avoids damp localities in northern Scandinavia, and according to SIMMONS *D. integrifolia* does not thrive in damp soil in Ellesmereland. HOLM, however, observed *D. octopetala* growing in the Tundras of Nova Zembla. Heaths and rocky flats are their home proper.

The alcohol material was collected in Greenland, Iceland, the Færöes, northern Scandinavia, Spitzbergen and Nova Zembla.

DRUDE has included *D. octopetala* among his "Holzstauden" (Halbsträucher),[3] but both HAGLUND and SCHRØTER (l. c.) refer it to the dwarf shrubs proper, and their reason for doing so is that the destruction by frost during winter is not great and that the plant is woody and attains a very considerable age. Thus KIHLMAN (loc. cit. p .229) records that he has found a plant which was upwards of 108 years old. And SCHRØTER figures (Fig. 65) a shrub about 50-years-old which attained a length of about 1.60 metres. The growth is espalier-like[4] and the branches may be fixed to the soil by adventitious roots. WARMING remarks in his

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[1] Die system. und geograph. Anordnung der Phanerog. in SCHENK: Handbuch der Botanik, III, 2, pp. 212 and 256, fig. 1.

[2] Fig. 24 represents different leaves of an intermediate form.

[3] Handb. d. Pflanzengeographie, 1890.

[4] WARMING's term for prostrate, outspread growth.

notes as regards D. *integrifolia* in Greenland, that it grows in flat, low tufts, usually almost circular in form and about a foot or so in diameter. Each tuft has a strong main root, and a few slender, weak adventitious roots arise from the branches. From the upper end of the main root the branches proceed laterally in a horizontal direction, and they may become fairly long. It hardly propagates vegetatively. — In *D. octopetala* from Russian Lappmark Kihlman (l. c.) measured branches which were about two metres in length. Haglund ascribes to *D. octopitala* a rich formation of adventitious roots from the prostrate parts of the shoots, according to him it is almost exclusively the adventitious roots, which provide the older individuals with nourishment; he has not been able to find a persistent main root. Schrøter records a rich supply of adventitious roots from the under side of the branches of *D. octopetala* in the Alps. In Warming's notes we read further as regards *D. integrifolia*: "The shoots are close-set and among them masses of dead leaves are found which persist several years; it grows in its own remains; the fresh shoots are seen in the midst of the blackish brown remains of old leaves. Large patches may be found dead in a tuft, but the leaves are still densely crowded."

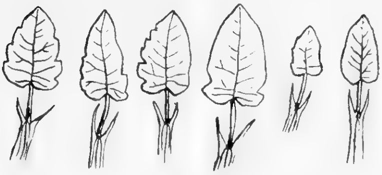

Fig. 24.

Leaves of a form intermediate between *Dryas octopetala* and *D. integrifolia* collected at Kingigtok in Vaigat by Hartz. All the six leaves were found on the same plant, and the different forms were represented almost to an equal degree (about natural size).

The young seedling of *D. octopetala* has been described by Haglund and Sylvén; it forms a rosette which is provided with a main root and which sooner or later develops lateral shoots. The structure of the shoot of the full-grown plant has been treated by Haglund (loc. cit. p. 7) who, however, doubtfully refers *Dryas octopetala* to dwarf shrubs with racemose shoot- structure, citing as additional examples *Cassiope tetragona* and *Empetrum;* and on p. 33 he says that there is a clear distinction between vegetative or vegetative-floral short shoots and vegetative long shoots. In Lappmark where he was staying the long shoots measured 2—4 cm., and had spirally arranged leaves in the axils of which short shoots developed even during the same year. ASCHERSON and GRAEBNER[1] ascribe to *D. octopetala* a long and much branching stem with prostrate long shoots and numerous erect short shoots. — The results of my investigations of *Dryas octopetala* and *D. integrifolia* are in several respects different from those arrived at by HAGLUND.

The same year in which a shoot flowers it produces a small number of usually close-set lateral shoots, as generally only the upper leaves subtend shoots. At first the shoots have a scale-leaf, afterwards foliage-leaves follow. In vigorous and luxuriant plants the shoots are usually distinguished into short shoots and long shoots, which otherwise behave as described by ASCHERSON and GRAEBNER. In investigating shoot-apices in plants both in the Botanic Garden in Copenhagen and in the alcohol material, small flower-buds were as a rule found on all shoots gathered in the autumn: when such were absent the shoots were frequently weak short shoots. Fig. 25 shows a longitudinal section through a flower-bud gathered in August in Greenland; the stamens have just been developed and there are indications of the outermost carpels. The young flowers in the Botanic Garden in Copenhagen had in January developed so far that the stamens were externally fully developed, but in the carpels no ovules were formed. Probably the development is not so advanced at the same time in colder regions where the flowering period also occurs later than in Copenhagen (see

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[1] Synopsis d. mitteleurop. Flora. VI, 1, pp. 889—90.

p. 73). It is not, however, by any means all the flower-buds that are formed which reach maturity. In Copenhagen numerous dead buds were found during autumn and winter. Otherwise such shoots with a dead apical flower-bud behave as do those that flower. The above-mentioned weak shoots which do not at once produce buds, may do so after having lived through one or perhaps several years of growth in vigour, but I also find that such shoots may after the lapse of a few years die in a purely vegetative stage, probably suffocated by the more vigorous shoots overshadowing them. HAGLUND writes that the short shoots immediately put forth new short shoots, and this is undoubtedly often true. I must regard the short shoots in *Dryas octopetala* and *D. integrifolia* simply as shoots which have become weakened by competition among themselves, and it is undoubtedly normal for the shoot-development to end with flower-formation. According to the above the branch-system in *Dryas*[1] is sympodial, a few new shoots being produced every year; of these usually one or two are more vigorous than the others.

Fig. 25. *Dryas octopetala.*

Median section through a young flower-bud which would not have attained the flowering stage until the following summer (Kingigtok in Vaigat; Aug. 2; $^{25}/_{1}$); *c*, indication of carpels; *st.*, young stamens; *p*, petal; *sp*, sepal.

Fig. 26. *Dryas octopetala* (Iceland). 16. 1. 1894.

a. A shoot-apex which shows how the rolling back of the leaves increases towards the apex of the shoot; the uppermost leaves are living the older are dead; *b*, a leaf seen from the lower surface; *c*, a highly revolute leaf seen from the lower surface (Helgi Jónsson's figures l. c.).

The length of the long shoots naturally

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[1] The North American and the North-east Asiatic *Dryas Drumondii* Richards. behaves in a similar manner.

varies greatly; I have found them to be from one to about 10 cm. long; the longest are often found at the periphery of the tufts.

Haglund (l. c.) records that the leaves of *D. octopetala* die away during winter; others find that the leaves remain green during winter, viz. Schrøter, Hartz (1895*a*, p. 182) and Jónsson (cf. Fig. 26); in my material there were specimens collected by Jónsson in January, and they agreed exactly with his figure and in this manner *D. octopetala* also behaves in the Botanic Garden in Copenhagen. Finally, Warming remarks in his notes that *D. integrifolia* has leaves which live through the winter. The oldest leaves on the shoot wither in the autumn but as figure 26 shows there are a few half expanded young leaves at the apex of the shoot and these live through the winter. Scale-leaves are not developed (cf. Haglund); the shoot-apices are protected by the leaf-sheaths.

Anatomy. The root-system as mentioned above is characterized by a vigorous main root which bears vigorous branches. The absorbent roots are richly branched and their apices are encompassed with a thick mantle of fungal hyphæ. Hesselman figures mycorrhiza of *D. octopetala* which resemble those of the *Cupuliferae; D. integrifolia* also has mycorrhiza. Hesselman also illustrates the structure of the root by several figures.

The central cylinder in the primary root is surrounded by a vigorous endodermis and in the innermost layer of the cortex the radial walls are highly thickened in the middle, so that the transverse section of the wall shows an almost circular figure. Periderm is developed in the outermost layer of the pericycle, and gradually as the periderm and the secondary wood grow the cortex dies and is thrown off together with the hyphæ. In older roots it attains a considerable thickness; it consists exclusively of cork-cells which often have somewhat curving tangential walls. There are no intercellular spaces in the periderm. The older roots consist mainly of secondary wood with medullary rays of one layer and several cells high which are united with one another by tangential bands of wood-parenchyma containing starch.

In the young shoot there are 3—5 primary vascular bundles. The cambium begins its activity quickly and in the first period of vegetation it forms a considerable quantity of wood. There is no endodermis, as HOLLSTEIN also has noticed. Outside the primary sieve-tissue, and afterwards also outside the secondary, bast is developed, usually in isolated groups, rarely as a continuous ring. The secondary bast is often present in less quantity than the primary, naturally enough, as the woody part affords sufficient support. In the Botanic Garden in Copenhagen there always occurred a more strongly developed bast than in plants from more northern regions. The cortex is of simple parenchyma and the epidermis is small-celled and has strong outer walls, about 3 μ thick, with a well-developed smooth cuticle. The pith is heterogenous. There is a peripheral part of active, starch-containing cells and in the central part similar cells form a network between larger and dead cells. The active tannin-containing pith-cells have strong walls.

Shortly after the cambium has begun to develop wood a phellogen arises in the cortex outside the bast. The first phellogen forms a cylinder which may be closed, but afterwards a typical crust-bark, "Schuppenborke" (cf. HOLLSTEIN) is formed. Each phellogen produces 3—4 layers of cork, and each new phellogen-layer cuts off a portion of the secondary cortex with the bast-groups or bast-cells enclosed in it. The primary, but dead cortex may be found on the branches even during the third year, and 5—6 cork-plates may be counted, separated by dead cortical tissue.

The secondary wood often, but by no means always, shows distinct annual rings. The growth-increment of the first year is equally vigorous on all sides, but afterwards the branch becomes highly hyponastic. The yearly growth on the hyponastic side is naturally very different in different localities; but it was always found to be less in the Arctic and Subarctic material of *D. octopetala*, on an average 0.2 mm. in younger branches, than in plants from the Botanic Garden in Copenhagen where the average growth, likewise for younger branches, was found to be 0.9 mm. Kihlman found an average yearly growth of 0.07 mm. in the 108-years-old branch mentioned above, and Schrøter measured a yearly mean growth of 0.22 mm. in a 50-years-old stem from the Alps. The maximum of the radial vessel-diameter was also greatest in specimens from Copenhagen. — The chief depository for reserve food-material in the two *Dryas* forms is naturally the branches, and the tissues containing starch are, in addition to the active part of the pith, the medullary rays, which may be as much as 3 cell-layers thick, and several cells in height, and here as in the root are connected by tangential bands of wood-parenchyma. During winter the starch disappears from the branches almost entirely and is replaced by fat. In Copenhagen this change took place in November.

In the peduncle there are no secondary formations. Outside the numerous (about 20) primary vascular bundles there is gradually formed a strong bast-cylinder which is correlated with the fruit-bearing function of the peduncle; there is no endodermis. The active cells in the pith have weaker walls than have those in the stem.

The leaf in *D. octopetala* and *D. integrifolia* is leathery and especially in the former is highly reticulated upon the upper surface. The lower surface is silver-white with a dense felt of hairs; the upper surface is usually glabrous, but in several forms it may be more or less hairy; for instance in *Dryas* *octopetala γ, hirsuta* Hartz and *δ, argentea A* Blytt, in the latter the upper surface is densely woolly, and *Dryas integrifolia* var. *canescens* Simm., in which the upper surface is densely tomentose. The leaves are revolute in the bud-condition and also as a rule, to a greater or less degree, when full-grown, especially in *D. integrifolia* (Fig. 27, *A*). In this respect it is of importance whether the plant grows in favourable or unfavourable localities. Thus the most revolute leaves are met with in dry rocky flats or on downs (Dove Bay in N. E. Greenland). Even in one and the same tuft there may be differences as regards the degree to which the leaf is revolute. Hartz (l. c. 1895 *a*, p. 311) figures a tuft of *D. octopetala β minor* from East Greenland, and writes regarding it that "to windward the branches are stunted and decorticated,

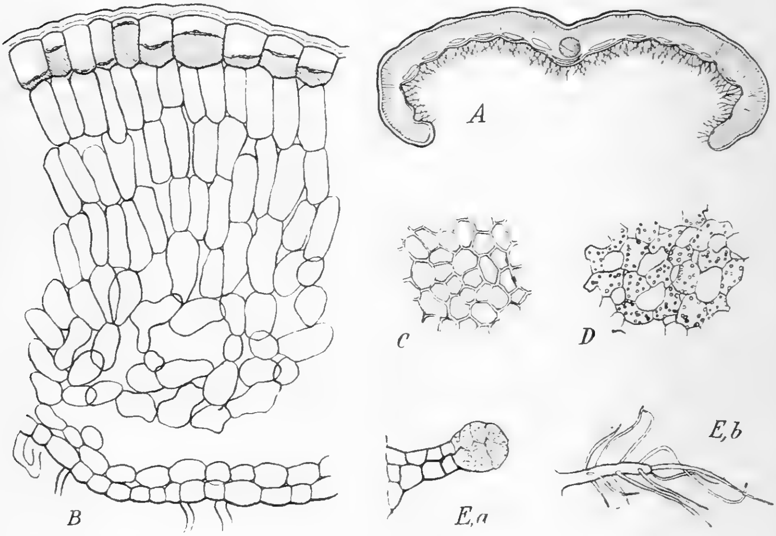

Fig. 27.

Dryas integrifolia. A, Transverse section of leaf; $^{20}/_{1}$ (Eug. Warming, 1887). *B*, Fragment of transverse section of leaf $^{220}/_{1}$). *C*, Surface view of epidermis of the upper surface ($^{140}/_{1}$). *D*, Section of the spongy parenchyma of the leaf ($^{190}/_{1}$). — *Dryas octopetala. E.* Hairs from the bundles on the upper surface of the leaf; *a*, glandular hair ($^{200}/_{1}$); *b*, branched hair ($^{50}/_{1}$).

the leaves are torn off or extremely small, and linear with involute leaf-edges; the leaves to the leeward of the shrub are larger and their leaf-edges are involute in a less degree or not at all." Hartz gives in the same place some information regarding the habitats of the different forms in East Greenland. Thus he found *D. octopetala α genuina*, which has large broad leaves, in damper localities in sheltered spots, and it was covered with snow during winter, while *β minor*, which had small narrow leaves, *γ hirsuta*, *δ argentea* and *D. integrifolia* were found in dry localities, and were usually not snow-covered during winter. The young leaves which live through the winter are so highly revolute that the lower surface is almost entirely covered. Warming remarks in his notes that the leaves when dry roll back towards the condition of the bud-stage, but on getting wetted they spread out again. As the stomata only occur on the lower surface the importance of the revolute condition is easily understood.

The epidermis of the upper surface has a very strong outer wall which is somewhat thicker in the winter leaves than in those of the summer. Thus in the latter it was found to be 2.5 μ (Iceland and Copenhagen), 4.4 μ (the most common) and 6 μ (*D. octopetala* from downs at Dove Bay in N. E. Greenland) and in the winter leaves 6—7 μ (*D. octopetala* from Danmarks Ø off East Greenland) and 8 μ (Iceland). The cuticle is considerable; it is smooth and the cutinized portion constitutes above one-half of the wall; its inner limit is distinctly toothed (Fig. 27, *B*). Kruch (l. c.) records that in *D. octopetala* the walls of the upper epidermis are mucilaginous; this I also have found to be the case, though not in all the cells; on the other hand, he denies the presence of mucilage in *D. integrifolia*, but this difference I have not been able to verify (cf. Fig. 27, *B*). The palisade parenchyma is very thick and is composed of about three layers of cells. The spongy parenchyma is rather loose and consists of slightly branching cells (Fig. 27, *D*).

The epidermis of the lower surface together with the subepidermal layer is as a rule separated from the rest of the leaf-tissue by large slit-like lacunæ occurring between the larger bundles (see Fig. 27, *A*, *B*). HOLM (l. c.), who has described and figured the anatomy of leaves from Nova Zembla, mentions similar lacunæ.

According to HOOKER (Fl. Bor. Amer.) the veins in the leaves of *D. octopetala* are distinctly visible on both sides of the leaf, and the upper surface acquires thereby a somewhat wrinkled appearance, while in the leaves of *D. integrifolia* they are only slightly or not at all visible, and therefore the upper surface is smooth. Also as regards the anatomy there is a difference in the leaves of the two forms in connection with the bundles, there being in the leaf of *D. integrifolia* less chlorophyll above and below the bundles than in the leaf of *D. octopetala*, so that the transverse section of the former shows as many bright transverse bands as there are larger bundles, while this appearance is far less distinct in *D. octopetala.* In other words, the vein-parenchyma is more strongly developed in *D. integrifolia* than in *D. octopetala.*

The stomata are situated on a level with the surface and occur especially in the spaces between the bundles. — The majority of the hairs are unicellular, they are erect and intertwining and form thereby the dense, thick layer of felt (Fig. 27, *A*). Upon the larger bundles which project as ribs the felt-hairs are partially wanting, but here large, several-celled, branched hairs and several-celled glandular hairs occur (Fig. 27, *E*).

During winter the chlorophyll takes up in a marked degree the winter-position described by KRAUSE. In the palisade-cells it gathers in the inner part, and in the cells of the spongy parenchyma it retires from the parts of the walls which border on the intercellular spaces.

The two species of *Dryas* flower generally very abundantly;

they appear to agree as regards the structure and the biology of the flower. Warming (l. c. 1886 *a*, pp. 127—28) has described and figured the flower of *D. integrifolia.* He writes: "that as *D. octopetala* (in Norway, Spitzbergen and the Alps) this also has hermaphrodite and male flowers and from a biological point of view they appear on the whole to resemble each other exactly." — Fig. 28 is a reproduction of his figure; *A* shows a branch with the terminal flower; *B*, a hermaphrodite flower; *C*, a male flower, at the base of the hypanthium of the latter are seen some pistil-rudiments. — "As in *D. octopetala* the hermaphrodite flowers are larger than the male flowers, but the smallest forms of the former are somewhat smaller than the largest of the latter"[1]. — According to Simmons (l. c.) the flower of *D. integrifolia* is on an average somewhat smaller than the average size of the flower of *D. octopetala.* — "The petals (8—11) are white or yellowish-white while young, but with increasing age become darker yellow or brownish yellow." — In *D. octopetala* they are almost pure white (Simmons). — "It appears that the hermaphrodite flowers may be both homogamous and slightly proterogynous or slightly proterandrous; on July 15, 1884, I gathered near Amerdlokfjord (W. Greenland) flowers, the anthers of which were open while the styles were still short, and the stigmas appeared to be quite immature; in other cases the pistils are very long and have ripe stigmas while the stamens are still lying bent inwards with closed anthers (Fig. 28, *D*); lastly there are cases where the anthers and stigmas begin to function simultaneously and as they are at the same level or the anthers are slightly higher than the stigmas and very close to the latter or rise above them, self-pollination will easily be able to take place; I have even repeatedly observed the anthers to be carried in between the stigmas." "Honey is secreted by the inner side of the hypanthium (the shaded part of the

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[1] A similar case is described by Müller in Alpenbl., p. 227.

figures). The stigmas are not very conspicuous or delimited from the rest of the smooth upper part of the style (Fig. 28, *F*)." LINDMAN has investigated *D. octopetala* on the Dovre (Scandinavia) (l. c. Tab. III, Fig. 30). AXELL[1] mentions polygamy, writes LINDMAN, but he himself found hermaphrodite flowers only. In the flowers he investigated he found proterogyny to be more decidedly pronounced than is the case in Central Europe according to RICCA (Att., XIV, p. 253) and MÜLLER (Alpenbl., p. 227). LINDMAN does not mention proterandry. EKSTAM (1897) records *D. octopetala* from Nova Zembla; the diameter of the flower was 10—25 mm., the

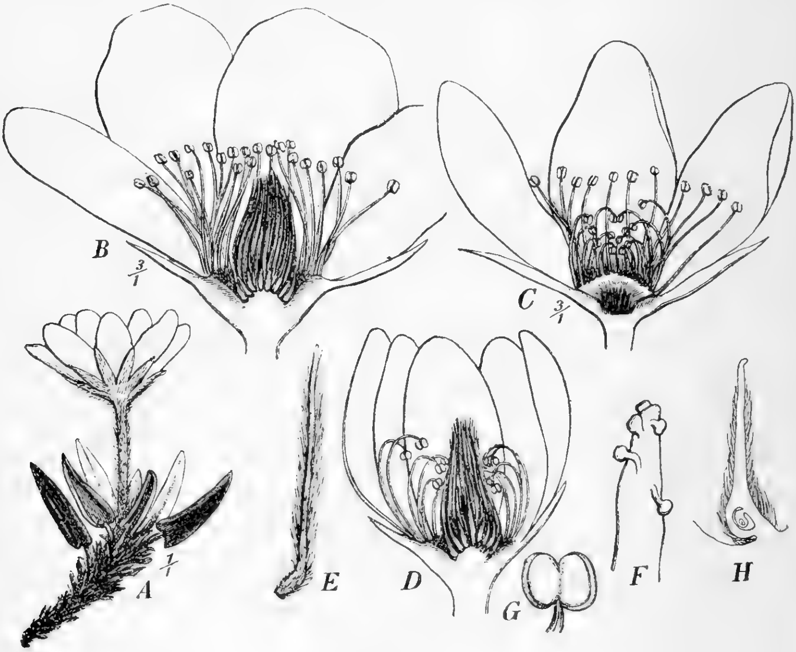

Fig. 28.

Dryas integrifolia. *A*, *B*, *C*, *D*, See text. *E*, Pistil. *F*, Apex of style with germinating pollen. *G*, Anther (Warming, 1886 a). — *Dryas octopetala.* H, Rudimentary carpel of a male flower from Bosekop (Arctic Norway; $^{13}/_{1}$).

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[1] Om Anordningarna för de fanerog. växternas befrugtning, 1869.

flowers had no perfume, and he found homogamy only. Self-pollination is made possible by the fact that the anthers bend over the stigmas or towards them. In 1898 the same author writes regarding the flowers from Spitzbergen; here the diameter was found to be 20, 25, 27 mm., exceptionally 28, 32, and even 38 mm. (Müller records the diameter of the flower in the Alps to be 27—40 mm.; l. c.). Self-pollination may easily take place as the anthers shed the pollen immediately upon the stigmas. Honey is secreted between the androecium and the gynoecium. Lastly, Dusén describes the flower-biology in East Greenland between 70° and 75°. He found *D. octopetala* to be homogamous; regarding *D. integrifolia* he writes that it is "dioecious (♀)."

In my material were 18 flowers (preserved in spirit) from Bosekop in Arctic Norway (collected by Warming, 1885), of these four were male, the others hermaphrodite; one of the latter showed a distinctly proterandrous stage; almost all the stamens had raised themselves into the air and had opened their anthers, while the pistils were yet without papillæ. The others were in a homogamous stage. Fig. 28, *H* shows a rudimentary carpel from Bosekop; the ovule with the embryo-sac is formed. Moreover, the material contained four flowers gathered by Holm at Mejduscharskji(?) and probably from Nova Zembla; three of these were distinctly male, the rudimentary carpels did not rise above the hypanthium. In the material was also found a male flower from Lille Snenæs in East Greenland.

The insect-visitors in northern regions appear chiefly to be flies and similar diptera (Lindman, Hartz and Ekstam).

D. octopetala and *D. integrifolia* flower in early and middle summer (June and August; Lange, Norman, Ekstam, Andersson and Hesselman, and Simmons), and Ascherson and Graebner (l. c.) record, as regards Central Europe, (May) June and August. In Ellesmereland *D. integrifolia* is one of the earliest flowering species (SIMMONS). The Scandinavian Floras, on the other hand, record July, August.

Usually fruit is set abundantly and regularly; as regards Spitzbergen ANDERSSON and HESSELMAN write, however, that fruitsetting is sometimes irregular, and in northern Sweden the fruit does not ripen at a height of 1000 metres above sea-level (A. CLEVE). NORMAN (l. c.) often finds empty fruit without kernel.

The fruit dispersal is decidedly anemophilous. The highly elongated and densely hairy styles in the ripe fruit spread themselves out in dry weather, but in damp weather they again unite into a single cone usually twisted to the right. The peduncle elongates considerably during fruit-setting and attains double its usual height (EKSTAM, 1898).

Rubus saxatilis L.

Lit. WARMING, 1884 and 1886, b. NORMAN, 1895. POPPIUS, 1903.

This species is not really Arctic; it is found in Greenland, but south of the Polar Circle, in Iceland, the Færöes, in Central and North Europe (also north of the Polar Circle), Siberia and in Caucasia (LANGE).

The alcohol material was collected in Greenland, Iceland and in several places in Denmark.

The shoots have a two-years period of development. In the first year a shorter or longer scale-leaf-bearing shoot is formed, which is erectly ascending or has an oblique lateral growth; it lives through the winter with its apex at the surface of the ground; next year the aerial shoot is formed. The length of the shoot of the first year is dependent on the distance of the subtending leaf from the surface of the ground, and also on the nature of the soil; as may be expected, in the loose leaf-mould of woods longer shoots are developed (Fig. 29, *A*), while in harder soil the shoots are often quite short. In conformity to this the rhizomes which persist for several years are shaped very differently. The scale-leaves are two-rowed as are the leaves of this species generally. There appears to be a difference between the upper and lower rejuvenating shoots, only the upper having been found to be floral, and those of them, which had not been proleptically developed in the same year as the parent-shoot, develop at the end of summer flower-buds for the next year (Fig. 29, *A*, *C*). I have not found flower-buds on the lower and longer shoots. Next year the flower-buds produce first 2—6 foliage-leaves and then the flowers expand, but the vegetative propagating shoots produce first an

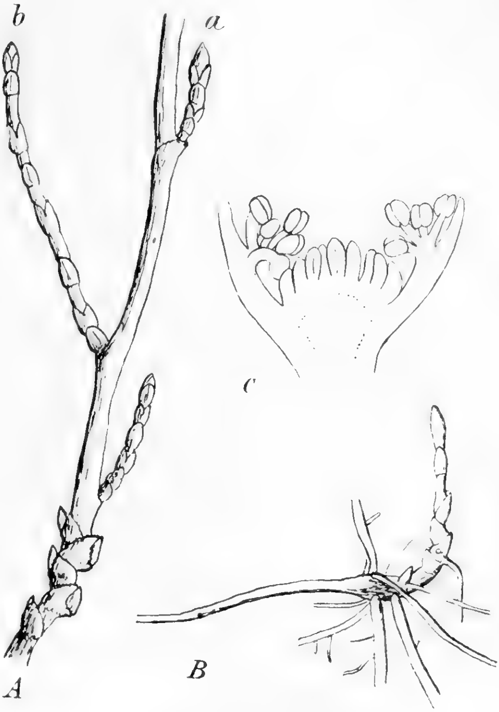

Fig. 29. *Rubus saxatilis.*

A, Shoot-base from Denmark (Oct. 22, 1912). The plant has been growing in loose leaf-mould and has therefore especially elongated internodes. The lateral shoot *a* was floral and would have flowered in the summer of 1913, while the two other shoots, at any rate the strongest, *b*, would have produced assimilatory and wandering shoots. The buds *a* and *b* reached the surface of the ground. Lowermost in the figure is seen the upper part of the shoot from 1911: there are dormant buds in the axils of the scale-leaves (slightly above natural size). *B*, Stolon-apex from Denmark (Oct. 1912). Just at the point where the stolon bends the axis is somewhat thickened, and from here numerous vigorous adventitious roots arise (slightly above natural size). C, Longitudinal section through the bud *a* in Fig. A; the exterior of the stamens well-developed, but the pollen was found not to have developed yet; nor had the ovules begun to develop in the carpels ($^{50}/_{1}$).

erect lower portion like the floral shoot and then creeping runners. The runners have elongated internodes, small leaves, and develop no roots; from the leaf-axils other runners arise. Towards the end of summer the apex of the stolon slightly penetrates the ground; it then becomes negatively geotropic, the internodes shorten and scale-leaves are developed. The stolon is somewhat thickened at the point where it bends and thence long, vigorous and richly branching roots arise (Fig. 29, *B*). These shoots also pass the winter at the surface of the ground. According to WARMING (1884) the stolons may attain a length of 1½—2 metres. In Arctic Norway they are, according to NORMAN, often above 2 metres, and he places the maximum at about 4 metres. During autumn the aerial shoots die away, at any rate partially, and the terminal buds of the stolons are set free and become independent individuals.

The structure of the shoot in *Rub. saxatilis* may be produced through a slight modification of the type common among the *Eubatus*. As the stolons live through one summer only, the flower-buds are placed near the surface of the ground, and new shoots arise from the base of the floral shoots as well as from the wandering shoots. Moreover, e. g. in Denmark, specimens are met with which form a transition between the two types, as they enter the winter with living shoot-bases, a few cm. long, which protrude above the ground and bear flower-buds.

Anatomy. Of roots only those adventitious roots have been investigated which arise from the apex of the stolons. The epidermis in the roots of the first order is thin-walled, while the subepidermal layer has stronger, brown walls. In the roots of the second order the epidermis has thicker outer walls, and the exodermis is not so well-marked. The central cylinder is in the former tetrarch and in the latter diarch. The roots of the second order are particularly characteristic owing to the structure of the cortical layer which is situated just outside the endodermis, the radial walls appearing as thick, refractive, non-stratified cushions (Fig. 30, *E*). Also in roots of the first order a similar structure has been found, but it is less common there. The periderm is formed during the first period of growth in the outermost layer of the pericycle at the same time as the primary cortex dies.

The stem is covered with a fairly dense layer of unicellular, thick-walled hairs; sometimes a few weak spines occur. The axis-system in this species illustrates fairly well how highly the development of the different tissues is dependent on the length of life and the function of the different parts of the stem. In the erect part of the stem no periderm occurs, with the exception, however, of the lower scale-leaf-bearing part which as already mentioned becomes at any rate partially perennial. In the first year it consists here of only about three layers, which develop immediately outside the bast in the cortex as is the case in the species of various other groups of *Rubi* investigated by Fritsch (l. c.). In the stolon the same features occur as in the stem of *Rub. arcticus;* a phellogen is developed which probably does not become functional. On the other hand, in the somewhat thickened apex of the stolon a fairly well-developed periderm is found towards the end of summer, in correlation with the altered conditions. In Denmark it consists chiefly of phelloid cells which at that time when the bud begins to become independent, contain a large quantity of starch. Also in the perennial subterranean axis the periderm, which is 10—15 layers thick, consists chiefly of phelloid, at any rate in Denmark in humus soil, while the periderm in the Iceland specimens was richer in cork. The periderm rich in phelloid makes a spacious reservoir of food-material. It contains small intercellular spaces. I have seen no endodermis either in the rhizome or in the aerial stem.

Bast-tissue is absent from the rhizome; it is most vigorously developed in the stem where it forms a continuous cylinder outside the sieve-tissue; the bast is connected with the secondarily formed portions of stereom in the outer part of the groups of wood by the lignified medullary rays. The stolon also contains bast abundantly: it is more slightly developed in the thickened apex.

In the rhizome a continuous cambium forms a continuous woody portion which shows distinct annual rings. The numerous medullary rays are 1—3-layered and upwards of 20 cells in height. In the stem there is no continuous cambium except in its basal part; on the other hand a continuous cambium begins to function early in the thickened apex of the stolon.

While the cortex in the stem is distinguished into an outer small-celled part filled with chlorophyll and an inner larger-celled part poor in contents, the whole cortex in the apex of the stolon functions as food-storing tissue, and is crowded with starch in the autumn. The 1—3 outer cortical layers are collenchymatous especially in the erect stem.

The pith is heterogeneous as in all the *Rubus*-species hitherto investigated (cf. FRITSCH). The active cells, especially the starch-containing ones in the rhizome and the apex of the stolon, are found chiefly in the periphery of the pith, but also in addition dispersed longitudinal rows of living cells occur in the central part which for the rest consists of larger dead cells. Anastomoses are rare.

During autumn the quantity of starch diminishes in the different tissues of the rhizome and at the same time large quantities of fat may be demonstrated.

The leaves are slightly hairy on both sides and are somewhat folded. No glandular hairs were found. On the lower surface the bundles are very prominent. The structure is mesophilous in correlation with the fact that the leaf lives one summer only, and is moreover strongly influenced by light The leaves from Greenland (Tasermiut-Fjord) had the following dimensions: Thickness of leaf 110 μ, thickness of the outer wall in the upper epidermis about 3 μ,

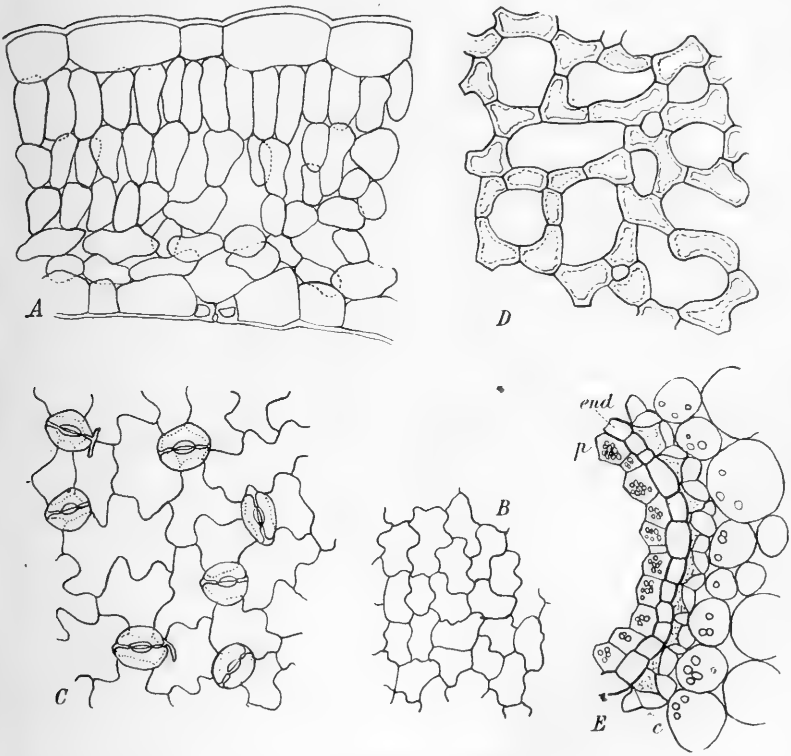

Fig. 30. *Rubus saxatilis*.

A, Transverse section of leaf. *B*, Epidermis of the upper surface of the leaf. *C*, Epidermis of the lower surface of of the leaf. *D*. Section of the spongy parenchyma of the leaf parallel to the surface. *E*, Fragment of an absorbent root of second order; *c*, the cortex, the radial and outer tangential walls of its innermost layer have highly thickened walls; *end*, endodermis; *p*, outermost layer of the pericycle. A, B, C, D from Greenland, E from Denmark (*A*, *C*, *D*, *E* $^{280}/_1$; *B* $^{130}/_1$).

in lower epidermis about 2 μ, the corresponding dimensions from leaves collected in Iceland (Aðalvik in N. W. Iceland) were: 130 μ, about 4.4 μ and about 3.3 μ. An explanation of these differences is suggested by the vague records on the labels: The Greenland specimens are said to be collected "under and between birch copses," consequently, most likely on shady ground, while those from Iceland grew on "Lien" (grassy slopes), consequently, probably in more open ground. Leaves collected in very shady localities in Denmark were about 90 μ thick and had in a high degree the character of "shade leaves," with only one layer of palisade-cells, which were funnel-shaped, and a few layers of spongy parenchyma. The proportion between the leaf-thickness and the thickness of the palisade tissue was about $\frac{2}{1}$ in leaves both from Greenland and Iceland. The figures show the leaf-structure of the common type; a loose palisade parenchyma consisting of 2 layers of cells ,about twice as high as broad, and a likewise very loosely built spongy parenchyma. The stomata occur only on the lower surface of the leaf; they are situated on a level with the surface. (Fig. 30, *A*, *B*, *C*, *D*.) — Bast-tissue is absent from the leaf.

Three distinct bundles enter the leaf-stalk (see p. 87); shortly afterwards the two upper lateral ones divide each into two bundles of which the lower one on both sides gradually approaches the median lower bundle and ultimately fuses with the latter the transverse section of which then becomes crescent-shaped. The fusion takes place a short distance above the point where the sheath ends, and in the rest of the stalk there are 3 bundles. The two upper are round in transverse section and lie in the ribs which form the furrow on the upper surface of the stalk; the two latter especially are accompanied by a strong fibrous tissue.

The flower-biology has been investigated by WARMING (1886, *b*). He writes (loc. cit. p. 40) "The petals in the latter (*Rub. saxatilis*) stand erect, and the stamens bend somewhat toward the centre without however uniting so closely together above it as in *Rub. arcticus;* there is, at any rate in a somewhat older flower, an entrance between them down to the pistils; they have similar finely warted filaments to those of *Rub. arcticus* (Fig. 37), which likewise terminate abruptly above in a smooth and much thinner portion, and in my opinion the pollen from them must certainly fall upon the stigmas." H. MÜLLER (Alpenblumen, p. 216) arrives at the same conclusion. (Compare Fig. 31). WARMING states in his notes that the stigmas become functional very early; even in the hardly expanded flowers from Talvik in northern Norway they are highly papillose; the outermost stamens are the next to become functional and afterwards the others. But even if the flowers have perhaps at that time a short proterogynous stage, they become homogamous at any rate early. As regards the supposed importance of the warts on the filaments see *Rub. arcticus*, p. 97. POPPIUS (l. c.) records that in Finland *Rub. saxatilis* is eagerly visited by *Vespa vulgaris* L.

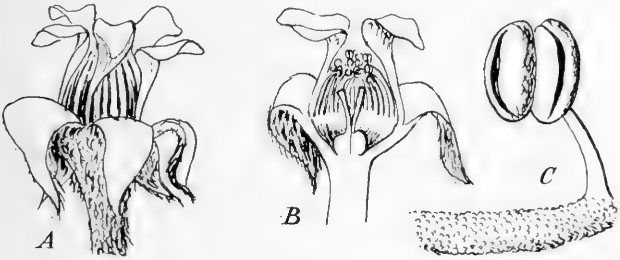

Fig. 31. *Rubus saxatilis* (Talvik in Arctic Norway).
A and *B*, Flowers (about 3/1); *B*, in longitudinal section. *C*, A stamen (about 25/1); cf. text. Drawn by Eug. Warming.

The flowering begins in Scandinavia in June; NORMAN records June 21. In some years it does not set fruit in the northern districts of Arctic Norway. The fruits may be ripe on July 28 (NORMAN). In Greenland it is usually found without fruit, and in the Færöes it sets fruit sparsely.[1]

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[1] Ostenfeld, Plantevæxten paa Færöerne, København, 1906.

Rubus chamæmorus L.

Lit. WARMING, 1886, a. LINDMAN, 1887. KIHLMAN, 1890, pp. 55, 113. HARTZ, 1894, p. 7. NORMAN, 1895. KOLDERUP ROSENVINGE, 1896, a. KRUCH, 1897. ANDERSSON and HESSELMAN, 1900. A. CLEVE, 1900, p. 47. POPPIUS, 1903. SYLVÉN, 1906.

Rubus chamæmorus is circumpolar, but thrives also in temperate regions in Asia, America and Europe, where in many places it must most properly be regarded as a relict. It occurs almost everywhere in damp localities, and grows by preference on the loose surface of bogs and marshes. A few exceptions from this rule are however known, the plant in Arctic Norway, according to NORDMAN, growing in dry localities furthest out towards the sea and especially at some height above it; an explanation of this phenomenon has been sought in the fact that the air from the sea is extremely damp. In Greenland also, where it only occurs in the coastal districts and on islands in the skerries, it grows on relatively dry and heath-like tracts.

The aerial shoots are vegetative or vegetative-floral. They usually bear 1—3 foliage-leaves and are terminated by a solitary flower or by a dead bud enclosed in the sheath of the uppermost foliage-leaf. The aerial shoot usually has at its base a few scale-leaves with intervening short internodes (Fig. 32, *C*). The uppermost of these scale-leaves are doubtless as a rule situated above the surface of the bog, and often from the axils of the lower arise during summer scale-leaf-bearing shoots which will next year produce aerial shoots. Consequently, the plant has a two-years development. During autumn the scale-leaf-bearing shoots form a distinct resting-bud which is situated at the surface of the bog. If the shoot arises from a point which is situated at some depth in the bog it assumes a more or less decided wandering stage before it enters into the assimilatory or ultimately floral stage; the shoot to the right in Fig. 32, *D* exemplifies this; but the development is nevertheless of two years duration. The plant has, however, a much greater power of wandering, because it gives off horizontal runners which may attain a length of above 30 cm. Fig. 32, *A*, *B* are apices of the latter in the wandering and resting stages respectively. These well-marked wandering shoots arise from deeper-lying parts of the plants, and their two-rowed sheath-like scale-leaves may subtend new runners. In the beginning of autumn they may either develop a resting bud which is situated almost at the surface of the bog and which in Denmark in October contains the first foliage-leaf of the assimilatory shoot of the next year, or the runner may live through the winter deeper down in the bog without developing a resting bud proper and next summer resume its

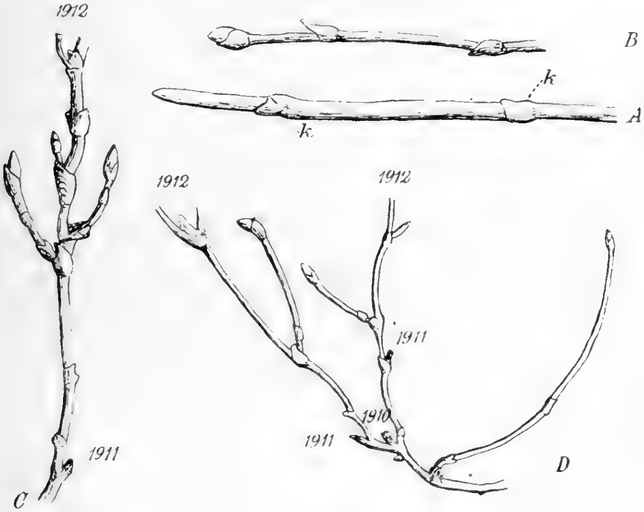

Fig. 32. *Rubus chamæmorus.*

A, Apex of a runner (Norway; July 22); *k*, bud. *B*, Runner with resting bud in which the first foliage-leaf is formed (Denmark; Oct. 6). *C* and *D* are branch-systems in the winter-stage (Denmark; Oct. 6). The shoots marked *1912* have that year been assimilatory shoots, from their base new shoots arise bearing winter-buds. Portions of axes marked *1911* and *1910* have been assimilatory during these years. All the figures are about natural size.

wandering life. The shoot then takes more than two years to develop. When a runner is entering on its last stage it grows upwards toward the surface of the bog and at the point where it bends the internodes usually become somewhat shorter, but by no means always, as easy transitions from runners with 3—4 short internodes at the bending point to runners which form aerial shoots without any shortening of their internodes are met with. This difference expresses the state of dependence in which plants growing in a bog stand to the moss-vegetation of the latter. The shoots, without the shortening of the internodes, were probably in danger of being overgrown by the moss, consequently, no short internodes have been formed but only elongated ones to carry the terminal bud upwards to reach the light.

The older plant probably develops only adventitious roots; the latter arise from the nodes of the runners during the second period of growth.

Among related species this *Rubus* has no doubt an unique shoot-structure which appears to make it specially adapted for life in the habitats it has chosen for itself.

Anatomy. The adventitious roots are diarch—tetrarch. The endodermis has rather thick walls which have become corky. Even before the periderm, which is developed in the outermost layer of the pericycle, is formed, consequently, in the absorbent-root stage, the epidermis is destroyed and the two outer layers of the cortex assume the appearance shown in Fig. 33, *G*. At a distance of a few mm. only from the root-apex we find the epidermis dead, while the cortical layer next to the outermost one only gradually attains the wall-thickness figured, viz. about 2.5 μ. The dead epidermis does not however persist everywhere, as the figure indicates, often only fragments of the radial walls are found.

There are somewhat considerable differences in the anatomical structure of the aerial and the under-ground stem in *Rub. chamæmorus*, differences which are connected with differences of life-duration and function. The conducting tissue exhibits the greatest differences. In the aerial shoot there are about 10 primary bundles separated by narrow medullary rays which remain in their primary condition; the intrafascicular cambium forms only a small amount of wood. I have not been able to see any endodermis in the aerial shoots, though such is distinctly seen in the wandering shoots. In the latter a continuous cambium begins to function very early and a considerable amount of wood is formed containing numerous medullary rays which are usually one cell-layer broad. In older rhizomes more or less distinct annual rings occur; the oldest I have seen were, however, only three years old. As regards the proportion between the diameter of the pith and that of the whole organ, the usual difference obtains between aerial and under-ground shoots; the proportion in the aerial shoot is larger (about $\frac{1}{2}$) than in the runners measured in their primary condition ($\frac{1}{3}$—$\frac{2}{5}$). In addition there is found in the aerial shoot, but not in the runners, a fairly thick fibrous tissue outside the phloem, and the outermost cortical layer is somewhat collenchymatous. The cortex in the runners is considerably thicker than in the aerial shoot, but more space is not thereby gained for reserve food-material, because even in the first vegetation-period of the shoot a periderm is formed in the outermost layer of the pericycle. Then the cortex collapses and persists during the following years as a loose brown mantle around the rhizome. But even in the third year the phellogen has not been able to form more than 3—4 layers of which the outer have become corky. In the aerial stem no periderm is developed, not even so much as in *Rub. arcticus* (Fig. 36, *F*); consequently, the structure of the assimilatory shoot of *Rub. chamæmorus* is the simplest among the species of *Sect. Cylactis* here investigated. — The epidermis around the young runner has thin walls, and the protective layer described for the roots is altogether wanting.

The pith is heterogenous as in the two other species; Fig. 33, *F* shows a somewhat tangential longitudinal section through the central part of the pith of a runner. The active cells, which have somewhat stronger walls in the aerial stem than in the runners, form in addition to a continuous marginal part (of which *mp* in the figure is the innermost layer) also slightly anastomosing rows in the central part (*mc*) of the pith where the majority of the cells are dead. But notwithstanding this structure the pith is the chief depository of food-material, and during autumn is found crowded with starch; in addition, the medullary rays and the pericycle in the runners serve as reservoirs of starch.

Though *Rub. chamæmorus* is not an evergreen yet its leaves have in one respect a xeromorphous structure: the upper epidermis has mucilaginous inner walls (Fig. 33, *A*), a fact which has already been mentioned by KRUCH (l. c.). KIHLMAN (l. c., p. 113) was probably ignorant of this since he mentions, among others, *Rub. chamæmorus* and *Potentilla palustris* (which has also mucilaginous walls in the upper epidermis of the leaf) as striking examples of bog-plants without special protective devices against excessive transpiration (see p. 119). Otherwise the leaf has the usual mesophyllous structure; it is rather thin (170—190 μ) and the proportion between the thickness of the leaf and the thickness of the palisade tissue varied from about $\frac{2}{1}$ (Godthaab in Greenland) to $\frac{2.4}{1}$ (Bosekop in Arctic Norway). The outer wall of the upper epidermis is 2—2.5 μ thick and that of the lower somewhat thinner. Stomata occur only upon the lower surface; they are not definitely arranged. The radial walls in the epidermis are somewhat wavy, usually somewhat more so upon the lower than upon the upper surface. The palisade parenchyma is present in 2—3 layers and the spongy parenchyma is loose in structure. (Fig. 33, *A*, *B*, *C*, *D*).

The larger bundles are very prominent upon the lower surface of the leaf which helps to support the large reniform blade. These ribs consist not only of conducting tissue proper, but also of rather thick-walled vein-parenchyma. True stereom was not observed in the leaf. Along the veins upon both sides, but especially upon the under side, such glandular hairs are found as shown in Fig. 33, *E;* scattered unicellular hairs of the usual appearance are also met with.

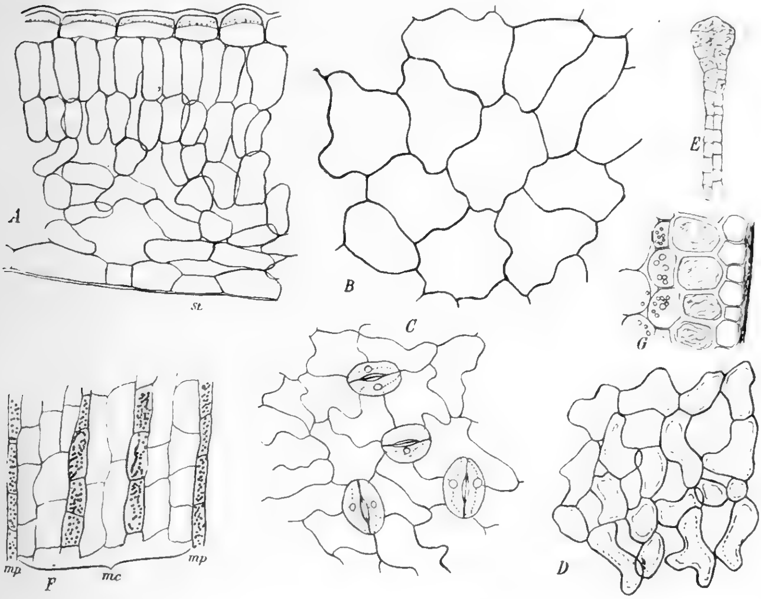

Fig. 33. *Rubus chamæmorus.*

A, Transverse section of leaf, the inner wall of the upper epidermis is mucilaginous. *B*, Epidermis of the upper surface of the leaf. *C*, Epidermis of the lower surface of the leaf. *D*, Section of the spongy parenchyma of the leaf parallel to the surface. (*A*, *B*, *C* and *D* from Greenland.) *E*, Glandular hair from the lower surface of the leaf (Norway). *F*, Longitudinal section through the central part of the pith in a runner (Denmark). *G*, The peripheral part of an absorbent root in transverse section, the epidermis has collapsed, the layer within the exodermis has strong walls (Denmark). *A*, *B*, *C*, *D*, *F* and *G* $^{200}/_{1}$; *E*,$^{90}/_{1}$.

In the anatomy of the leaf-stalk *Rub. chamæmorus* differs considerably from *Rub. saxatilis* and *Rub. arcticus*, which is of interest as Fritsch has shown that a certain systematic importance must be attached to the number of the vascular bundles and their course in the leaf-stalk of *Rubus*. And as the group *Cylactis* (Raf.) Focke in this as well as in most other points has not previously been anatomically investigated I shall give a description of the present case. With the exception of some individual variations the facts are as follows: As in all the species investigated by FRITSCH, and as in the two other species mentioned here, so also in the present species three vascular bundles enter the leaf-stalk; after a course of about one cm. the two upper divide each into two bundles, and in the whole length of the stalk up to a few mm. from the leaf-blade there are five bundles; at this level one lateral bundle on each side unites with the median one, but the latter divides again into three before the stalk passes into the leaf-blade. The bundles are stiffened by a fibrous tissue along the sieve-tissue.

As regards the structure of the flower of *Rub. Chamæmorus* WARMING says in his notes: "Both in northernmost Norway and in Greenland I found the cloud-berry to be purely dioecious and the degree of abortion of the one sex was almost the same in both places. If I may point out any differences it would be that: (1) The Greenlandic flowers are perhaps slightly smaller than the Norwegian; the diameter of the latter I have found to vary between 2½ and 3½ cm. as regards the male flowers and to be about 2½ cm. for the female flowers; the Greenlandic were 2—2½ cm. for both kinds of flowers, but the material in hand was extremely sparse. (2) The Greenlandic appear to have slightly less rudimentary stamens in the female flowers and likewise slightly less rudimentary pistils in the male flowers than have the Norwegian. In the former the stamens had a somewhat larger anther, in the latter the carpel was more highly developed and the ovule was even indicated, as the figures show." . . . . "As regards the flower it may be added, that it is 4—6-merous in calyx and corolla, sometimes purely so, but sometimes with one or other sepal broader than the rest and cleft, a transitional stage to becoming two. In some flowers the hypanthium is quite smooth in the interior, in others it is, over the greater part of the surface or only at the bottom, covered with long, stiff, thick-walled hairs which are quite smooth exteriorly. In the male flowers many pollen-grains were found between these hairs and between the pistil-rudiments."

In 1887 LINDMAN recorded *Rub. chamæmorus* from Dovre (Scandinavia). He found only unisexual flowers with very small rudiments of the other sex. In the female flowers the petals were 8—10 mm., in the male flowers about 15 mm. long. AXELL[1] (pp. 46—48, Fig. 11, *a*, *b*) records *Rub. chamæm.* as trioecious-polygamous (quoted after LINDMAN). In 1903 POPPIUS mentions *Rub. chamæm.* In the female flowers he finds slight or no secretion of honey; in the male flowers honey

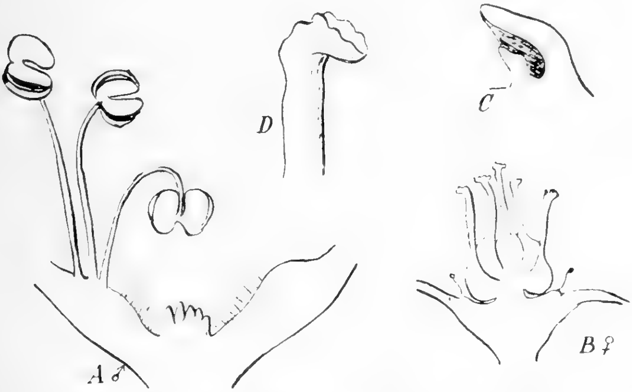

Fig. 34. *Rubus chamæmorus.*

A, Male flower from Arctic Norway; June 25 $(^2/_1)$. *B*, Female flower from Greenland $(^4/_1)$. *C*, Carpel of a male flower from Arctic Norway, in the hollow a slight indication of the ovule is seen $(^{45}/_1)$. *D*, The somewhat folded and slightly lobed stigma of a female flower from Arctic Norway (about $^{50}/_1$). Drawn by Eug. Warming.

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[1] Om Anordningarne för de fanerog. växternas befruktning. 1869.

is secreted more abundantly, the stamens are well-developed, with brown anthers, the carpels are very rudimentary and scarcely visible in the hypanthium. Insect-visitors to the flowers are fairly frequent, especially flies. In the male flowers they devour partly honey and partly pollen, in the female flowers it is probably the white stamen-rudiments which attract them, because their attention is always drawn to these staminodes.

In Spitzbergen the plant has been collected with flowers twice only; the second time numerous flowers were found at Kol Bay (23 . 7 . 1898); they were smaller than those from the district of Tromsö (Arctic Norway) and were all female (ANDERSS. and HESSELM.).

In Greenland it is peculiar that the two sexes have not been found in the same locality. Thus, only male flowers have been found at Julianehaab and on the large island to the west of Ameralikfjord, while only female flowers have been gathered in different localities near Godthaab (VAHL [see WARMING, 1886], LANGE, ROSENVINGE and HARTZ). WARMING (l. c.) mentions that WORMSKJOLD records fruit of *Rub. Chamæmorus* from Greenland, and ROSENVINGE (l. c.) says that it appears to set ripe fruit at Kasigiànguit near Godthaab. Otherwise it is not known to bear fruit in Greenland. As regards this point NORMAN records from Arctic Norway that it sets fruit there in favourable years, even in the northernmost districts; in the highest habitats it never flowers, and A. CLEVE (loc. cit., p. 47) records that it is often sterile in the mountains of northern Sweden. In places on the coast of Arctic Norway, at higher levels above the sea, it bears almost exclusively male flowers and probably every year; and NORMAN says that in certain years, only or almost only male flowers occur over very large areas so that the harvest fails entirely. Lastly, POPPIUS (l. c.) mentions the distribution of the two sexes;

he found that at Esbo in Finland the female flowers which were somewhat more numerous than the male, usually occurred in more open places in the marshes and bogs, while on the other hand the male flowers were somewhat more numerous in shady localities.

Flowering begins in June (LANGE, NORMAN). In Arctic Norway birds are important agents in fruit-dispersal; and bears probably also play a part in this connection (NORMAN).

Rubus arcticus L.

Lit. TRECUL, 1865. WARMING, 1886, b. NORMAN 1895. POPPIUS, 1903. SYLVÉN, 1906.

This species is found in the whole of the Subarctic zone, and extends but rarely into the Arctic, namely in Norway, where its northern limit lies somewhat to the south of 71°. NORMAN writes that it thrives both in dry and damp localities and even in bogs, where it occurs especially on knolls.

The alcohol material was collected in northern Scandinavia.

Rubus arcticus does not develop wandering shoots, but vegetative propagation is effected by bud-producing roots; WARMING (1886) records this from Bosekop in Arctic Norway: "Its (*Rub. arct.*) unbranched or slightly branching shoot, which is a few inches high, occurred always singly but socially over larger or smaller patches of the field" and "it was proved that this species was chiefly propagated by root-shoots, consequently it has shoots of the same structure as have those of a great many similar plants, e. g. *Cirsium arvense*, *Sonchus arvensis*, *Pyrola uniflora*, etc. Its shoots have elongated internodes without rosette-leaves at the base; remains of it may keep alive through the winter and next spring produce a new shoot as the figure (Fig. 35, *A*) shows." A sympodium is thus formed which may include at least four shoot-generations. These root-shoots sometimes go through a stage of growth in vigour before they flower, but I have not been able to investigate such shoots in the material at my disposal, therefore I shall only deal with the propagative shoots formed by the stems.

In correlation with the fact that vegetative propagation is effected by the roots, the plant has one kind of shoot only, viz. assimilatory floral-shoots which have a two years development. In the first year an erectly ascending, and when the plant is growing in dry soil, short propagating shoot is

Fig. 35. *Rubus arcticus.*

A, Portion of root with a shoot-complex arising from it. The first leaf of the lateral shoots is marked with a × (Arctic Norway, July, 1885; $^1/_1$); drawn by Eug. Warming (l. c.). *B*, A plant which had been growing in a sphagnum-bog in the province of Quebec in Canada, Aug., 1907; *l*, the stalk of a foliage-leaf; *s*, propagating shoot; (slightly above nat. size); drawn from a specimen in the Botanical Museum in Copenhagen.

formed, which usually bears 4—6 scale-leaves in two rows; it probably does not elongate until the end of summer. The specimens figured in Fig. 35, *B* had been growing in a sphagnum-bog, and the height of the latter has compelled the young shoot to elongate to an unusual extent. The propagative shoots pass through the winter with their apices at the surface of the ground. Next year the assimilatory shoot is formed, which also has elongated internodes; it is terminated by the solitary flower or by the dead apex of the stem which is hidden in the upper leaf-sheath. The foliage-leaves, which are usually few in number, are two-rowed as are the scale-leaves. Often, the foliage-leaves, especially the upper, also subtend solitary flowers, or slender vegetative shoots occur. The propagating shoots, two or more of which may occur, are as a rule subtended by the lower scale-leaves; buds subtended by other scale-leaves remain dormant or the upper ones may develop proleptically during the same year as the parent-shoot, which results in the individuals becoming fairly rich in shoots. — According to SYLVÉN *Rub. arcticus* appears to pass through the winter in a partially green condition.

Anatomy. The horizontal shoot-bearing roots are protected by a cork-periderm of about 6 layers without intercellular spaces. They are in connection with the shoot-bases, the plant's reservoir of food-material, and in them the several-layered pericycle and the one-layered, but several cells high, medullary rays in the secondary wood become filled with starch. From the rhizome adventitious roots arise. The absorbent roots are of the nature of mycorrhiza and have a peculiar structure. The epidermis consists of low cells with very strong outer walls (4 μ thick). The structure of the inner layer of the cortex, which is about 4 layers thick, is as in *Rub. saxatilis*, but the thickenings of the walls are less and there is an unthickened part on the outer tangential wall. The rather thick endodermis, the thickenings of the walls mentioned above, and the epidermis turned yellow when treated with chloride-zinc-iodine. (Fig. 36, *E*).

The anatomical structure of the annual aerial shoot is naturally very different from that of the perennial rhizome. In the latter secondary wood is developed which forms annual rings, and the primary cortex is thrown off, a periderm of about 6 layers without intercellular spaces and consisting chiefly of cork being formed in the pericycle. The latter, a few layers of phelloid-cells, the medullary rays, which are of the same structure as those of the root, and especially the peripheral part of the pith are depositories for starch. The aerial shoot remains in a far higher degree in the primary condition. A continuous cambium in the lower part forms only a small quantity of wood, and it is likewise only in the lower portion that a periderm is found like that shown in Fig. 36, *F*. In the cortical layer bordering on the bast-ring tangential walls are developed, the walls in the outer layer thereby formed become corky, but the inner layer which corresponds to the phellogen remains unaltered. This rudimentary periderm distinguishes with certainty the stem of *Rub. arcticus* from that of *Rub. Chamæmorus*. — The bast, which is absent from the rhizome, is about 3 layers thick in the lower part of the stem and forms a continuous ring, becoming weaker upwards. Endodermis is absent, but is present in the perennial part of the stem. The outer wall of the epidermis is rather thick and has a well-developed cuticle. Within the epidermis there are two layers of slightly developed collenchyma. — The pith has the usual peripheral layer of starch-containing cells, but in the central part I have seen no such cells. TRECUL (l. c.) who has described the pith records that in the central part a few isolated cells were found containing tannin.

The leaf, which probably as a rule lives one summer only (see p. 93), has the usual mesophyllous structure;

it bears on both sides, especially on the veins, scattered unicellular hairs. The outer wall of the upper epidermis is about 2.5 μ thick. The stomata occur only upon the lower surface and are on a level with the surface. Palisade parenchyma occurs in 1—3 layers. The proportion between the leaf-thickness (about: 155 μ) and the thickness of the palisade tissue was about $\frac{2}{1}$. The spongy parenchyma is loose. Fig. 36, *A*, *B*, *C*, *D*.

The structure of the leaf-stalk is as in *Rub. saxatilis;* along the greater part of the length of the stalk there are three bundles, and only along a very short distance, immediately after the three bundles have emerged from the stem there are 5 bundles. The stereom is very much as in *Rub. saxatilis.*

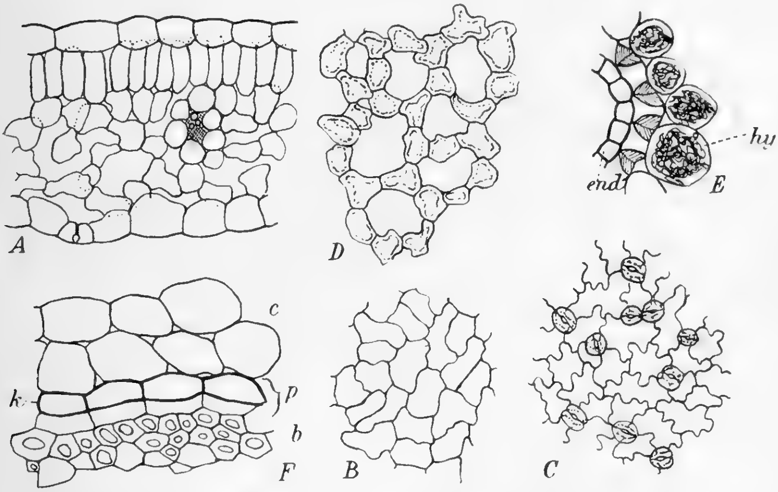

Fig. 36. *Rubus arcticus.*

A, Transverse section of leaf. *B*, Epidermis of upper surface. *C*, Epidermis of lower surface. *D*, Section of spongy parenchyma parallel to the surface. *E*, Portion of a transverse section through an absorbent root; *end*, endodermis; *hy*, fungal hyphae, the innermost layer of the cortex has highly thickened radical walls. *F*, Portion of a transverse section through an aerial stem; *b*, the bast outside the leptome; *c*, cortical cells; *k*, the cork-layer in the rudimentary periderm *p*. *A*, *B*, *C*, *D*, *E* from Bosekop and *F* from Ångermanland in Sweden. (*A*, *D* $^{190}/_{1}$; *B*, *C* $^{140}/_{1}$; *E*, *F* $^{314}/_{1}$).

The flower-biology was first treated by WARMING

(1886), who says: "The hermaphrodite flowers are 6- or 7-merous, more rarely 8-merous and have a varying diameter (about 18—30 mm.). The dark-crimson, stellately expanded or even somewhat reflexed petals are highly conspicuous with the green field as a background; therefore it is interesting that the flower is nevertheless well adapted for self-pollination."

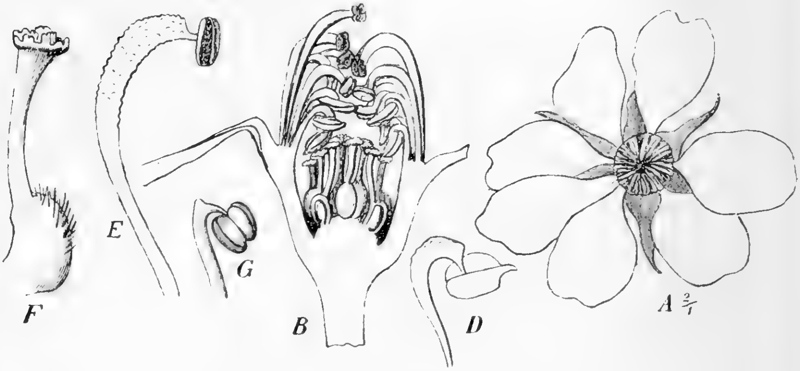

Fig. 37. *Rubus arcticus*.

A, A flower seen from above. *B*, A longitudinal section through a flower the anthers of the outermost stamens have opened. *D* and *G*, Two stamens from the innermost circle. *E*, A stamen from the outermost circle. *F*, A pistil. — Cf. text. *D*, *E*, *F* *G* $^{10}/_{1}$; Arctic Norway. (Eug. Warming l. c.)

"On regarding the flower from above one does not see, as in the other *Rubus*-species, that the styles with the stigmas are situated in the middle and are closely surrounded by the stamens, which are of about the same length; here, only the stamens are seen which from all sides bend inwards toward the centre of the flower so that the central part is quite hidden. A longitudinal section shows best how they unite closely in a conical fashion with the upper ends more or less bent inwards and with all the anthers gathered above the centre of the flower. (Fig. 37, *A*, *B*). The outermost stamens are the longest, their filaments become, from a thinner, entirely smooth base, gradually thicker and also covered with small warts. Immediately below the anther the filament becomes suddenly thinner. The nearer the stamens approach the centre of the flower, the smaller they are and the more bent inwards; the smallest of all have short much bent filaments the upper thinner part of which is however as long or even longer than that of the outermost stamens (Fig. 37, *D*, *G*). As the stamens are so densely and closely united above the centre of the flower it appears as if all smaller and weaker insects must be entirely excluded from access to the honey secreted by the inner side of the hypanthium. I think that only strong insects such as humble-bees and bees will be able to force a way, but perhaps the slender proboscis of the butterfly may discover a way down between the filaments."

"Longitudinal sections show moreover that the pistils are lying hidden just below the stamens. The styles, which are slightly thickened towards the apices, are erect, and the irregularly lobed stigmas (Fig. 37, *F*) are thereby placed immediately below the anthers, and partially even in direct contact with those of the innermost, short stamens. The flowers are slightly protandrous; the outermost stamens open their anthers very early even at the time when the petals still stand almost erect, and before the stigmas are quite mature, though large. But the stigmas evidently become functional very quickly after the outermost stamens, because I have seen the stigmas covered with quantities of germinated pollen before the anthers of the innermost stamens have opened. Cross-pollination must be possible; but I also believe that pollen must almost certainly fall from the anthers of a flower upon its own stigmas, when an insect thrusts its proboscis down between the stamens, and this evidently happens the more easily because the filaments are rough and must therefore offer more resistance to the intruding proboscis of an insect, and thus be shaken so much more effectively. It will then depend on whether the pollen from the flower of another individual germinates or develops more quickly than does the pollen of the same flower. But in case cross-pollination does not take place, self-pollination is inevitable ultimately when the short stamens dehisce."

"I know no other *Rubus*-species in which self-pollination is so well secured as in the present species, and this must undoubtedly be regarded as an adaptation of the species to the inclemency of the weather, to which it is probably often exposed during its flowering period. The species which comes nearest to it is, according to my observations, *Rubus saxatilis*, which as is well-known extends even to the North Cape and East Finmark and above the wood-limit in the mountains of Norway and in the Alps."

POPPIUS (l. c.) finds that the flowers are without scent and secrete very little honey; he also records a proterandrous stage before the homogamous. He writes that in foggy or overcast weather the stamens bend inwards so that the anthers and filaments entirely cover the pistils. Numerous insect-visitors are mentioned. NORMAN records that in the districts of Arctic Norway where the plant sets fruit rarely or only sparingly, the corolla is largest and most showy, frequently with 6—8 petals which are 13—14 mm. long and 8—10 mm. broad, while in districts where the plant bears fruit frequently the corolla is often much smaller, with petals the length of which may be reduced to 9 mm. and breadth to 5.5 mm. In Arctic Norway *Rub. arcticus* flowers in the end of June and has ripe fruit in August (NORMAN). — Fruit-dispersal probably by birds.

According to the microscopical investigation of *Rubus chamæmorus*, *Rub. saxatilis* and *Rub. arcticus* mentioned above, the first-named differs in several points from the other two, viz. (1) in the structure of the absorbent roots, (2) in the structure of the aerial shoot, (3) by the fact of its leaves bearing stalked glands and having mucilaginous inner-walls in the epidermis of the upper side, and lastly (4) in the number of the vascular bundles in the leaf-stalk, where *Rub. chamæmorus* has five and the others three. According to Fritsch (l. c.) special importance should be attached to the last feature when the question is to distinguish anatomically species and groups of species among the *Rubi*. Thus, the anatomical investigation together with the morphological appears to support Focke[1] who separates *Rub. chamæmorus* from the other herbaceous *Rubi* and places it in a distinct subgenus.

Alchimilla alpina L and **A. færøensis** (Lge) Buser.

Lit. Müller, 1881. Jónsson, 1895. Norman, 1895. Knothe, 1902. Schrøter, 1904. Hollstein, 1907.

As these two species agree in many of the points which have been investigated they are here treated jointly for brevity's sake.

A. alpina extends north of the Polar circle in Scandinavia only; it is found also in Greenland, Iceland, the Færöes, the mountains of Central Europe and in the Urals. *A. færøensis* has been found only in the Færöes and in Iceland. The habitats are more or less dry, but *A. alpina* at any rate can live in widely different conditions: in grassy localities, on cliffs, on heaths, rocky flats, in willow copses, etc.

The alcohol material was gathered in Greenland, Iceland and the Færøes.

A. alpina has a primary root of rather long duration from which the shoots spread out upon the ground with apices turned upwards. Usually the shoots do not reach any considerable length; they branch freely and are fixed to the ground by adventitious roots. Looser or denser tufts are formed. The rhizome in *A. færøensis* is thicker than that in *A. alpina;*

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[1] Abh. d. Naturw. Ver. Bremen, IV, 1874 and Synopsis Ruborum Germaniæ. Bremen, 1877.

it is vertical or obliquely ascending, branches less freely, and the branches are considerably shorter, but they develop adventitious roots as in *A. alpina.* Undoubtedly, neither species is entirely dependent on the primary root for the continuation of life; vegetative propagation takes place. Fragments of the dead leaves persist for a longer time, but in *A. alpina* at least the shoots may ultimately get rid of them.

The leaves are placed in a rosette, but in luxuriant specimens of *A. alpina* the internodes may be somewhat elongated. The first leaf of the shoots — both of the floral and the vegetative — is a scale-leaf in the form of a closed sheath; also the other leaves have closed sheaths which are ruptured on the vegetative shoots owing to growth in thickness. In Iceland JÓNSSON found *A. alpina* with green leaves in the winter. The old leaves had not fallen off, but formed a sort of waterproof roof over the shoots (l. c.). In the Botanic Garden in Copenhagen the leaves which remain green through the winter are, in both the species, very small, few in number and not quite expanded. The summer-leaves wither in the autumn and a few new leaves may grow out, but strictly speaking the plant is scarcely winter-green. The shoot-apices are protected by the closely folding leaf-sheaths; scale-leaves are not developed.

In the Botanic Garden in Copenhagen there is no fixed flowering-period, but new floral shoots are constantly being developed as in the *A. vulgaris*-forms, though not to the same extent as in the latter; and not until the low temperature of winter sets in does the development cease. In December all transitional forms are found, from flowering shoots to quite young buds which are hidden by the leaf-sheaths of the terminal bud. I am not prepared to state whether a similar proleptic development takes place in Arctic Norway and in Greenland. NORMAN and LANGE record that the flowering in these regions ends on September 20 and in August respectively. In Iceland Jónsson (l. c.) found no flower-buds on March 26, but, as Fig. 38, *A* shows, young inflorescences are at any rate to be found in Greenland in August.

Anatomy. The adventitious roots are triarch-tetrarch. The central cylinder is surrounded by a suberized endodermis. The outer wall of the epidermis, especially in *A. alpina*, is somewhat thick (2.5 μ), but the skin is functional for a certain period only, after which it is thrown off; this is due to a structural feature which is shown in Fig. 38, *B* and which was especially pronounced in *A. færøensis.* The exodermis consists of large cells, the thin radial walls of which are ruptured sooner or later, and the following layer of the cortex which has fairly thick walls and gradually becomes corky, functions then as epidermis till the periderm is formed. The primary epidermis is thrown off before the root in the zone in question has begun its secondary growth in thickness.

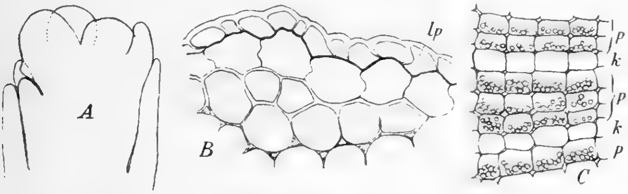

Fig. 38.

Alchimilla alpina: ***A***, **Longitudinal section through a young bud containing the primordium of an inflorescence (Greenland; 1. 8. 1885; $^{1}/_{60}$).** ***C***, **Portion of a transverse section through the periderm of a rhizome (Greenland; $^{175}/_{1}$);** ***k***, **layer of cork;** ***p***, **phelloid-cells. —** ***Alchimilla færøensis:*** ***B***, **Portion of a transverse section of a young adventitious root of the first order;** ***lp***, **epidermis ($^{240}/_{1}$).**

In the primary cortex in the roots of *A. alpina* fungal hyphæ have been found.

Periderm is probably formed in the pericycle; it is not developed until a continuous woody portion is produced in the central cylinder; it consists of alternating series of layers of 1—3 layers of cork-cells and phelloid-cells; it contains rather large intercellular spaces which are however often absent from the inner side of the cork-layers. The phelloid-cells contain starch-grains which are found especially along the inner walls. The periderm may constitute as much as $\frac{1}{5}$ of the radius of the root. Medullary rays are absent from the wood. There are distinct annual rings; the oldest roots I have seen were 5 years.

The central cylinder in the rhizome is surrounded by a distinct endodermis. The primary bundles are considerable in number and are more or less confluent. The pith which is of simple parenchyma lives in *A. alpina* as long as the shoot, but in *A. færøensis* it apparently dies at an earlier period. In the latter species the pith constitutes a larger portion of the diameter of the shoot than in the former; it is the chief reservoir of food-material and in the autumn is found crowded with starch. Rhizomes of *A. alpina* collected in Iceland in March contained, on the other hand, almost no starch, and shoots of both species collected in the Botanic Garden in Copenhagen on Jan. 5 contained only a small quantity; on the other hand, they contained large quantities of fat.

In the first period of vegetation of the shoot a continuous cambium produces a small quantity of wood. Medullary rays are absent from the latter (cf. HOLLSTEIN who has studied *A. alpina*). In *A. alpina* the diameter of the vessels was larger in specimens from Copenhagen than in those from more northern regions.

The periderm is formed by the division of the outermost layer of the pericycle and is developed even in the first period of vegetation of the shoot. 2—3 layers of phelloid-cells alternate with one layer of cork-cells. But in the Botanic Garden in Copenhagen the periderm in these two species contained only scattered cork-cells; in such plants it functions almost solely as a depository of food-material while the protective layer proper consists of dead masses of leaf-sheaths, primary cortex and the older layer of the periderm.

Fig. 38, *C* shows a transverse section of the periderm of *A. alpina;* it contains large intercellular spaces. During summer the starch-grains are found especially along the inner walls of the phelloid-cells; in the autumn the cells are entirely filled by them.

The primary cortex is ruptured owing to secondary formations, but even in the second summer it may be found alive. Bast does not occur.

The structure of the floral-shoot is very much like that described by Hollstein from the Dauphiné-Alps. A collenchyma, 1—2 layers thick, occurs, and within the endodermis 2—3 layers of bast unite with the secondary wood, which consists of several-layered strong-walled tracheids, so that the groups of sieve-tissue are entirely surrounded by stereom. The pith dies away in the centre.

The leaves are from 200 to 220 μ thick, and generally somewhat thicker in *A. alpina* than in *A. færoensis.* The epidermis of the upper surface is glabrous in the former and slightly hairy in the latter; it is high, and the outer wall in *A. alpina* is about 6 μ and in *A. færoensis* 4—5 μ thick, while the outer wall in the epidermis of the lower surface is about 3.3 μ and about 2 μ thick respectively. Stomata serving as respiratory organs are absent from the upper surface. The lower surface is densely hairy and here the stomata occur abundantly and are somewhat sunk below the level of the surface (Fig. 39, *B*). Knothe (l. c.) illustrates by a figure of *A. alpina* how the hairs are appressed upon the lower surface of the leaf, and he states that this is not wetted. The palisade parenchyma consists of a well-marked layer which constitutes about one-half of the thickness of the mesophyll. The proportion between the leaf-thickness and the thickness of the palisade tissue is in *A. alpina* about $\frac{2}{1}$ and in *A. færoensis* about $\frac{2.4}{1}$. The intercellular spaces in the spongy parenchyma are not large, but sections often show large slit-like lacunæ on the dorsal side of the leaf. Stereom is absent from the leaves. Fig. 39 (*A*, *B*, *C*, *D*, *E*).

At the apex of the leaf-teeth there is a slightly developed epithema, below which tracheids terminate; water-stomata occur upon the upper surface of the leaf-teeth on a limited area.

The three bundles in the leaf-stalks of these two species are concentric in structure. This peculiar feature was first demonstrated by C. de CANDOLLE[1] in a great many *Alchimilla*-species, among others also in *A. alpina* and *A. minor*, and afterwards BOUYGUES[2], without mentioning de CANDOLLE's paper, has published a short note upon the same subject. BUSER[3] has been studying de CANDOLLE's

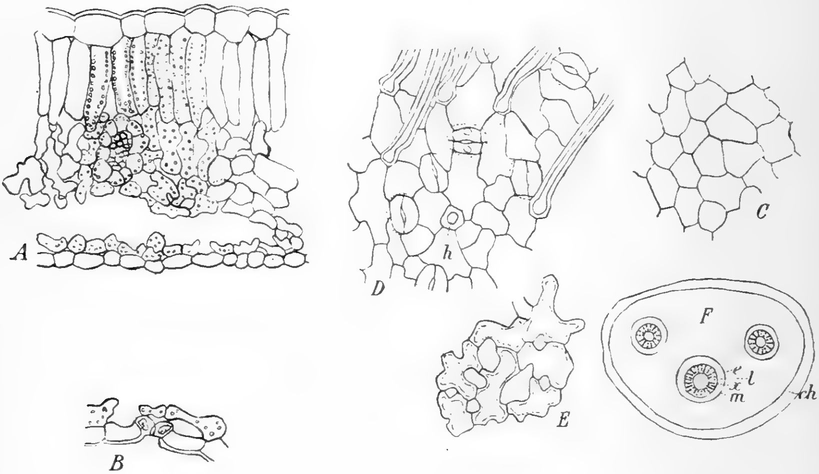

Fig. 39.

Alchimilla alpina from Greenland. *A*, Transverse section of leaf $(^{160}/_{1})$. *B*, Stoma $(^{200}/_{1})$. *C*, Epidermis of the upper surface of the leaf $(^{100}/_{1})$. *D*, Epidermis of the lower surface of the leaf with hairs and stomata $(^{200}/_{1})$. *E*, Section of spongy parenchyma parallel to the surface $(^{200}/_{1})$. — *Alchimilla færoensis*. *F*, Transverse section of leaf-stalk $(^{20}/_{1})$; *ch*, collenchyma; *e*. endodermis; *l*, leptome; *x*, xylem; *m*, "pith".

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[1] Bull. de l'herbier Boissier, T. I, 1893.

[2] Act. soc. Linn. de Bordèaux, 1900.

[3] Bull. de l'herbier Boissier, T. II, 1894.

results and shows that the species which have the concentric structure of the bundles of the leaf-stalk are found in the "region montagneuse" of the Alps, while the subnival Alpine species have the common collateral structure of the bundles. Fig. 39, *F* shows a transverse section of the stalk of *A. færoensis.*

As is well-known S. Murbeck[1] has demonstrated parthenogeny in a whole series of *Alchimilla*-species including *A. alpina* in which development of the embryo frequently takes place even while the flower is in the bud-condition. Murbeck did not find a single pollen-grain capable of germination in *A. alpina.* Nor does *A. færoensis* appear to develop pollen-grains capable of germination.

In the insignificant yellowish-green, apetalous flowers there is around the gynaeceum a broad fleshy disk which secretes honey. H. Müller (l. c.) has described the structure of the flower of *A. alpina.*

Alchimilla vulgaris L.

Lit. H. Müller, 1881. Leist, 1889. Jónsson, 1895. Norman, 1895. Sylvén, 1906.

In Arctic Norway this collective species grows in widely different localities, having been found both in dry and in damp places, in open spots and in birch-woods (Norman). In Greenland it grows in damp grassy fields and in willow-copses.

In my material the following elementary species occurred: *A. acutidens* Bus., *glomerulans* Bus., and *minor* Huds. All these species extend to the north of the Polar circle in Greenland and Europe; they are also found in Iceland, and *A. acutidens* and *A. minor* occur in the Færoes; they are found, in

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[1] Parthenogen. Embryobild. in d. Gattung *Alchimilla.* Act. Univer. Lundensis T. 36, 2.

addition, in northern temperate Europe[1]. — The alcohol material is from Greenland, Iceland and the Færøes.

The young seedling of *A. vulgaris* is according to SYLVÉN a rosette, and in older plants also the leaves are always placed in a rosette even if the internodes are often somewhat elongated. The rhizome is vertical or oblique or almost horizontal, and in the last case there may be a slight wandering. It does not branch so freely as in *A. alpina.* Even during the year in which it germinates adventitious roots arise, and these are afterwards developed abundantly.

The floral axes are lateral, and there occurs, at any rate in several of the elementary species growing in Denmark, a similar proleptic development of the floral shoots as in *A. alpina* in Copenhagen, only the development is more vigorous. It appears to be external factors (e. g. fall of temperature) rather than internal which limit the flowering period; we may be justified in presuming that something similar happens also in the Arctic regions; NORMAN records that in Arctic Norway *A. vulgaris* may flower till September 20.

The plant lives through the winter in a more or less green condition (WARMING, 1884; JÓNSSON and SYLVÉN); but we may also find it without any green leaves (in Denmark) and as in *A. alpina* the summer leaves wither in the autumn. The shoot-apex is protected by the sheaths of the foliage-leaves; scale-leaves are not developed.

Anatomy. — Roots of *A. minor* and *A. acutidens* have been investigated; in structure they resemble essentially those of *A. alpina* and *A. færøensis* (cf. Fig. 38, *B*). Mycorrhiza has been found in *A. acutidens* from Iceland.

The rhizomes are on an average thicker than those of *A. alpina;* this is especially due to the fact that the pith is

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[1] See Harald Lindberg. Die nordischen *Alchimilla vulgaris*-Formen und ihre Verbreitung. Acta Soc. Scient. Fenn. XXXVII. Helsingfors, 1909.

largely developed. Otherwise, the structure of both the rhizomes and the stems is practically similar to that in *A. alpina* and *A. færøensis.*

The anatomy of the leaves (Fig. 40) is the same in all these three species, and closely resembles that of the two species mentioned above; the leaves are, however, somewhat more mesomorphic than those in *A. alpina.* The upper surface of the leaf is glabrous, or in *A. glomerulans* slightly hairy, the lower surface is slightly hairy. The outer wall of the epidermis of the upper surface is about 2 μ thick; the radial walls are slightly undulating. Stomata occur scattered upon the upper surface and, as upon the lower, they are situated below the level of the surface and on an average somewhat more so than is the case in the two species of the *Alpina*-group (Fig. 40 *A*). The radial walls of the lower epidermis are somewhat more strongly undulating than those of the upper. A layer of well-marked palisade-cells occur and sometimes another layer consisting of more irregularly formed cells. Leist records only one layer of palisade-cells. The proportion between the leaf-

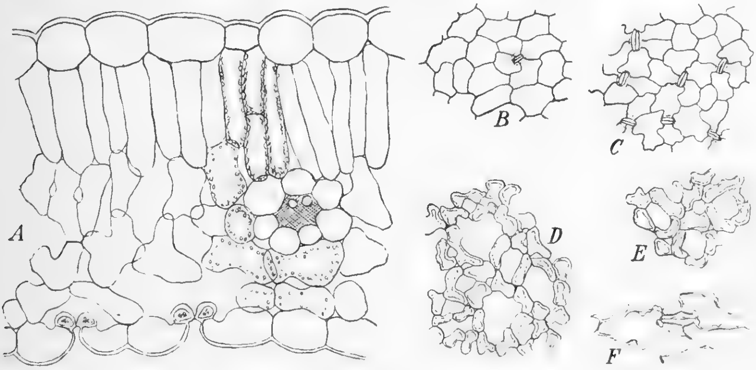

Fig. 40. *Alchimilla vulgaris.*

A. glomerulans. *A*, Transverse section of leaf. *C*, Epidermis of the lower surface of the leaf. *E*, Section of spongy parenchyma parallel to the surface. — *A. minor.* *B*. Epidermis of the upper surface of the leaf. *D*, Section of spongy parenchyma parallel to the surface. — *A. acutidens.* *F*, Stoma from the epidermis of the lower surface of the leaf (*A*, about $^{220}/_1$; *B*, *C*, *D* and *E*, about $^{100}/_1$; *F*, about $^{150}/_1$; *A*, *C* and *E* from West Greenland, *B* and *D* from Dr. Louises O in East Greenland, *F* from Eskefjord in East Iceland).

thickness (about 190μ) and the thickness of the palisade-tissue is about $\frac{2}{1}$. Below the stomata of the upper surface air-spaces are produced in the same manner as described for *Sibbaldia procumbens* (p. 58). The spongy parenchyma is rather loose in structure and contains, as shown in Fig. 40, *D*, besides large intercellular spaces numerous very small ones. The cells are branched.

The leaf-teeth contain a slightly developed epithema; the water-pores occur on a limited space upon the upper surface; these structures have been mentioned by REINKE[1].

The structure of the leaf-stalk is as in *A. færøensis* and *A. alpina* (see Fig. 39, F).

MURBECK has demonstrated parthenogeny in *A. minor*, which produces only a very small quantity of imperfect pollen. — In the flowers of *A. glomerulans* from Greenland a great many of the anthers had fallen off; in those which were still attached I found no fully developed pollen.

The flowers of *A. vulgaris*, which in structure almost agree with those of *A. alpina*, have been described and figured by H. MÜLLER 1873[2] and 1881 (l. c.).

Sorbus americana Willd.

Lit. WARMING, 1887. ROSENVINGE, 1896.

The alcohol material is from Ivigtut in Greenland.

This *Sorbus* which bears much resemblance to *S. aucuparia* is a small tree with an erect, straight growth; it does not branch much, but several stems may proceed from the same root. The largest trees hitherto found in Greenland measured about 4 metres in height and the stems were about 9 cm. thick. These trees were 56 years old (ROSENVINGE). Generally, however, it is lower in growth. It occurs in south-

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[1] Secretionsorg. Pringsheim Jahrb. Bd. X. 1876.

[2] Die Befruchtung der Blumen durch Insekten. Leipzig.

ern Greenland, in the valleys within the fjords, dispersed through *Betula* and *Salix* copses; it grows also in N. America.

The leaves are smooth. The epidermis shows strong cuticular stripes, strongest upon the upper surface, and upon the lower surface stronger along the margins (Fig. 41, *A*, *C*, *D*). The outer wall of the upper epidermis is about 4.5 μ thick, of the lower about 2.5 μ. Some of the cells in the upper epidermis have highly mucilaginous inner walls, and such cells are often particularly large (Fig. 41, *B*), compare p. 57. Stomata occur, with the exception of the water-stomata on the leaf-teeth, only on the lower surface; they are on a level with the surface. There are two layers of palisade-tissue of

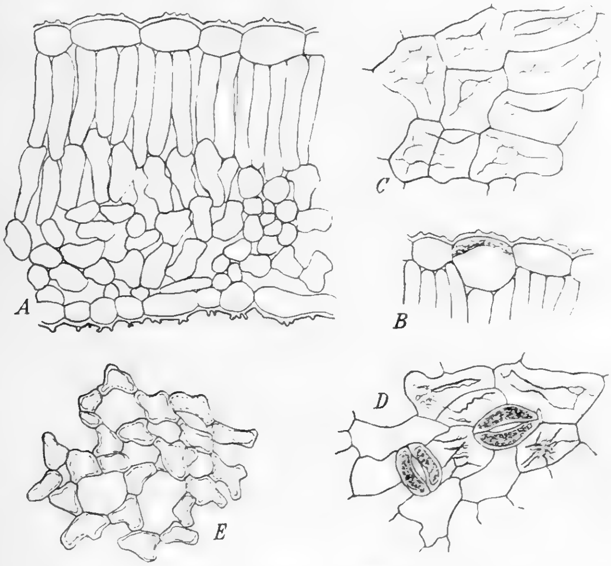

Fig. 41. *Sorbus americana*.

A, Transverse section of the leaf. *B*, Transverse section of the epidermis of the upper surface showing a cell with highly mucilaginous inner wall. *C*, Surface view of the upper epidermis of the leaf. *D*, Section parallel to the surface of the lower epidermis of the leaf; the cuticular folds of some of the cells are shown as in *C*, usually each epidermal cell has its own system of folds. *E*, Section of the spongy parenchyma of the leaf parallel to the surface. — *A*, *B*. *C*, *D*, *E* $^{185}/_{1}$. Ivigtut in Greenland.

which the upper consists of high, narrow cells which enclose large intercellular spaces. The cells in the second layer are often very irregular; this layer is absent above the smaller bundles in the marginal portion of the leaf. The proportion between the leaf-thickness (about 220 μ) and the thickness of the palisade tissue is about $\frac{2}{1}$. Above the larger bundles the assimilatory tissue is replaced by vein-parenchyma. The spongy parenchyma is very loose in structure, the cells are slightly or shortly stellately branched (Fig. 41, *E*).

In the flower of *Sorbus americana* I have found about 15 stamens, of which the ten episepalous were only a little taller than the five epipetalous. In *Sorbus aucuparia* there are twenty stamens[1]. — In flower-buds which are on the point of opening the stamens are found to be bent inwards over the 2—3 styles. The anthers are closed, but the stigmas are highly papillose and apparently ready to receive the pollen. When the flowers expand the stamens gradually straighten and bend outwards towards the petals. I have not found open anthers which were in contact with the stigmas, but they are seen to be bending over the latter some time after they have dehisced, and the pollen must almost certainly fall upon the stigmas. In this homogamous stage the stigmas were found to be covered with germinating pollen.

In Greenland the flowering period occurs in July and August, but according to LANGE the plant does not flower at higher altitudes. ROSENVINGE thinks that the rowan sets fruit regularly in favourable localities, and he gives some instances of its having probably been dispersed by the agency of birds.

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[1] Cf. fig. 422 in Eug. Warming: Frøplanterne (Spermatofyter), København, 1912.

Summary.

A. Account of the growth-form of the species.

I. Microphanerophyte: *Sorbus americana.*

Tree, low in growth. Lives through the winter without green leaves; the shoot-apex is covered by smooth bud-scales. The leaf-structure is mesomorphic.

II. Chamæphytes: *Dryas octopetala* and *D. integrifolia.*

Dwarf shrubs with a primary root of long duration. The prostrate long shoots can be somewhat individualized. In autumn the leaves die with the exception of a few half-unfolded ones at the shoot-apices. The apex of the shoot is covered by the sheaths of the young and dead foliage-leaves. The leaf-structure is xeromorphic.

III. Hemicryptophytes:

a. Dwarf shrubs or undershrubs.

Potentilla palustris is a dwarf shrub (see p. 9) which may be a hemicryptophyte, a chamæphyte[1] or a helophyte. The shoots with elongated internodes live through the winter without green leaves and with their apices covered by the sheaths of the foliage-leaves and by scale-leaves. Much wandering takes place, as also vegetative propagation. The leaf-structure is slightly xeromorphic.

Pot. tridentata is a creeping rosette-forming undershrub. Some of the summer-leaves may live through the winter; there is no closed winter-bud. The leaf-structure is xeromorphic.

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[1] See also Vahl, Growth-forms of some Plant Formations of Swedish Lapland. Dansk bot. Arkiv, Bd. I, No. 2, Köbenhavn, 1913.

These two species have terminal floral-shoots while all the other *Potentillas* mentioned in this paper are monopodial.

b. Perennial herbs.

1. Spotbound are *Potentilla pulchella*, *Pot. nivea*, *Pot. Vahliana*, *Pot. emarginata*, *Pot. maculata*, *Sibbaldia procumbens*, *Alchimilla alpina*, *A. færoensis* and *A. vulgaris.* Features common to them all are monopodial, rosette-formed assimilatory-shoots and lateral floral-shoots. The *Potentillas*, *Sibbaldia* and *Alchimilla alpina* have primary roots of long duration, and they distinctly belong to the type "Radix vel rhizoma multiceps"; the other *Alchimillas* branch less freely, and their primary root undoubtedly dies rather early. They live through the winter with their shoot-apices protected by the sheaths of dead and living leaves. To evergreens proper only *Pot. maculata* can be referred. It is however probable that other species also may live through the winter with a few green leaves, and as regards this point local differences no doubt take place. In species such as these which have no true winter-buds it is difficult to draw a sharp limit between the winter-green and the not winter-green habit, since the leaves of the following summer may grow out slightly in the preceding autumn. This uncertainty is no doubt the reason of the often contradictory records. — The leaf-structure would most nearly be characterized as mezomorphic in *Pot. emarginata* and *Alch. vulgaris* and as more or less xeromorphic in the others.

2. Wandering perennial herbs are *Pot. anserina* and the *Rubus*-species.

Pot. anserina has a rosette-formed, monopodial main shoot and lateral floral axes which behave as runners. Vegetative propagation takes place by the individualization of the rosette-formed lateral shoots of the runners. Food-storing roots often occur. It lives through the winter without green leaves and with its shoot-apex covered by scale-leaves. It is typical for the leaf-structure to be slightly xeromorphic.

As features common to all the *Rubus*-species may be mentioned that they do not form rosette-shoots, that the floral shoots are terminal; and that they live through the winter without green leaves[1] and with their winter-buds covered by scale-leaves. *Rubus arcticus* wanders by means of its roots, and *Rub. saxatilis* by the development of certain shoots into aerial runners the apex of which is developed into a winter-bud situated at the surface of the ground. *Rub. chamæmorus* has scale-leaf-bearing underground runners. The leaf-structure in the two first-named is mesomorphic and in the last-named slightly xeromorphic.

There are at least two points connected with the shoot-structure of several of these *Rosaceæ* which appear to be favourable to plants living in Arctic climates, as regards the way the latter influence the plants, e. g. by desiccation (physiological desiccation) and by the shortness of the growth-period. A great many of the species, and more particularly those that are true Arctic (see p. 121), are more or less highly cæspitose, and may have in addition very closely packed shoot-masses (closest in *Pot. Vahliana*); it appears certain that by this method of growth the amount of transpiration is lessened, in that the outer shoots of the tuft protect the inner from the wind, and the shoot-apices are surrounded and protected by the dead masses of leaves.

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[1] See p. 93.

From KJELLMAN'S classical work "Ur polarväxternas lif" it has long been well known that the Arctic summer begins very suddenly and that a great many Arctic plants live through the winter with leaves which need only elongate slightly in order to attain full power of assimilation. The majority of the true Arctic species mentioned here live through the winter in this way; some even have small, green, half-opened leaves (*Dryas*). They have moreover no closed winter-bud surrounded by scale-leaves (except, e. g. *Rubus chamæmorus*) and with but very little room for the new foliage-leaves; but the "buds" are open, and the new organs — leaves and flowers — have ample room and grow out quickly, as soon as ever external conditions permit their doing so, and begin work in the short summer[1].

B. In the following species the flowers are formed during the

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[1] As regards light-conditions in Arctic regions I would remark, that from Porsild's "Actinometrical observations from Greenland" (Arbejder fra den danske arktiske Station paa Disco, No. 4, Medd. om Grönland, XLVII, Köbenhavn, 1911) it is seen (from Tables II and III) that the mean light-total for the months May—August is about the same on Disco as in Denmark (Anholt). On comparing the assimilation-conditions of the plants on Disco and Anholt it is seen that the Greenlandic plants must, besides a lower temperature, also suffice with less light for their summer work than the Danish, the latter having longer time at their disposal. So far as I know it is an open question what use the plants make — if any — of the light of the midnight sun. The investigations made by Curtel (Rev. générale de botanique, Tome II, 1890) and Porsild (Meddel. om Grönland, XXV, 1902, pp. 25 and 26) regarding this point gave contradictory results. Besides Porsild, Wiesner has also studied the light-conditions in Arctic regions (Norway and Spitzbergen) and he finds by comparison with the Alpine regions of Central Europe that these are characterized not only by a greater light-intensity, but also by a greater amount of light in the period of vegetation. (Beitr. z. Kenntniss des photochem. Klimas. im arct. Gebiet. Denkschr. math. nat. Cl. d. K. K. Ak. Wien. LXVII, 1908, and Beitr. z. Kenntniss des Lichtklimas von Tromsø, etc. Tromsø Museums Aarshefter, 24. Tromsø, 1901).

summer previous to the year in which they expand, viz. *Alchimilla alpina*, *Alch. vulgaris*, *Dryas octopetala*, *Potentilla emarginata* and *Rubus saxatilis*, all of which flower in June. It is probable that the great majority of the species behave as these, with the exception however of *Pot. palustris* in which the young flower-buds have not been observed until the spring of the year in which they expanded.

C. The absorbent roots often present anatomical peculiarities, for instance, a thin epidermis which is usually more or less collapsed is found in the majority of the Potentillas (*anserina*, *emarginata*, *maculata*, *nivea* and *pulchella*), and in addition in *Sibbaldia* and *Rubus saxatilis*. In *Rubus chamæmorus* it is destroyed early. A stronger epidermis occurs in *Pot. palustris*, where it is very small-celled, and in the *Alchimilla*-species where there is a tendency to throw it off entirely, because the thin-walled exodermis ruptures. In *Pot. emarginata*, *P. nivea* and *P. pulchella* the radial and the outer walls of the exodermis are very highly thickened, and this cell-layer is also very strong in *Rubus chamæmorus.* In the *Alchimilla*-species the cortical layer within the thin exodermis is fairly strong. In *Dryas*, *Rubus arcticus* and *R. saxatilis* the radial walls — and in the two last species also the outer walls — of the cortical layer outside the endodermis are very strong.

Ectotrophic mycorrhiza occurs in *Dryas;* and endotrophic mycorrhiza has been found in *Pot. anserina*, *Pot. emarginata*, *Pot. nivea*, *Pot. palustris*, *Pot. pulchella*, *Sibbaldia*, *Alchimilla alpina*, *Alch. acutidens* and *Rubus arcticus.* All the *Rosaceæ* mentioned here have probably mycorrhiza, except *Rub. chamæmorus.*

D. A continuous cambium is found in the perennial portion of the shoots in all the species. According to the nature of the tissue produced by the cambium the species may be divided into two main groups. One, more herbaceous, in which the secondary formations consist of groups of vessels rich in parenchyma and separated by broad medullary rays; the Potentillas with the exception of *Pot. palustris* and *Pot. tridentata* belong to this group. Another, more lignified, in which the cambium produces a ring-shaped woody portion; to this belong the rest of the species. In *Dryas*, *Potentilla palustris.*, *P. tridentata*, *Sibbaldia* and *Rubus* are found medullary rays, one to a few cells broad; medullary rays are absent from *Alchimilla* except above the leaf-trace bundles ("Blattspurstränge"). In *Alch. alpina* and especially in *Alch. vulgaris* and *Alch. færøensis* the secondary wood-formations constitute only a comparatively small portion of the shoots, and these are then more herbaceous.

Bast occurs regularly only in *Dryas*.

In *Dryas*, from which, as already mentioned, an endodermis is absent, cork is formed in the inner part of the cortex; in all the others which have an endodermis, a periderm is probably always formed in the outermost layer of the pericycle (cf. SOLEREDER[1]). *Dryas*, only, has a scaly bark ("Schuppenborke") formed of centripetally developed phellogens which develop only cork-cells without intercellular spaces. In the other species, on the other hand, the periderm consists of one layer of cork-cells alternating with usually three layers of phelloid-cells. It contains large intercellular spaces, which are however absent from the inner side of the cork-layers in the great majority of the species.

SOLEREDER (l. c.) who also describes the periderm has found intercellular spaces in the phelloid in *Pot. palustris* and *Poterium sanguisorba;* in his opinion this suggests a resemblance to aërenchyma and he regards it as an adap-

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[1] Anatomie d. Dicotyled. Stuttgart, 1899, p. 348.

tation to life in bogs in these species. It is true that respiration in the inner part of the shoots is facilitated by the presence of the intercellular spaces in the periderm, but the comparison with aërenchyma does not appear appropriate when we consider that species from extremely dry habitats, such as *Pot. tridentata*, *Pot. nivea*, *Alch. alpina* and others have a quite similar structure of the periderm. A contribution to the explanation of the structure of the periderm in these *Rosaceae* may perhaps be found in the fact that it no longer functions only as a protection from excessive transpiration, as for instance in *Dryas*, but that it has also developed into a very important starch-storing organ; at any rate, a periderm with this function requires an ample supply of oxygen so that the necessary condensations and hydrolyses can take place in it. — It may be mentioned that a similar periderm also occurs in the roots of the species which have been investigated, with the exception of *Dryas* and *Rubus arcticus*. As regards this point the reader is referred to MARTHA BUNDING[1] who has investigated the root-cork in many *Rosaceae* and finds as a rule intercellular spaces in the herbaceous species, but not in the woody or shrubby (cited from FREIDENFELT).

E. Special food-storing organs are absent except in *Pot. anserina* which frequently has spindle or club-shaped food-storing roots of a peculiar anatomical structure. Otherwise reserve food-material is found in the root (many of the species have primary roots of long duration and considerable size) and in the perennial portions of the shoots. The tissues which contain reserve food-material are the

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[1] Structure of the Cork Tissues in Roots of some Rosaceous genera. Publ. of the Univer. of Pennsylv. New Ser. No. 5. Contrib. fr. the Bot. Laborat., Vol. 2, 1898. (Unfortunately, the paper has not been available to me).

phelloid, the pericycle, the medullary rays and the wood-parenchyma; and in the pith, especially the peripheral part.

The reserve food-material consisted especially of starch in all the species which have been investigated in regard to this point; but in several of these species (*Dryas*, *Alchimilla*, *Pot. emarginata*, *Pot. nivea*, *Pot. palustris*, *Sibbaldia*, *Rubus saxatilis*) it has been demonstrated that during winter the starch disappears more or less completely and is replaced by fat.[1] Probably during autumn the starch is converted into fat, and then during spring the fat is again converted into starch. Similar conditions are well-known as regards several trees. It is apparently a common occurrence among perennial herbs and dwarf-shrubs that during winter the starch is replaced by fat, the amount of fat increasing from October or November and reaching its maximum in January or February, then during spring it disappears entirely in temperate regions; this is at least the case as regards a great many Danish species. On the other hand, there are a number of species in which no fat is visible during winter; as an example, the food-storing roots in *Pot. anserina* may be mentioned. While, as mentioned above, fat is absent from the depository organs of the herbs during summer in Denmark, I have, in *P. nivea*, *P. emarginata* and especially in *P. pulchella* (from N. E. Greenland) found fat in rhizomes and roots throughout the whole summer; this is probably due to the comparatively low temperature during summer in Arctic regions.

F. A great many of the species have leaves which in one way or other illustrate xeromorphy. Transpiration is lessened (a) by a hairy covering: in several of the species the under side of the leaf is densely matted or hairy, espe-

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[1] Indicated by use of Sudan III.

cially in *Dryas*, *Pot. nivea*, *Alch. alpina* and others; (b) by a revolute leaf-edge, which is found especially in several *Dryas*-forms and in *Pot. pulchella* f. *humilis;* (c) by sunken stomata, which are found in *Alchimilla*, *Pot. palustris*, *Pot. tridentata*, and *Sibbaldia*, while in several of the species, which have a dense hairy covering upon the under side of the leaf, the stomata there project slightly above the leaf-surface. For the rest, stomata occur on both surfaces of the leaf in almost equal number in *Sibbaldia* only; of the other species, stomata are entirely wanting upon the upper side in the following: *Alch. alpina*, *Alch. færøensis*, *Dryas*, *Pot. Vahliana*, *Rubus* and *Sorbus*. Lastly, transpiration must also be lessened by (d) a thick outer wall in the epidermis, and here *Dryas* and especially *Pot. tridentata* may be mentioned; and (e) by the mucilaginous covering of the inner wall in the upper epidermis (pectin-mucilage). This is found in *Dryas*, *Pot. maculata*, *Pot. nivea*, *Pot. palustris*, *Pot. pulchella* and *Pot. tridentata*, *Sibbaldia* and *Sorbus*. Very often not all the cells are mucilaginous; in *Pot. tridentata* besides the inner wall the outer wall is also somewhat mucilaginous and in *Pot. maculata* a few mucus-cells were also found in the lower epidermis. The importance which should at any rate be attached to a cellulose-mucilaginous covering of the inner walls of a leaf-epidermis is among others mentioned by VOLKENS[1], who is of the opinion that such mucilage in the cells does not function as a water-reservoir, but checks transpiration in the same manner as does a gelatinous layer which is spread over a slightly evaporating surface of water (compare also WARMING, 1887).

The mesophyll in the leaves of the species which have been investigated has a very ordinary structure, and it shows only to a slight degree such adaptations to

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[1] Die Flora der Aegypt.-Arab. Wüste. Berlin, 1887, pp. 43—45.

external conditions as are evident in the structure and hairy covering of the epidermis of at least several species. The palisade-tissue in almost all the species consists of 2—3 layers of cells; in the *Alchimilla*-species only, there is usually a single layer of very long palisade-cells. In these the relation between length and breadth is as 4 or 5 to 1; the same relation is also found in the upper layer of palisade-cells in *Sorbus;* but in the remaining species the palisade-cells are only 2—3 times as long as they are broad; they are often somewhat barrel-shaped. In all the species the relation between the thickness of the leaves and the thickness of the palisade-tissue is about $\frac{2}{1}$; as regards this point some variations have been found to occur in various species, but such special records of the nature of the habitats as are necessary in order to be able to understand such variations have unfortunately not been at my disposal. In the majority of the species there are large intercellular spaces in the palisade-tissue. In *Pot. tridentata* these are however small, and as regards the mesophyll, this species has the most xeromorphic leaf, while the least xeromorphic is that found in *Rubus saxatilis* and *R. arcticus.*

The transpiration-parenchyma is throughout of loose structure and consists of short, branched cells. Large slit-like lacunæ occur commonly within the subepidermal layer on the lower surface of the leaf (e. g. in *Dryas. Pot. pulchella, Alch. alpina*).

The species may be divided into two groups according to the anatomy of the leaves; viz. into those species which have a mesomorphic leaf-structure and those which have more or less well-marked xeromorphic leaves. To the first group belong *Rubus saxatilis* and *Rub. arcticus, Alch. vulgaris* and *Alch. færoensis*, and perhaps also *Pot. emarginata* and *Sorbus americana.* The remaining species are referable to the other group; particularly, *Dryas*, *Pot. tridentata*, *Pot. nivea* and *Pot. pulchella* (especially f. *humilis*). Some understanding of the leaf-structure in the different species may be gained by a consideration of the habitats. Species of the first group, with the exception of *Pot. emarginata*, are generally associated with relatively favourable soil, moreover, none of them — again with the exception of *Pot. emarginata* — are true Arctic species. The majority of the species in the other group are natives of dry localities such as fell-fields, rocks and heaths, and a great many of them are High Northern species, while two of them are bog-plants. The few species which may be regarded as more or less evergreen belong to this group. It does not appear, however, that the leaf-structure is governed thereby to any special degree, perhaps, however, with the exception of *Pot. tridentata*; it is tempting, more particularly on account of the leaf-structure in this species, to conclude that it is an evergreen; but beyond the surmise that a few of the summer leaves may undoubtedly live through the winter I am prepared to state nothing. In *Dryas* the outer wall in the upper epidermis of the leaf is somewhat thicker in the leaves which live through the winter than in the summer leaves which die away during autumn; but the common xeromorphy in the leaf-structure of this species must upon the whole be due to other reasons, because the number of the summer leaves is far greater than that of the leaves at the shoot-apex which live through the winter. One of the reasons for the xeromorphy in the *Dryas*-leaves is undoubtedly that already mentioned: the dryness of the soil, or, at any rate, the physiological dryness of the heaths and rocks where the plants grow. A similar consideration to that which holds good for *Dryas* may be applied to the other species which may occasionally be found with green leaves during winter. *Pot. maculata* is however an exception, as it must undoubtedly be called a true evergreen; but in comparison with the other herbaceous *Potentillas* its leaf-structure does not exhibit any special xeromorphic characters.

Among the 14 species of Arctic *Ranunculaceæ*, which I have investigated[1], there are only two, at most three species, the leaves of which have a xeromorphic character, viz. *Thalictrum alpinum* and *Coptis trifolia* which have leathery leaves, which in the latter live at least two years, and *Ran. glacialis* with a somewhat succulent leaf which has a well-developed palisade-tissue. Of the remaining species all the land-plants have a decidedly mesomorphic leaf-structure. By comparison of the individual leaf-tissues in the species of *Ranunculaceæ* and *Rosaceæ* which have been investigated the difference between the two families is distinctly seen.

The epidermis in all the *Ranunculaceæ*, with the exception of certain forms of *Ran. acer.*, is glabrous or only slightly hairy. The outer wall of the epidermis of the upper leaf-surface, except in *Thalictrum alpinum* and *Coptis trifolia*, is thin, not above 2μ thick, and the walls are not mucilaginous as in the *Rosaceæ*. In the paper cited it is recorded that chlorophyll was usually found in the epidermis of the leaf of the Arctic *Ranunculaceæ* which had been investigated, but I did not observe this in the *Rosaceæ* which I have had for investigation. The stomata in our *Ranunculaceæ* are always situated on a level with both leaf-surfaces, and as in the *Rosaceæ*, they occur especially upon the lower surface of the leaf; three of the species have, however, the majority of their stomata upon the upper

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[1] The Structure and Biology of Arctic Flowering Plants, I. 6. *Ranunculaceae* by Knud Jessen. Medd. om Grönland, XXXVI, København, 1911.

surface of the leaf, viz. *Ran. glacialis*, *R. hyperboreus* and *R. reptans.* The palisade-tissue is on an average somewhat more strongly developed in the *Rosaceæ* than in the *Ranunculaceæ*, and the intercellular spaces are usually smaller. It is recorded that the palisade-tissue in the *Ranunculaceæ* constitutes about one-half of the thickness of the mesophyll, but in several of the species it is, however, considerably less thick, e. g. *Anemone Richardsoni*, *Ran. Pallasii*, *Ran. pygmæus* and *Ran. nivalis.* The respiratory tissue is on an average looser in structure in the *Ranunculaceæ.* Several of the *Ranunculi* have leaves which in their anatomical structure recall the type which is common among woodland plants in temperate regions, thus especially *R. pygmæus* and *R. nivalis*, and a similar structure is found in *Rubus arcticus* and *Rub. saxatilis.*

The fact that the leaves of the *Ranunculaceæ* which have been investigated, are, as already mentioned, on the whole, to a greater extent mesomorphic than are those of the Arctic *Rosaceæ* is I find, partially explained — as in the *Rosaceæ* — by a consideration of the habitats. It is commonly stated that the Arctic *Ranunculaceæ* prefer damp localities, often bogs; thus *Ranunculus reptans*, *Ran. hyperboreus*, *Ran. lapponicus*, *Ran. Pallasii* and also *Ran. affinis*, *Ran. nivalis*, *Ran. pygmæus*, *Ran. sulphureus* and *Ran. glacialis* are mountain plants that live near the snow line in soil saturated with melting snow. *Anemone Richardsoni* lives by preference in copses, and *Thalictrum alpinum* and *Coptis trifolia* are met with in similar localities, or at any rate on luxuriant heaths. *Ran. acer*, on the other hand, often occurs on rather dry and stony soil, and in such localities its leaves are more hairy. We have, however, a peculiar instance of the fact that different plants react differently under apparently the same conditions. Thus, both *Potentilla palu-*

stris and *Rubus chamæmorus* show characters in their leaf-structure which undoubtedly should be regarded as agents serving to prevent excessive transpiration, and yet they grow in *sphagnum*-bogs as do *Ran. Pallasii* and *Ran. laponicus*, the leaves of which I should characterize more closely as mesomorphic-hydrophilous — a fact which indicates that the adaptation of plants is not evidenced solely by morphological conditions.

G. In the majority of the species the flowers are fairly conspicuous, least so in the *Alchimilla*-species and in *Sibbaldia*, but here they are gathered into more or less considerable inflorescences; *Sorbus* has richly flowering corymbs, but in the remaining species the flowers are either solitary or gathered into usually few-flowered cymes. Two species have red flowers, viz. *Pot. palustris*, and *Rub. arcticus;* the following have white flowers: *Pot. tridentata*, *Dryas*, *Rub. chamæmorus*, *Rub. saxatilis* and *Sorbus*; the rest have yellow petals. All the species undoubtedly produce honey, which is secreted by the inner side of the hypanthium; in several species a disk is developed (*Pot. tridentata*, *Sibbaldia* and *Alchimilla*). A slight perfume has been noted in a few species only. Well-marked hercogamy occurs in only a few of the species; *Rubus chamæmorus* is dioecious, *Dryas* is andro-monoecious and *Pot. palustris* is highly protandrous. The others are homogamous or have, at the most, a short preliminary unisexual stage. Slight protandry has thus been observed in *Pot. tridentata*, *Pot. maculata*, *Dryas* (some of the hermaphrodite flowers) and *Rubus arcticus*, while *Pot. anserina*, *Pot. emarginata*(?), *Dryas* (some of the hermaphrodite flowers) and *Sorbus* are slightly proterogynous. It must be assumed that self-pollination can take place in all species except in the *Alchimillas*, *Rub. chamæmorus* and *Pot. palustris.* There are only very sparing notes to hand as regards direct observations of insect-visitors, in true Arctic regions, to the species in question, viz. only in the case of *Pot. emarginata*, *Pot. nivea*, *Pot.emarginata* and *Dryas*, which were visited by flies and other diptera.

H. Many of the Arctic *Rosaceæ* mentioned here have a very considerable area of distribution. Eight of the species are circumpolar or almost circumpolar — of these *P. pulchella* and *emarginata* are distributed only in the Arctic zone; the others extend far southwards, and of these the two bog-plants *P. palustris* and *Rubus chamæmorus* are especially confined to the low lands, while the others (*P. nivea*, *maculata*, *Sibbaldia* and *Dryas octopetala*) are confined to mountainous districts in temperate regions. *Pot. tridentata* and *Pot. Vahliana* are also true Arctic species, but their area of distribution is smaller; this is also the case with *Dryas integrifolia*, which in America, however, has advanced somewhat southwards. *Pot. anserina* is almost cosmopolitan. According to WOLF the Tertiary circumpolar land was probably the home of the original *Potentillas*, whence they have migrated southwards. He ascribes to those groups, among others to which our *Potentillas* belongs, a very high age, and regards several as palaeotypic; the majority of the species must be regarded as very old. *Dryas octopetala* and *Sibbaldia procumbens* are probably also originally true Arctic forms, which have afterwards extended towards the south. The great Glacial period may have helped them, together with *P. nivea* and *maculata*, to cross the Central European low land; they are also very old species.

Of these species only the following appear to have qualifications for wide fruit-dispersal: *P. palustris* and *P. anserina* by the agency of the water, *Dryas* by the wind and *Rubus chamæmorus* endozoically.

Another group of the species in question comprises temperate forms, viz. *Rubus saxatilis*, *R. arcticus* and *Alchimilla vulgaris*; they have extended more or less further towards the north, and have in several places passed beyond the Polar Circle. To these *Sorbus americana* may also be referred. This and the two *Rubus*-species have endozoic or at least synzoic fruit-dispersal, and the *Rubus*-species (especially *R. arcticus*) have attained a very wide distribution.

Alchimilla alpina is presumably an Alpine form, which has probably during the Glacial period migrated northwards and has in Scandinavia passed over the Polar boundary (Buser in Schrøter; l. c.).

12.—3.—1914.

The
Structure and Biology
of
Arctic Flowering Plants.

II. 2.

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9.

Cornaceæ.

By

Carsten Olsen.

1914.

Preface.

The material used for the following investigation is the property of the Botanical Museum in Copenhagen. A large material of *Cornus suecica,* preserved in spirit and collected at several places in Greenland has been placed at my disposal, also a smaller quantity of similar material from Finmark, other places in Norway, from Sweden and Denmark. Besides this, I have used dried material of *Cornus suecica* from Greenland, Iceland, the Færöes, Denmark, Norway, Sweden, Finland and North America.

Amongst the dried specimens from Greenland I found three specimens of *Cornus canadensis,* determined as *Cornus suecica*; these specimens were collected by A. Jessen, July the 28th 1894, on a small, remotely situated island, Inuarudgligak, near the southern point of Greenland (60° 23″). *Cornus canadensis* has not hitherto been known to exist in Greenland; certainly W. Meehan mentions it as found here, but Th. Holm, who has gone through his material from Greenland, has shown, that Meehan was probably not in position to determine his plants correctly, especially as he has not even collected the plant, but simply made a note of its occurrence. I have also had ample material of *Cornus canadensis* from North America and Japan.

Fig. 2 is drawn by Professor Warming; the photograph fig. 10 is taken by H. E. Petersen, mag. sc., while the remaining figures are drawn by myself.

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Cornus suecica L.

Norman, 1901, p. 322. Warming, 1887, p. 18, 34, 40, 75, 138. Rosenvinge, 1896, p. 67, 128, 161, 197, 198. Hartz, 1894, p. 57. Buchenau, 1859, p. 87. Sylvén, 1906, p. 135. Silén, 1905, p. 87. Willis & Burkill, 1903, p. 343. Sernander, 1901, p. 141, 142, 164. Sertorius, 1893, p. 622. Knuth, 1898, vol. 2, part 1, p. 51).

Cornus suecica is mostly found in the subarctic regions, and most frequently in the northern part of the Scandinavian peninsula, but is fairly common everywhere in Finland, Sweden, Norway and in the northern parts of Denmark. Elsewhere in Europe it is found near Reval, in Holstein and Pomerania, and the Alps, also in the Færöes and Iceland. Outside Europe it grows in West Greenland, in Labrador, New Foundland, Alaska and Baffinsland.

In Greenland it appears most frequently in "Urtelierne" and in thickets; Hartz says it is nearly always found in birch thickets and Rosenvinge, that it is also present in the willow thickets and on the heaths in the southern part. Its northern boundary in Greenland is according to *Rosenvinge*, at 69°14.

According to *Norman* it occurs in Finmarken in the birch woods, where it often by itself forms the undergrowth, growing closely like corn in a field.

The development of the shoots of *Cornus suecica* has been described by Buchenau (1859), and my own observations quite agree with his description. The rhizome is horizontal and bears opposite triangular scale-leaves, two to three centimeters apart. It is of several years duration, while the scale-leaves die already the first year; and from their base adventitious roots appear, with a rich ramification. In the axis of the scale-leaves buds develop, some becoming runners, resembling in all particulars the mother-shoot, others remain dormant. The runners, which attain a length of up to 30 centimeters, finally turn their apex upwards, forming a stem with foliage-leaves, terminating with an inflorescence or else remaining vegetative. The perpendicular part of the shoot commences with a series of pairs of scale-leaves, red while fresh, but withering quickly; their number varies from 3 to 9 pairs, and is as a rule 5. The foliage leaves develop next, Danish specimens showing 4 to 8 pairs, those from the arctic 3 to 4 only.

Fig. 1. *Cornus suecica.*

A, Flowering Plant; *B*, Apex of Runner (Godthaab, Greenland); *A*. about 3/4, *B*, 2/1.

Buchenau states, that the two uppermost pairs are closely placed, resembling a whorl; all the specimens from one Danish locality (Maglemose in Grib Skov) examined by me showed the same, while plants from other Danish localities did not. On arctic material I never found it.

The aërial part of the shoot attains a height of from 6 to 30 centimeters and is annual. The stem is quadrangular and has two opposite grooves (fig. 12), which change sides at each internode, the leaf pairs being placed at their lower ends. The scale-leaves, with which the perpendicular part of the shoot commences, support buds, the first pair excepted; and some of the buds develop next year into shoots with foliage leaves, growing upwards immediately, and showing no inclination to become runners. These shoots also commence with a number of red scale-leaves, after which follow foliage-leaves. The same ramification takes place the following year from the scale-leaf buds of these shoots, and so on, thus forming a tufty growth.

According to Buchenau, it is always the buds appearing in the axis of the second pair of scale-leaves which develop, so that all the shoots are placed at the same level. This is however far from always being the case, often it is from the uppermost pair of scale-leaves or the one next to this, from which next year's shoot develops, and often only one bud from a pair of scale-leaves develops, although the second one can very well develop later during one of the following years.

The buds which are to develop into shoots next year, are in the autumn of a considerable size and the first two pairs of leaves are brown and formed like bud-scales. The whole shoot completely formed is inclosed in the winter-bud, also the inflorescence and the first indications of the buds to develop the 2nd year.

The leaves of *Cornus suecica* fall in the autumn, while the stem is yet fresh; towards the winter it dies, but can very well remain standing in a withered state for several years. The winter buds are located near the surface of the ground, and the plant is thus, as regards its life habit, a hemikryptophyte. Buds are formed in the axis of the foliage leaves, which however are very small, and as a rule only the buds of the uppermost pair of foliage leaves develop; at the time of flowering they are only small, but during the summer they develop into large side branches. I have noticed a Danish specimen, not flowering, where all the buds of the foliage leaves were developed, with the exception of the lowest pair.

The leaf is ovate and sessile, with two or three veins diverging from each side of the midrib, near its base. On arctic specimens the uppermost pair of leaves (100 specimens were measured), had an average length of 19 mm, the average width being 12 mm. On Danish specimens, however, the average length was 28 mm with an average width of 17 mm, 100 specimens also being measured in this case. The leaves of the Danish specimens thus distinguish themselves by being considerably larger than those from the Arctic.

The seedlings have been described by SYLVÉN; the cotyledons are shortstalked, ovate-lanceolate, about 7 mm long. The primary root is strongly ramificated, and the development of the adventitious roots seems only to take place during the second period of growth; only few internodes are formed on the aerial shoot during the first year. The hibernation takes place by means of buds in the axis of the cotyledons, which next year develop into new aërial shoots, and the formation of runners only commences several years later.

In Greenland the flowering takes place in July and August. The inflorescence is a head-like or umbelliforme cyme, surrounded by four yellowish-white involucrals, by which, as is well known, the whole inflorescence gets the appearance of one single big flower, with four petals. Each flower has a short stalk, about 2 mm long; the sepals are very small, and the petals, of which one is often elongated, have a dark red-violet colour, and are turned sideways. The style is surrounded at its base by an annular brown disc; the stamens are turned to the side in the spaces between the petals.

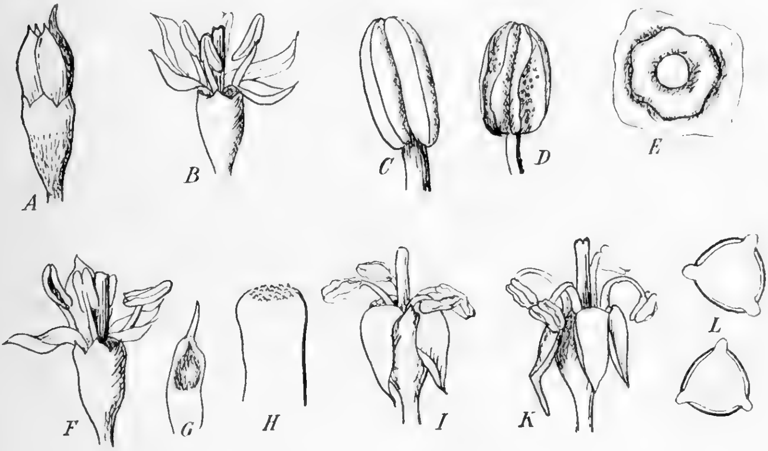

Fig. 2. *Cornus suecica.*

A—E from West Greenland, (Sukkertoppen, 16th August); *A*, Flower in bud ($^{10}/_{1}$), *B*, Flower in full bloom (just opened); *C*, Anther, not open ($^{25}/_{1}$); *D*, Anther, open ($^{25}/_{1}$); *E*, Discus, seen from above ($^{25}/_{1}$); *F—K* from Northern Norway (Tromsø, 24th July) ($^{10}/_{1}$); *F*, Flower with one anther (to the left) open ($^{10}/_{1}$); *G*, The elongated petal (see fig. *A*); *H*, Part of style with stigma; *J*, Empty anthers, pollen apparently on stigma; *K*. Same, but filaments more curved; *L*, Two pollen grains. from Northern Norway (Bosekop) ($^{410}/_{1}$); (*A—K*, Eug. Warming del.).

Concerning specimens from "Sukkertoppen" WARMING writes in his notes from Greenland: "Slight protandry is noticed. Simultaneous with the opening of the petals, the stamens extend and the anthers open, but the stigma is not yet fit to retain the pollen; when this shortly afterwards happens, the anthers are still full of pollen and self-pollination possible, though I think, not easily, by reason of the spread of the filaments (Fig. 2 *B*, *F*); as the flowers stand so very close to each other, it is more likely they could reach the nearest ones and deposit pollen on their stigmas, and, as a matter of fact, I have seen the anthers of neighbouring flowers in close proximity to a flowers stigma".

WARMING found the same form of development in arctic Norway (Tromsø, Alten) and pure homogamy was only found once. The pollination takes place by insects, which are guided to the flowers by the four big and petal-like involucrals; according to WILLIS and BURKILL the visitors are few, mainly of the order of *Diptera.*

The pollen grains, which are only few in number, have three strongly projecting pores (fig. 2).

Deformity of the inflorenscence is not quite uncommon; sometimes the involucral is partly and even completely green. WARMING mentions such deformities in his notes from "Sukkertoppen"; in the same locality he found specimens with 6 or 7 involucral leaves.

The fruit is a drupe; the stone is two-celled, one of which nearly always remains barren; the ripe fruits, red in colour, are found in Greenland in August and September. The dispersal takes place by animals (HESSELMAN found 40 stones in the excrements of a *Larus marinus*), and partly by means of water; the plant often grows near water-courses, and the stones being lighter than water, will often be carried far away; SERNANDER found them thrown up by the sea near a small island in the Baltic, more than 400 km from its nearest habitat.

Anatomy.

The leaf is dorsiventral, with a pallissade tissue of one layer of cells and a pronounced spongy tissue (fig. 4). The epidermis of the upper surface consists of very large cells, while those of the epidermis of the lower surface are smaller and with undulating sidewalls. This undulation is more pronounced in leaves of Danish specimens than in those from the Arctic (fig. 3). The sidewalls of the upper surface are also undulating, but in a lesser degree, and also in this case is found the same discrepancy between Danish and Arctic leaves, though less pronounced. The cuticula is thin on both sides, and shows opposite the larger veins fine stripes, running parallel to the longitudinal axis of the leaf.

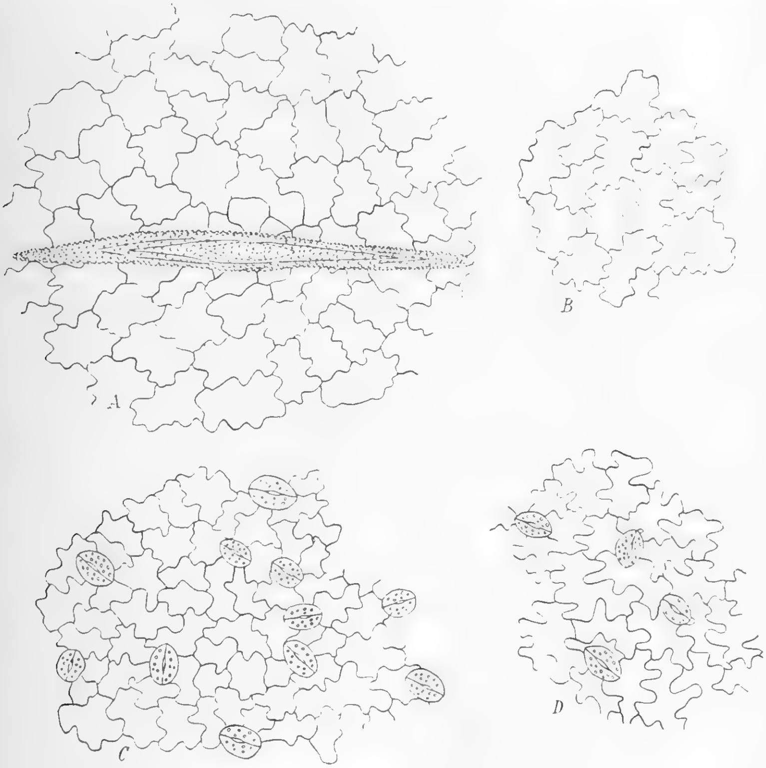

Fig. 3. *Cornus suecica.*

A, Epidermis, upper surface, with a two-armed hair (Sukkertoppen, Greenland); *B*, Epidermis, upper surface (Maglemose, Denmark); *C*, Epidermis, lower surface (Sukkertoppen, Greenland); *D*, Epidermis, lower surface (Maglemose, Denmark); *A*, *B*. *C* and *D* about $^{136}/_{1}$.

Only the lower surface has stomata, these are placed over the level of the other epidermal cells, more pronounced on Arctic than Danish leaves. As to the number of stomata on a given area, they are perhaps more numerous in the Arctic specimens than in Danish. The table below gives the number of stomata pr. Sq. m. m. of a number of Danish and arctic leaves:

Danish Leaves		Arctic Leaves	
Locality	Number of Stomata pr. □ mm	Locality	Number of Stomata pr. □ mm
Maglemose (Grib Skov)	70	Egedesminde	100
Vildmosen	100	Tromsø	84
Hæsede	78	Nunatsuk	82
Silkeborg	85	Julianehaab	120
Skibsted	66	Ilua	134
Vildmosen	127	Godthaab	75
Mariager	82	Sukkertoppen	109
Hillerød	70	Sukkertoppen	79

Among other differences between leaves from the Arctic and those from temperate localities, the following is particularly pronounced and has shown itself to be very constant: The Arctic leaf is thicker than the Danish (fig. 4). This substantial difference is chiefly due to the strongly developed spongy tissue of the Arctic leaf, while the length of the cells of the palisade tissue is rather smaller than in Danish leaves. Besides this, the Danish leaves have a more loosely built mesophyll with the palisade cells only loosely connected, diverging below, and the spongy tissue has large intercellulars and more slender cells than is the case with arctic leaves (fig. 4, *C—D*). The relation between the size of the spongy tissue and that of the palisade tissue of Arctic and Danish leaves is plainly given by the following measurements of leaves from eight different Danish localities and a similar number from the Arctic.

Danish Leaves				Arctic Leaves			
Locality	Thickness of			Locality	Thickness of		
	Leaf	Palisade tissue	Spongy tissue		Leaf	Palisade tissue	Spongy tissue
Maglemose				Godthaab …	231μ	51 μ	138 μ
(GribSkov)	174μ	66 μ	90 μ	Sukkertoppen	234 -	54 -	135 -
Hæsede….	174 -	57 -	78 -	Egedesminde.	210 -	57 -	120 -
Mariager ..	168 -	57 -	81 -	Julianehaab .	246 -	60 -	150 -
Helsingør..	174 -	66 -	75 -	Nunatsuk …	246 -	72 -	144 -
Hillerød …	177 -	66 -	78 -	Ilua………	210 -	54 -	120 -
Skibsted…	174 -	66 -	81 -	Tromsø……	189 -	48 -	114 -
Vildmosen .	180 -	75 -	78 -	Sukkertoppen	240 -	60 -	138 -
Silkeborg ..	156 -	60 -	66 -				

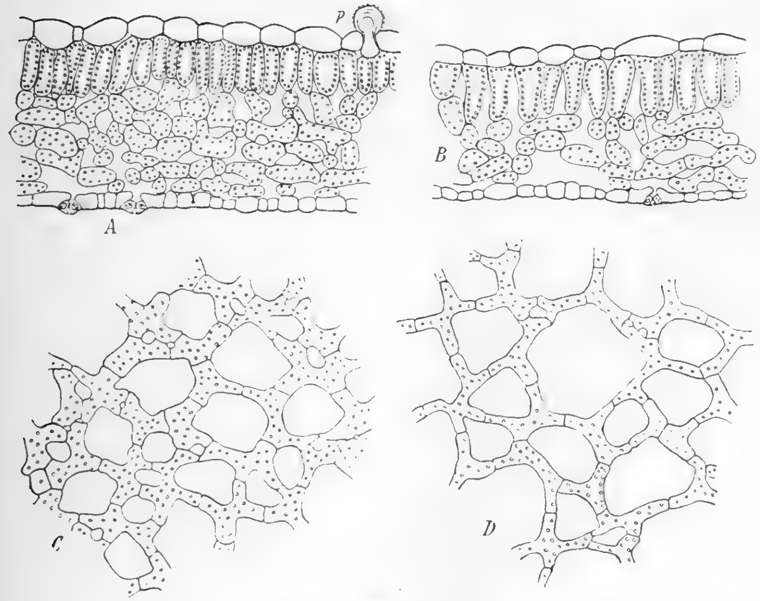

Fig. 4. *Cornus suecica.*

A, Transverse section of leaf, p, two-armed hair (Godthaab. Greenland); *B*, Transverse section of leaf (Maglemose, Denmark); *C*, Section through the spongy tissue, parallel to the surface (Godthaab, Greenland); *D*, Section through the spongy tissue (Maglemose, Denmark); *A*, *B*, *C* and *D* about $^{136}/_{1}$.

The upper as well as the under surface of the leaf is provided with large two-armed hairs (Malpighia-hairs), fig. 3 A, shaped like a pickaxe, the upper-surface having, on the same area, about three times as many as the under surface; they are one-celled and the stalk is exceedingly short (fig. 4 A). The surface of the hair (the short stalk excepted) has numerous projections, thickenings of the walls, and the latter plainly show several layers which are much thickened; the lumen is extraordinarily small and seldom reaches the ends of the arms, which are consequently solid (fig. 3, 4).

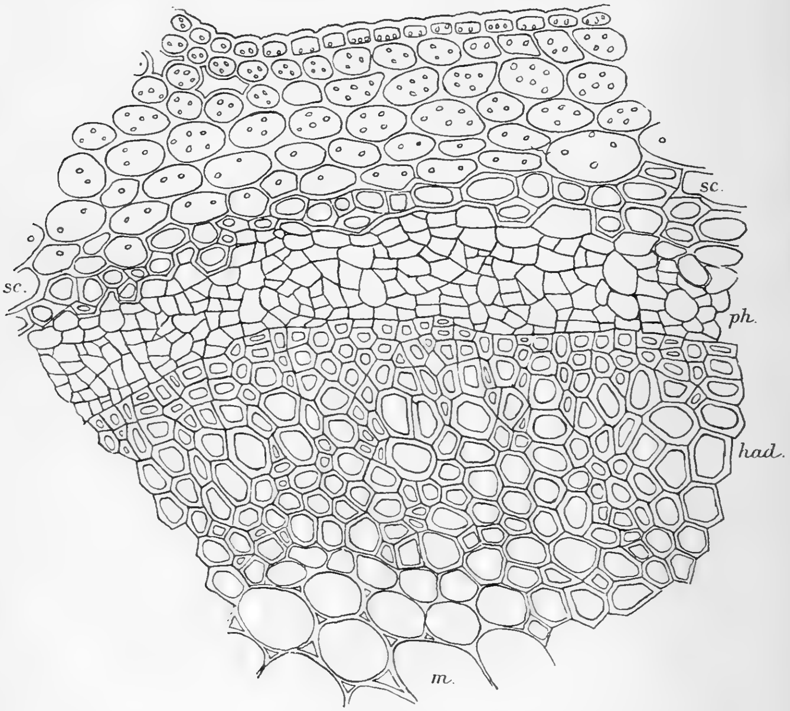

Fig. 5. *Cornus suecica.*
Transverse section of stem; *ph*, Leptom; *had*, Hadrome (Egedesminde, Greenland); about $^{270}/_{1}$.

The main veins of the leaves have on their under surface, below the phloëm, a slight sclerenchyma, which is not present in the smaller ones.

The Stem (fig. 5). The aerial shoot is annual. The epidermis has thickened outerwalls and is covered by a thin cuticula, striped parallel to the stem's longitudinal axis; stomata are present. Five layers of large chlorophyllaceous bark-cells follow inside the epidermis, and after these a more or less developed annular schlerenchyma, consisting of elongated parenchymatic cells, with much thickened walls (fig. 5, *sc*). The phloëm appears inside this annular sclerenchyma and, like the woody tissue, forms a coherent ring

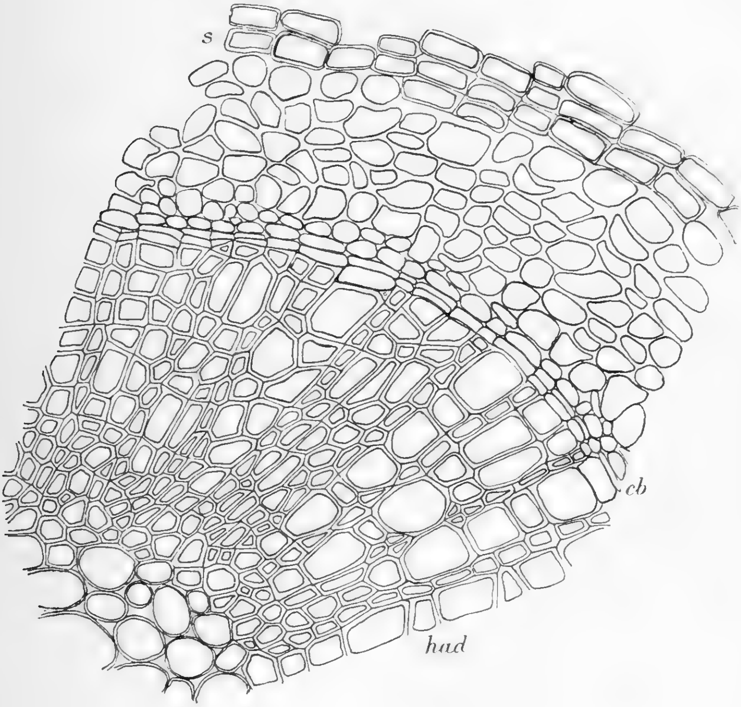

Fig. 6. *Cornus suecica.*
Transverse section of rhizome; *S*, Cork; *cb*, Cambium; *had*, Hadrome (Egedesminde, Greenland), about $^{270}/_{1}$.

round the stem. The cambium is rudimental in the fully developed stem, its activity soon ceasing as the whole of the woody tissue is already formed while the stem is quite young.

The wood consists chiefly of spiral and pitted vessels, tracheids and wood-parenchyma. The vessels are fairly narrow, and in transverse sections, angular; the pitted vessels have ringpores, while the wood-parenchyma has single pores; medullary rays are not present, but starch is found in the wood-parenchyma, and inside the latter a medulla with large cells runs in the longitudinal direction of the stem.

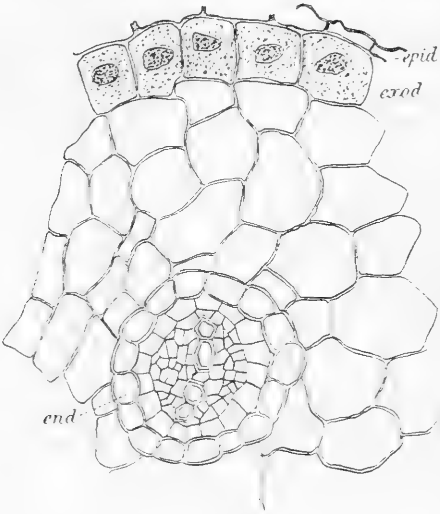

Fig. 7. *Cornus suecica.*

Transverse section, showing primary structure of root; the epidermis is dead and partly fallen off; *exod,* Exodermis; *end,* Endodermis (Sukkertoppen, Greenland) about $^{330}/_1$.

The rhizome (fig. 6) is covered with cork, consisting of rather thickwalled cells and formed sub-epidermally. The bark-cells are arranged rather irregularly inside the cork, they are somewhat thickened collenchymatically and contain starch, which as far as *Cornus suecica* is concerned, always consists of composite granules. On the innerside an even transition from the bark-cells to the phloëm is to be found. As in the stem, the wood consists of a coherent ring, and has rather indistinct annual rings. The secondary wood consists of trabecular and ringpored vessels, together with tracheids and wood-parenchyma, this latter being rich in starch. Medullary rays are not present, the medulla consisting of large cells filled with starch.

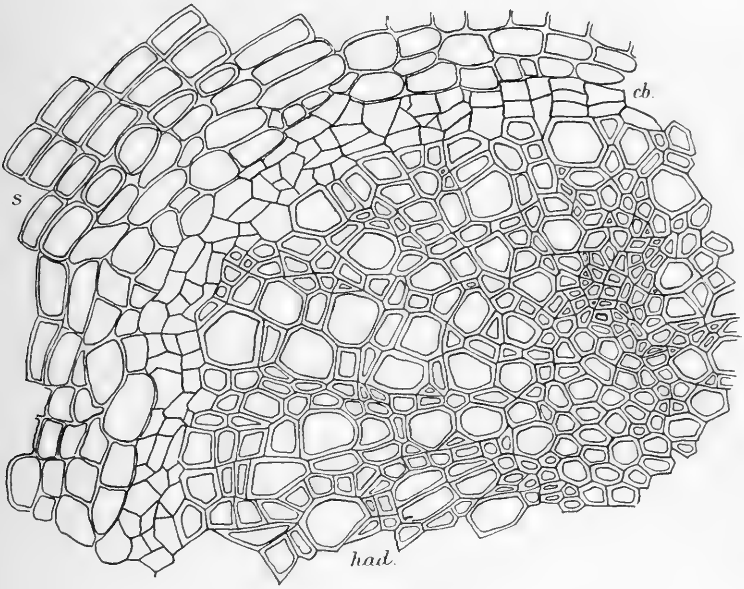

Fig. 8. *Cornus suecica.*

Transverse section, showing secondary structure of root; *S*, cork (Greenland); about $^{312}/_{1}$.

The bark-cells of the rhizome contain large quantities of tannin, which is also found in the bark-cells of the stem and in the leaf.

The Root: the primary structure is diarch, it has a suberized rather thickwalled endodermis and a distinct pericycle (Fig. 7).

The bark consists of rather large cells; the epidermis dies away very quickly, and remains as a loose sheath round the very young root, while the exodermis, the cells being yet well filled with protoplasm, soon produces a layer of corky tissue with thickened cells, and resembles otherwise the cork of the rhizome.

The secondary root (fig. 8) is on the whole of the same structure as the rhizome, the exception being that no medulla is found.

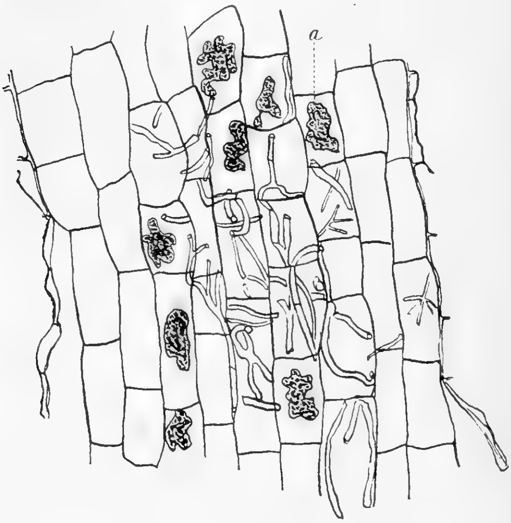

Fig. 9. *Cornus suecica.*

Tangential, longitudinal section through the bark of a young root, containing mycorrhizae; *a*, destroyed hyphae (Greenland) about $^{240}/_{1}$.

Endotrophic mycorrhiza is always found in the young root, in Arctic as well as in Danish specimens (fig. 9); the fungal hyphae are rather thick and not very closely knotted together, as is most often the case with roots having endotrophic hyphae. The hyphae are both inter- and intracellular, and in the cells are also found irregular or coral-shaped clumps, probably destroyed hyphae, which like the former colour strongly when treated with Hansen's haematoxylin. The cells containing these lumps or living hyphae contain no starch, other cells are rich in this.

Cornus canadensis L.

Sertorius, 1893, p. 619; Lovell, 1898, p. 386; Holm, 1895, p. 544; Meehan, Th., 1892, p. 376; Meehan, W., 1893, p. 211.

Cornus canadensis (fig. 10) is found most frequently in North America; it is met with throughout Canada, with the exception of the most northern parts, from New Foundland and Labrador to Southern Alaska. Its southern boundary passes through the states of West Virginia, Ohio, Indiana, Wisconsin, Minnesota, Nebraska, Colorado and California. It is found also in the northern Islands of Japan, and now, as mentioned in the preface, in the most southerly part of Greenland, in the small, remotely situated island, Inuarudgligak. It does not reach as far North as *Cornus suecica*, which e. g. is met with at Baffinsland, where *C. canadensis* is not found, whereas it is found considerably further South. In North America *C. canadensis* has its habitat in damp, cold woods (*Pinus*, *Larix*) and in thickets, and evidently grows in more shady places than *C. suecica*; in Japan it grows in the mountains.

Fig. 10. *Cornus canadensis* from Inuarudgligak in Greenland, about $^3/_4$ (H. E. P. phot.).

As to the structure of the shoot, this corresponds in the main to that of *C. suecica*; all the foliage leaves are placed in a whorl at the top of the stem, though occasionally one or two leaf pairs are found lower down. The leaf-whorl is formed by the suppression of the uppermost internodes on the main as well as on the secondary axis. In contrast to *C. suecica* the leaves are said to be everlasting (ASCHERSON and GRAEBNER); they are considerably larger and tapering at the base; and also differ as regards the venation; in *C. suecica* the veins all diverge from the base of the leaf, while in *C. canadensis* the two uppermost side-veins diverge from the midrib somewhat higher up.

The involucral leaves are as a rule larger than those of *C. suecica.* The petals are green, one of them often having an awl-shaped elongated point. In material from North America I have found specimens with red petals edged with green, which together with other characteristics made them form a transition in appearance to *C. suecica*[1]). The three specimens from Inuarudgligak which constitute the whole material from Greenland had green petals.

The biology of the flower has been treated by LOWELL, who writes: "As the flower-bud approaches maturity the filaments grow rapidly, breaking apart the petals at the base, and protruding as four V-shaped arches. If at this stage the awl-shaped appendage is touched by the body of an insect, or by a needle, the petals are instantly reflexed, the elastic filaments straighten, and a minute shower of pollen is projected upward. In fully matured flowers a faint snap may be heard. Self-fertilization is prevented by the immaturity of the stigma. Both stamens and petals soon fall away, and the capitate stigma, composed of white

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[1] I have seen a similar intermediate specimen from Neriak on the East coast of Greenland (61° 3″); the involucral leaves were very large, and the petals red, edged with green; it had 2 pairs of large, opposite leaves of which the uppermost pair supported short-jointed shoots; the leaves tapered at the base and the venation and anatomy were quite similar to those of *C. canadensis.*

papillae, subsequently matures. Though self-fertilization is prevented by proterandry there may occasionally be observed, resting against the stigma, the anthers of neighbouring flowers. The honey is secreted in a very thin layer by a dark brown ring at the base of the style[1].

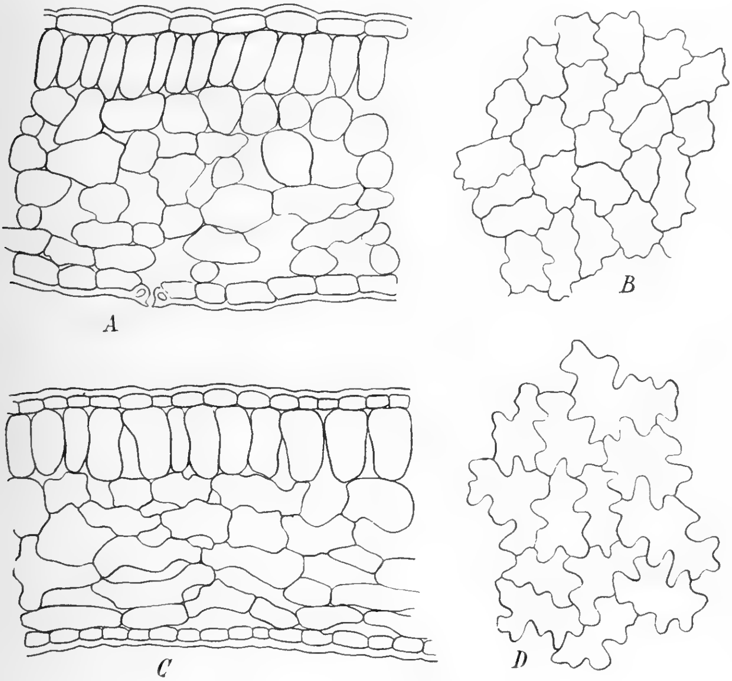

Fig. 11. *Cornus canadensis.*

A, Transverse section of leaf (Inuarudgligak, Greenland), *B*, Epidermis, upper surface (Greenland); *C*, Transverse section of leaf (Minnesota); *D*, Epidermis, upper surface (Minnesota); *A*, *B*, *C* and *D*, about $^{185}/_{1}$.

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[1] Thomas Meehan reports having observed, that *C. canadensis* is partly monoecious, partly dioecious. He has only seen plants with ripe fruit, not any flowering specimens, and found, that the inflorescences of some plants were quite sterile, others had a single berry in the middle of the cyme, while others again were rich in fruits; from this he draws his conclusion. All the individuals I have examined have been hermaphrodite, and as Lowell, who has studied the biology of the flower, does not

Anatomy.

The Leaf. The leaf is dorsiventral as in *C. suecica*, but differs in having the epidermal cells of about the same size on both surfaces; also by the cells having strongly thickened outer walls, this latter being caused by the cellulose-membrane; the cuticula is quite thin. The palisade-cells are rather thick and short. Apparently there is the same difference between leaf specimens from Greenland and those from more southerly latitudes, as is the case with those of *C. suecica*. The leaves from Greenland are thicker than those from further South, and the extensiveness of the spongy-tissue is much greater in comparison to the palisade-tissue.

The following table gives a few measurements of leaves from different latitudes:

Locality	Thickness of leaf	Extensiveness of Palisade-tissue	Extensiveness of Spongy-tissue
Greenland	90 μ	16 μ	56 μ
Vancouver Island	60 -	18 -	30 -
Minnesota	55 -	20 -	26 -
New Foundland	70 -	16 -	37 -
Turnavik (Labrador)	50 -	19 -	25 -
Specimen from the Botanical Garden at Berlin	77 -	27 -	40 -

On the American specimens the epidermis of both surfaces have strongly undulating sidewalls, while this is much less pronounced in those from Greenland (Fig. 11). Stomata are only present on the under surface; the specimens of *C. canadensis*

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mention diclinous flowers, these must consequently be very rare, if existing at all.

from Greenland having 160 of these pr. square mm, while specimens from Canada had only c. 140 pr. sq. mm.

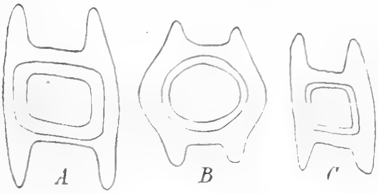

Fig. 12.

Transverse sections of stems. *A*, *Cornus canadensis* from Vancouver Island; *B*, *Cornus suecica* (Greenland); *C*, *Cornus canadensis* from Greenland; *A*, *B* and *C* about $^{12}/_1$.

The Stem. The stem is very much like that of *C. suecica*, the transverse section being however somewhat different. As Fig. 12 shows, the stem of *C. suecica* seen in transverse section is more barrel-shaped, and the groove not very deep, while that of *C. canadensis* is considerably deeper, making the stem "four-winged"; besides this, the circumference of the medulla of *C. canadensis* is quadrangular, while that of *C. suecica* is round. In *C. canadensis* the distal part of the wings of the stem consists of collenchyma while such is practically missing at this place in *C. suecica* (Fig. 13).

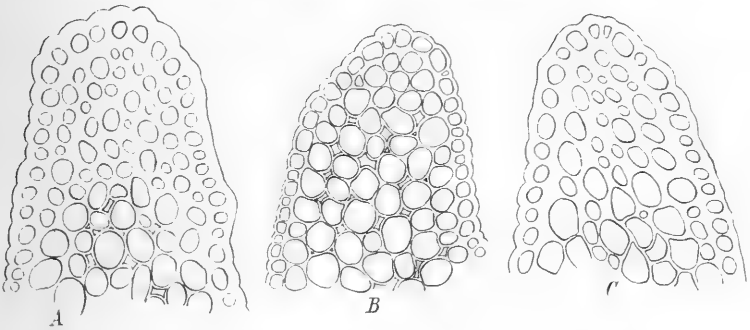

Fig. 13.

Transverse section of the winged part of the stem. *A*, *Cornus canadensis* from Vancouver Island; *B*, *Cornus suecica* from Greenland; *C*, *Cornus canadensis* (Greenland); *A*, *B* and *C* about $^{175}/_1$.

The sclerenchyma in the bark of *C. canadensis* is often greatly developed in vigorous specimens, while it is about missing in poorly developed plants, e. g. in the specimens from Greenland.

The anatomic structure of the rhizome and the root is exactly like that of *C. suecica.* Tannin is present throughout the plant.

The mycorrhizas of *C. canadensis* and *C. suecica* are alike.

Summary.

Cornus suecica is a distinct mesomorphic plant which completely lacks xeromorphic characters; such are however found in *C. canadensis*; the epidermal cells of the leaves of this species have thickened outer walls, which is correlated to the fact of the leaves being perennial. The more loose construction of the mesophyll of Arctic plants mentioned by BØRGESEN[1] does not apply to the species here dealt with; on the contrary, the Arctic specimens of *C. suecica* have a mesophyll of a much closer structure than the specimens from more southerly localities. Besides this, the leaves of *C. suecica*, grown in Arctic localities, are distinguished by being smaller, but decidedly thicker than those of specimens from Denmark. The spongy-tissue is very strongly developed in Arctic specimens.

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[1] Bidrag til Kundskaben om arktiske Planters Bladbygning (Botanisk Tidsskrift, Bd. 19, 1895; also in "Journal de Botanique", vol. 9, Paris 1895).

X.

PLANTS COLLECTED DURING THE FIRST THULE EXPEDITION TO NORTHERNMOST GREENLAND

DETERMINED BY

C. H. OSTENFELD

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Arbejder fra den botaniske Have i København.

7/11.18

During the first Thule-Expedition (1912) Mr. Peter Freuchen collected a fair number of plants at several of the tent-places of the expedition. It is quite remarkable that he succeeded in making botanical collections under the circumstances under which he worked, and in bringing the plants collected home in good condition.

His time for collecting was very restricted, and we may therefore not expect that the list given below comprises the entire flora. It is merely a list of the more conspicuous flowering herbs and shrubs, while such plants as grasses and sedges naturally have been neglected, at least in part. Of course also the cryptogames are very poorly represented in the collection; some few tufts of mosses and single pieces of lichens and algæ are brought home, and in the moss-tufts and among the basal parts of the flowering plants several other mosses have been discovered, when I was working up the collection. Mr. A. Hesselbo has been good enough to prepare a list of the mosses, while I have thought it of no importance to try to get names to the few pieces of algæ and lichens which are only very commonly distributed arctic forms.

In 1909 Dr. H. G. Simmons published "A revised list of the Flowering Plants and Ferns of North Western Greenland" (Rep. Sec. Norweg. Arct. Exped. in the "Fram" 1898—1902, No. 16), in which he has critically compiled all earlier contributions to the flora of N. W. Greenland north of Melville Bay. If we compare his list with that given below, we will find no species enumerated here which has not been found before in N. W. Greenland. On the other hand, our list is very useful with regard to the regional distribution within this big area, extending from ca. 76° Lat. N. to nearly 84° Lat. N., as it brings the records of several species much farther north than hitherto. N. W. Greenland may, from a botanical point of view, be divided into two natural parts, a northern part north of the big Humbolt Glacier, and a sounthern part south of it. The southern part is much richer in plants — is also better explored, botanically, — than the northern one. Simmons (l. c., p. 22) gives only 27 species known from the northern part, while the flora of the whole N. W. Greenland contains 108 species, and all of the 27 species of the northern part (except one: *Dupontia Fisheri*, which occurs farther south in Greenland) are also found in the southern part.

The region explored by the first Thule Expedition belongs most naturally to the northern part of N. W. Greenland in spite of the fact that Independence Bay has its opening towards East, and therefore the collection here treated means a considerable addition to the poor flora hitherto known from this northernmost part of Greenland.

The list of the flowering plants and ferns given below enumerates 45 species, 28 of which were not found before in the northern part of N. W. Greenland, the flora of which consequently now has (28 + 27 =) 55 species. 10 species recorded earlier from N. W. Greenland did not not occur in Freuchen's collection, viz. *Poa cenisia*, *Dupontia Fisheri*, *Juncus biglumis*, *Melandrium apetalum*, *Hesperis Pallasii*, *Braya purpurascens*, *Lesquerella arctica*, *Cochlearia officinalis* and *Ranunculus nivalis* (the last one being represented by the nearly allied *R. sulphureus*).

Several of these (e. g. *Hesperis*, *Braya*, *Lesquerella* and *Cochlearia*) are too conspicuous to have been overlooked by Freuchen's keen eyes, and it is therefore probable that they do not occur in the region visited by him, which may be too far North for them. On the other hand the grass-like plants may have occurred in the region in question where undoubtedly several more grasses and the like could be found, if investigated by a botanist.

As it might be expected, most of the species collected are hardy and common arctic species of a wide geographical distribution. They occur both to the east and to the west of the area investigated. But still some species may deserve a special attention. I may here point out the discovery of the rare arctic grass *Pleuropogon Sabinei*, which was hitherto only found in one place in N. W. Greenland and has been reported from Germania Land and other places on the N. E. Greenland coast. Arctic species not occurring everywhere are further: *Erigeron compositus*, *Taraxacum phymatocarpun* and *Poa abbreviata*, the last being evidently common in the area investigated. As species the occurrence of which at this high latitude was not to be taken for granted, I may name: *Statice armeria*, *Cardamine bellidifolia*, *Trisetum spicatum*, *Sagina intermedia*, *Silene acaulis*, *Woodsia glabella* etc.

The more common and conspicuous species in the area seem to be, besides *Poa abbreviata*, — *Carex nardina*, *Papaver radicatum*, *Saxifraga oppositifolia*, *Cerastium alpinum*, *Dryas* and *Salix arctica*.

The localities where Freuchen had time to collect plants are the following:[1]

A. The region of the Danmarks Fjord.

18. May: The Zigzagdalen, Sjællandssletten, on the western side; moraine, dry, sandy soil.

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[1] A preliminary report on the Expedition was given in Geografisk Tidsskrift, Bd. 22, Hefte V, 1914, Köbenhavn, by Knud Rasmussen: Forelobig Beretning om "Den første Thule-Ekspedition" 1912—1913.

23. May: Sjællandssletten; slope facing south; dry moraine gravel of a river bottom.

3. June: Valdemar Glückstadts Land (Cape Kronborg), snow-covered clayey plain.

B. Melville Land.

5. June: The south coast, opposite J. C. Christensens Land.

C. Head of Independence Bay.

18. June: Heilprin Land, "Sidste Næs".
20. June: Cape Schmelck.
11. July: Valmuedalen (Valley of Poppies).

D. Vildtland, west of Independence Bay.

20. July: Western part.
3. August: Western part.

The localities are situated between 81°15′ and 82°15′ Lat. N. and between 22° and 38° W. Long.

In the list below is given under each species only the date of collecting, from which it is easy to find the locality in question as given above. The names of the plants have been arranged as follows: Within the four main groups of vascular plants the families (orders) are enumerated in alphabetical order; the same is the case as regards the genera within the families and the species within the genera.

I. Pteridophyta.

Fam. Polypodiaceæ.

1. **Cystopteris fragilis** (L.) Bernh.

20/VI: Specimens with young leaves bearing unripe sori and with year-old leaves with emptied sori.

2. **Woodsia glabella** R. Br.

20/VI: Year-old leaves with emptied sori were found among the leaves of the foregoing species.

II. Monocotyledones.

Fam. Cyperaceæ.

3. **Carex nardina** Fr.

18/V, 23/V: Old tufts in winter-stage, numerous fruiting stalks from the year before. 18/VI: The leaves begin to grow by basal growth, the basal parts being green, the distal ones faded and pale; some fruiting stalks from the year before.

4. **Eriophorum polystachyum** L.

3/VIII: Low (ca. 5 cm) specimens with unripe fruits (the bristles half way grown).

5. **Eriophorum Scheuchzeri** Hoppe.

11/vii: Low (8—11 cm) specimens with unripe fruits (the bristles more than half way grown).

Fam. Gramineæ.

6. **Alopecurus alpinus** Sm.

18/v: Year-old culm only. 3/viii: Medium sized (15 cm) specimens in full flower.

7. **Hierochloe alpina** (Liljebl.) R. & S.

3/viii: Large and strong specimens with ripe fruits.

8. **Pleuropogon Sabinei** R. Br.

11/vii: 10—12 cm high specimens in full flowering.

9. **Poa abbreviata** R. Br.

18/v, 3/vi: In winter stage, with year-old culms.

3/viii: Flowering over, the fruits have dropped, year-old culms present.

10. **Poa glauca** M. Vahl.

18/vi, 20/vi: Year-old culms and just beginning growth of the roset leaves. 3/viii: Panicle well developed, year-old culms present.

11. **Trisetum spicatum** (L.) Richter.

20/vi: Year-old panicles only.

Fam. Juncaceæ.

12. **Luzula arcuata** (Whbg.) Sw., subsp. **confusa** Lindeb.

18/vi: Year-old culms with clusters. 20/vi: New clusters begin to develop.

13. **L. nivalis** (Læst.) Beurlin. (**L. arctica** Blytt).

3/viii: The seeds in the capsules nearly ripe.

III. Choripetalæ.

Fam. Caryophyllaceæ.

14. **Cerastium alpinum** L.

17/v: A condensed form with year-old fruiting stalks; winter stage. 18/vi: Long shoots with new buds in the axils of the year-old, withered leaves; old fruiting stalks. 20/vi: A condensed specimen with nearly fullgrown flowering buds. 11/vii: Condensed specimen in full flower and with year-old fruiting stalks. 3/viii: Strong and rich-flowered specimen in full flower and with year-old fruiting stalks. — All these specimens are hairy. There was also found a single small specimen of the small-leaved, glabrous, condensed f. *pulvinata* Simmons (18/vi, no trace of flowering organs).

15. **Melandrium affine** J. Vahl.

20/vi: Low specimens, just beginning to flower.

16. **M. triflorum** (R. Br.) J. Vahl.

11/vii: Small specimens in bud and with fruits developing. 3/viii: Specimens with nearly ripe fruits.

17. **Minuartia verna** (L.) Hiern, var. **rubella** Wahlenb.

17/v and 18/vi: Winter stage. 20/vi: Strong rosette with buds and year-old fruiting stalks. 11/vii and 3/viii: Strong rosettes with flowers and year-old fruiting stalks.

18. **Sagina intermedia** Fenzl.

18/vi: One very small specimen with year-old stalks bearing withered flowers (no developed fruit).

19. **Silene acaulis** L.

23/v: Winter stage with year-old fruits and withered flowers. 18/vi: With young leaves and young flower buds. 11/vii: In full flowering. 3/viii: Only a small fragment present.

20. **Stellaria longipes Goldie.**

2/vi: A big tuft with year-old broad leaves and young leaf-buds in the axils. 18/vi: Fragments of elongated stolons with young leaf-buds in the axils of the old leaves. 3/viii: Condensed broad-leaved shoots without flowers; they have been covered in moss tufts.

Fam. **Cruciferæ.**

21. **Cardamine bellidifolia** L.

20/vi: A single specimen in full flower.

22. **Draba alpina** L., var. **glacialis** (Adams) Dickie.

18/v: Winter-stage; old rosettes. 20/vi: In full flower. 11/vii: In flower.

23. **Draba fladnizensis** Wulf.

23/v: Winter-stage; old rosettes. 20/vi and 11/vii: In flower and with year-old fruit-scapes.

24. **Draba hirta** L., var. **arctica** (J. Vahl) S. Wats.

3/viii: A low coarse specimen with unripe new fruits and year-old fruit-scapes.

Fam. **Oenotheraceæ.**

25. **Epilobium latifolium** L.

23/v: Year-old dead shoots. 20/vi: Nearly fully developed new shoots with flower buds.

Fam. **Papaveraceæ.**

26. **Papaver radicatum** Rottb.

Common everywhere. 18/v and 3/vi: Year-old withered leaves and scapes. 18/vi: Young new leaves and old scapes. 20/vi: Flowering just beginning. 11/vii and 20/vii: In full flower and with year-old scapes. 3/viii: The petals have dropped; empty year-old capsules.

Fam. **Polygonaceæ.**

27. **Oxyria digyna** (L.) Hill.

11/vii: Medium sized (12 cm) specimens with unripe new fruits and year-old fruiting scapes. 3/viii: Low specimens (4 cm) with unripe fruits.

28. **Polygonum viviparum** L.

11/vii: Medium sized specimen; most of the bulbils dropped. The underside of the leaves rather hairy.

Fam. **Ranunculaceæ.**

29. **Ranunculus sulphureus** Soland.

11/vii: Small specimens (ca. 5 cm) in full flower. 3/viii: Flowering over and fruits developing.

Fam. **Rosaceæ.**

30. **Dryas integrifolia** M. Vahl.

18/v: Winter stage.

The specimens from Zigzagdalen are quite typical *D. integrifolia* with regard to the dentation of the leaves etc.

The two nearly related species, *D. octopetala* and *D. integrifolia*, which mostly exclude each other as regards their areas of occurrence, are both present in the northernmost parts of Greenland, and intermediate specimens occur here. Hence we have the diverging records, some authors giving *D. octopetala*, others *D. integrifolia* from the same or closely neighbouring regions. Thus H. G. Simmons (1909, l. c.) has referred all records of *Dryas* from Northwestern Greenland to *D. integrifolia*, taking var. *intermedia* Nath. as a form of this species. In North-eastern Greenland on the other hand *D. octopetala* is the commoner species and *D. integrifolia* the rarer one. Kruuse (Medd. om Grønland, XXX, 1905, p. 148) reports *D. octopetala* (in several forms) from his whole area and *D. integrifolia* (which he regards as a subspecies) only from a few places — all situated in the inner parts of the fjords. Ostenfeld and Lundager (Danmarks Ekspeditionen, Medd. om Grønland, XLIII, 1910, p. 28) also give *D. octopetala* as the common species in Germania Land and the other localities investigated which all are near or comparatively near to the coast; only the specimens from Hyde Fjord belong to var. *intermedia* Nath., and on closer examination now I should prefer to put them under *D. integrifolia.*

Thus it seems that the true *D. integrifolia* in the northernmost part of Greenland is rather rare and restricted mostly to the heads of the fjords.

31. **Dryas octopetala** L., f. **minor** Hook.

23/v: Winter stage. 20/vi: in full flower. 3/viii: in beginning fruit-setting.

The specimens from 23/v are good *D. octopetala* f. *minor*; those from 20/vi are a mixture: 1) some are good *D. octopetala* with regard to dentation of the leaves, but hairy on the upper side of the leaves (f. *hirsuta* N. Hartz) or lanate on the upper side (f. *argentea* A. Blytt), 2) others are intermediate between *D. octopetala* and *D. integrifolia* and must be referred to var. *intermedia* Nath. The specimens from 3/viii agree with the last mentioned and must also be named var. *intermedia.* It is remarkable that in the area where *D. octopetala* and *D. integrifolia* both occur, the variability of the species is much greater than elsewhere and that this variability concerns not only the distinctive marks between the two species, but also other characters, e. g. hairiness.

32. **Potentilla emarginata** Pursh.

18/vi: Winter-stage with old leaves and flower stalks; new leaves only as small buds (locality correct?). 20/vi and 11/vii: Low specimens in flower and with year-old flower stalks.

33. **Potentilla nivea** L.

18/v: Winter-stage; condensed specimens with old leaves and flower stalks; also as "pillars". 20/vi: Flowering just begun, old flower stalks present; also as "pillars". 3/viii: Fruiting specimens.

The specimens from 18/v and 20/vi belong to var. *pinnatifida* Lehm., while those from 3/viii are more like the typical *P. nivea.* In the first two collecting places wind-affected specimens forming compact "pillars" (with a few living leaves in the top of the erect standing axis covered densely with dead leaves) were found, like those mentioned and figured by OSTENFELD and LUNDAGER (l. c. p. 27 and plate V). The "pillars" collected during the Danmark Ekspedition were referred to *P. pulchella* R. Br., but on repeated examination I have found that some of them belong to *P. nivea*, as also those here mentioned.

34. **Potentilla pulchella** R. Br.

18/vi: A medium sized specimen with large year-old leaves and new leaves in buds. 3/viii: A low specimen (f. *humilis* Lge.) with ripfruits.

Fam. **Salicaceæ.**

35. **Salix arctica** Pall.

18/v and 23/v: Branches in winter-stage and with empty year-old capsules. 3/vi: Branches, dropping the scales covering the catkins. 20/vi: Female specimens with flowering catkins and half developed leaves. 3/viii: Leaves fully developed, broadly ovate in some specimens, ovate-lanceolate (f. *groenlandica* Lundstr.) in others.

Fam. **Saxifragaceæ.**

36. **Saxifraga cernua** L.

18/vi: Year-old flower scapes and new leaves. 11/vii: In full flower; not only the terminal flower developed, but also the terminal flowers of the branches; numerous small bulbils in the axils.

37. **Saxifraga flagellaris** Willd.

20/vi: Small, low (1—2 cm) specimens in flower. 11/vii and 3/viii: Medium sized and coarse (7 cm high) specimens towards the end of the flowering period.

38. **Saxifraga groenlandica** L., var. **uniflora** (R. Br.) Simmons.

20/vi: Flowering beginning. 11/vii: In full flower; scapes slender, flowers rather small.

39. **Saxifraga nivalis** L.

3/viii: A rather slender specimen; flowering nearly over.

40. **Saxifraga oppositifolia** L.

Common everywhere. 18/v and 3/vi: Winter-stage; year-old empty capsules. 5/vi: Flowering just beginning. 18/vi and 20/vi: In full flowering and with year-old empty capsules. 11/vii: Flowering over. 3/viii: Fruits half-ripe; year-old empty capsules still present.

IV. Gamopetalæ.

Fam. **Compositæ.**

41. **Erigeron compositus** Pursh.

20/vi: New young leaves and flowering buds present, but the scapes of the flower heads are not stretched; old scapes (1 and 2 years old) present, with empty heads.

42. **Taraxacum phymatocarpum** J. Vahl.

23/v: Very small specimen with young leaves and small flowering buds (locality correct?). 11/vii: Specimens with unripe fruits and still also heads in bud. 3/viii: Specimen with half and wholly ripe fruits (achenes).

Fam. **Ericaceæ.**

43. **Cassiope tetragona** (L.) D. Don.

23/v: Winter-stage. 18/vi: No flower buds to be seen. 20/vi: Flower buds present. 11/vii: In flower and some flowers already gone, year-old empty capsules. 3/viii: Flowering over, young fruits.

Fam. **Plumbaginaceæ.**

44. **Statice armeria** L., var. **sibirica** (Turcz.) Rosenv.

11/vii: Low specimens in beginning of flowering and with scapes with year-old fruits. Involucral bracts and flowers purple.

Fam. Scrophulariaceæ.

45. **Pedicularis hirsuta** L.

11/VII: A low (5 cm) specimen in full flower.

Bryophyta,

determined by A. HESSELBO.

3/VI. *Ditrichum flexicaule* (Schw.) Hampe, and *Encalypta commutata* Br. Germ.

18/VI. *Pohlia cruda* (L.) Lindb., *Bryum oenum* Blytt, *Bryum crispulum* Hagen (♀), *Timmia austriaca* Hedw., *Bartramia ityphylla* Brid., and *Lophozia bicrenata* (Schmidel) Dum.

3/VIII: *Racomitrium canescens* (Hedw.) Brid. (very common), *Polytrichum alpinum* L., *Polytrichum pilosum* Neck., *Tortula ruralis* (L.) Schwgr., *Pohlia cruda* (L.) Lindb., *Bryum ventricosum* Dicks., *Encalypta commutata* Br. Germ., *Grimmia apocarpa* (L.) Hedw., *Myurella julacea* (Willd.) Br. eur., and *Hypnum revolutum* (Mitten) Jaeger.

The Botanical Museum, Copenhagen.
11th June 1914.

$^{15}/_{9}$ 1915.

KBH. BIANCO LUNO

The

Structure and Biology

of

Arctic Flowering Plants.

II. 3.

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Hitherto, the following papers have been published in "Meddelelser om Grønland":

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Vol. XXXVII:

10.

Caprifoliaceae.

Linnaea borealis L.

By

O. Hagerup.

1915.

The present investigation is carried out with the aid of material from the herbaria belonging to the Botanical Museum at the University of Copenhagen; it is brought from many different localities by several investigators. Besides this, material from Denmark, preserved in spirit has also been used. All material from Greenland was dried, which has caused difficulties, especially as regards the leaf anatomy; some material was also collected by WARMING in Northern Scandinavia. *Linnaea* being a plant about which many investigations have been made and many papers written, especially GIGER's monograph, a more complete treatment is superfluous, and in this general statement it has only been necessary to mention the main points.

As regards the distribution of the plant the above named paper may be referred to.

As to the localities in Greenland in which *Linnaea* is found, the following are represented in the herbaria:

1. Præstefjeldet near Holsteinsborg, in a thicket of *Salix glauca*, *Empetrum* and *Vaccinium uliginosum*, collected by WARMING and TH. HOLM.
2. Ivnarsuak in Tasermiut Fjord, leg. F. BENJ. PETERSEN.
3. Ivigtut, leg. AUG. BERLIN.
4. Kvannit Sarok in Diskofjord (Lat. 69° 33′ N.), copiously flowering in the outskirts of willow thickets; leg. MORTEN P. PORSILD; this being the most northern locality in which *Linnaea* has been found in Greenland.

The following literature has been used (complete list of literature available is given in Gigers monograph).

Brenner, M., 1909: Några Linnaea-former i Finland (Medd. af Soc. pro fauna et flora Fennica, h. 34, p. 89—97 og h. 35, pag. 56).

Giger, Emil, 1913: Linnaea borealis L., eine monographische Studie (Beihefte zum Bot. Centralblatt, Band XXX, Zweite Abt.).

Gundersen, 1910: Recherches anatomique sur les Caprifoliacées (Thesè; Paris).

Leist, K., 1889: Über den Einfluss des alpinen Standortes auf die Ausbildung der Laubblätter. (Mittheil. d. Naturf. Gesellsch. v. Bern.)

Norman, J. M. 1895: Norges arktiske Flora, II, pag. 324. Kristiania.

Petersen, O. G., 1901: Diagnostisk Vedanatomi, pag. 93. København.

Poppius, B. R., 1903: Blombiologiska iakttagelser (Acta Soc. pro fauna et flora Fenn. 25, No. 1).

Schröter, C., 1904: Das Pflanzenleben d. Alpen, I. p. 235.

Sernander, R., 1891: Studier öfver skottbyggnaden hos Linnaea borealis L. (Bot. Notiser 1891, p. 225).

Silén, F., 1905: Blombiologiska iakttagelser i Kittilä Lappmark (Medd. af Soc. pro fauna et flora Fenn., h. 31, p. 88).

Sylvén, N., 1906: Om de svenska Dikotyledonernas första förstärkningsstadium; 1 (Kungl. Svenska Vetenskapsakademiens Handlingar, Band 40, No. 2, p. 65).

Wagner, A., 1892: Zur Kenntniss des Blattbaues d. Alpenpflanzen und dessen biol. Bedeutung. (Sitz. Ber. der Wien. Akad., math.-nat. Cl., p. 615, Bd. C 1, Abt. 1).

Wittrock, V. B., 1879: Om Linnaea borealis (Bot. Not. 1878, p. 17, 49, 83, 122 and 1879, p. 9, 137).

— 1907: Linnaea borealis (Acta Horti Bergiani, Bd. 4, No. 7).

Wydler, H., 1859: Morphologische Mittheilungen (Flora N. R. 17, p. 1).

Germination. According to the literature *Linnaea* seldom produces germinable seeds in Central Europe, while seeds from the North germinate within a few weeks. Wittrock has found a seedling grown under natural conditions. The further development of the seedling has been examined through cultures by Giger; the results are briefly as follows: the germinable power of the seeds lasts for at least three years, and the development of the seedling proceeds slowly, especially at first; during the second year the main axis, consisting of 2—4 internodes, inclines horizontally towards the ground, and becomes the rejuvenating runner, bearing buds, which, as described later, become fructification or assimilation shoots, respectively. In its third year the plant has reached its full development, consisting of a main root (which can live a few years), some adventitious roots, and two succesive long-shoots.

Morphology of the Stem. *Linnaea borealis* L. is an evergreen woody plant (not an undershrub) with a long, creeping main axis, sending off rootlets, and bearing two kinds of erect, short shoots, which according to their function may be called, respectively: assimilation and fructification shoots (WITTROCK).

The Rejuvenating Shoot. The rejuvenescence takes place by the terminal bud of the main axis yearly producing a creeping shoot, 6—45 centimeters long, consisting of 10—16 internodes, the individual length of which is lessened towards both ends of the shoot. WITTROCK mentions, that these shoots can reach an age of up to 13 years. The plant can quickly spread over large areas. The terminal bud is covered by rudimentary green leaves, which do not wither during the next period of growth, but on the contrary lengthen somewhat in their outer half, and act as organs of assimilation. As a rule all the leaves of these rejuvenating shoots support buds, which during the next period of growth develop into one of the three kinds of shoots. Generally however one of the two buds of a leaf-pair becomes a "dormant bud", while the other, distinguished by its greater size, develops into an

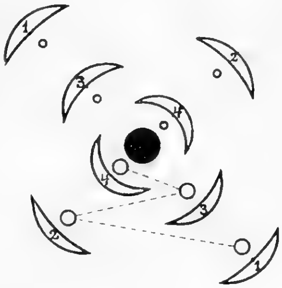

Fig. 1.

Diagram, showing the more vigorous buds (the larger circles) supported by the leaves placed on the underside of the rejuvenating shoot.

assimilation or fructification shoot. Through the twisting and turning of the petioles, the leaves apparently stand in two rows, whereas in reality they are placed crosswise opposite. It is always the leaves nearest the ground, which support the most vigorous bud, and as a consequence of this, the short-shoots are placed in a zig-zag line with an ascending base. Fig. 1 illustrates this, which disagrees with the general view, that the leaves have been placed in two rows by the twisting of the stem.

New rejuvenating shoots may appear by the development of older and younger buds from all three kinds of shoots, which enables the plant to spread in all directions (see GIGER).

The Assimilation Shoot develops, as already mentioned, from a side bud on the horizontal rejuvenating shoot. It is characterised by a short axis (4—6 cm high) with 4 or 6 internodes, and especially by a relatively great number of foliage leaves, which gain for it the name of assimilation shoot; besides these leaves, one or two pairs of scale leaves are present, which quickly wither. The axillary buds seldom develop; the rejuvenescence is, as in the rejuvenating shoot, monopodial; the terminal bud, covered by 1 or 2 pairs of scale leaves, develops during the following period of growth into a shoot similar to that of the previous year; this is continued for 3 or 4 years, when at last the shoot ceases its function. New assimilation shoots may also develop from older or younger side shoots or end shoots, of any of the other kinds of shoots (see GIGER).

The Fructification Shoot consists of two different parts, viz. a lower vegetative part, which is perennial, and an upper floral one, which is annual.

Of these the lower one is much like the just mentioned assimilation shoot, but differs by nearly always sending out adventitious roots from its ascending base. The shoot terminates in a floral part, which withers every year, and the rejuvenescence takes place by a vigorous bud, situated in the axis of one of the upper leaves, so that the fructification shoot, contrary to the two other forms of shoots, becomes a sympodium.

The floral part consists of a long thin internode, the terminal bud of which does not reach development under natural conditions. Below this point is a pair of bracts, each supporting a flower, the inflorescence thus being a two-flowered cyme. Just below each flower, three alternating pairs of bracts are found; the uppermost pair grows bigger as the fruit ripens, finally quite enclosing it. The whole of the floral part of the shoot is covered by glandular hairs, which have a many-celled head, and a long, two- or three-celled stalk. These hairs increase in numbers towards the upper end of the shoot; they are especially numerous on the uppermost pair of bracts, which (according to GIGER) produces additional glandular hairs towards the time of maturity; by means of their sticky secretion they are said to further the dispersal of the fruits by causing it to become attached to passing animals.

The Flower. A zygomorphy is often present both in calyx and corolla ; it varies however much, as does also the colour of the corolla ; both of these peculiarities have been closely studied by WITTROCK (1907), to whose work reference is made. The flowers have a pleasant, strong scent of vanilla, and on the innerside of the corolla, at the base of the lowermost petal, is a nectarium partly covered by long hairs. The secreted fluid shows distinct sugar reaction.

The anthers are didynamous and develop simultaneously with the stigma (according to WARMING). The list of the visiting insects (GIGER) shows a comparatively great number of *Diptera*, honeyseekers with short proboscis, which without any difficulty can enter the corolla by reason of its large opening. Besides, visits by *Lepidoptera* and *Hymenoptera* have been observed. The ovary is trilocular, two compartments containing several ovules which do not develop, while the third contains one only, which however is fit for development.

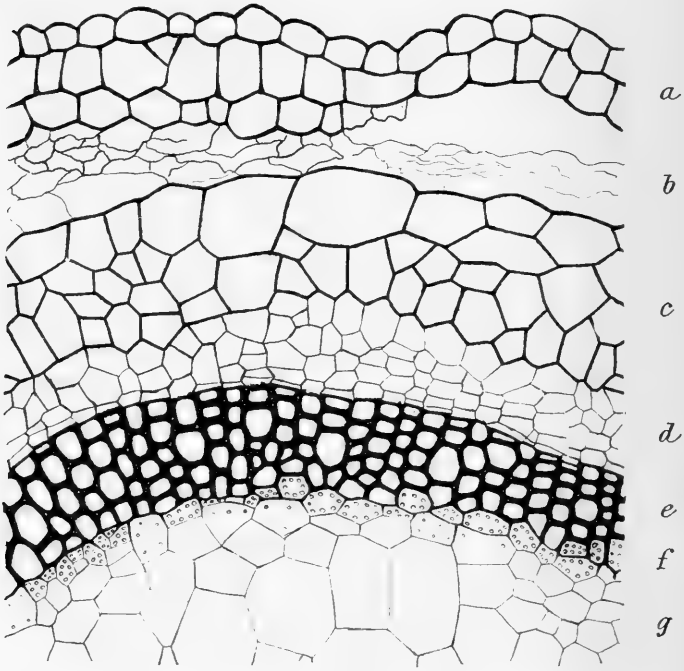

Fig. 2. Transverse section of the rejuvenating shoot (material from Greenland).

Compared with material from Denmark, the Arctic *Linnaea* has a compact growth, owing to shorter internodes; this mode of growth causes the deviating habitus, peculiar to many Arctic plants.

Anatomy of the Stem. The bark and the wood together only amount to half the diameter of the stem, the pith being relatively strongly developed. The bark passes through peculiar phases of development. The epidermis and hypodermis (Fig. 2*a*) start to fall off in the 3rd year, through the destruction of the underlying 2—3 layers of cells (Fig. 2*b*); the protective function of the former is then taken up by the 1—(5) layers of large bark cells (Fig. 2*c*) underneath, the walls of which become woody. During the 4th year however, this protecting layer is also partly thrown off, owing to the cells immediately underneath being similarly destroyed; the outer cells then form a third protective layer by a strongly developed formation of cork.

The diameter of the stem is about the same all over, as the growth in thickness keeps pace with the decrease in diameter, caused by the falling off of the several layers of bark. Under the bark is the cambium (Fig. 2*d*) and under this the wood (Fig. 2*e*), which yearly grows a little in thickness and shows annual rings. The wood consists of vascular tissues, tracheids, libriform-cells, wood-parenchyma and medullary rays.

The original transverse walls have the appearance, even in the fully developed vessels, of a grate, consisting of very thin, parallel staffs. The vessels lie scattered in the wood, but not in such great numbers as the tracheids; all kinds of transitions to these latter are however found, and the circular or oblong pores have the same trabeculate arrangement.

The greater part of the wood consists of tracheids; libriform-cells and wood-parenchyma are rarely met with, and are of quite subordinate importance. Between the pith (Fig. 2*g*) and the wood are found a few layers of cells, which both in shape and position form the transition between the medullary cells and the tracheids; as the figure shows, their walls have circular pores (Fig. 2*f*).

The numerous medullary rays consist of 4—8 radiant rows of cells placed vertically above each other; they are always well filled with starch, which can however also be the case with the cells of the living bark.

Short- and long-shoots have in the main the same anatomic structure.

The Leaf. Its duration is from 2 to 3 years; in shape it varies somewhat, most often it is ovate, but elliptical-round or nearly kidney-shaped leaves are also found. As a rule 2 faint incisions are to be seen on each side of the leaf, but some variations are also found in this respect; it is pinnately veined. Scattered hairs are present, of the same type as those on the stem; on the lower surface of the leaves are some glandular hairs, with a short one-celled stalk and a many-celled head, which secretes a sticky substance in which fungus spores are often caught and germinate.

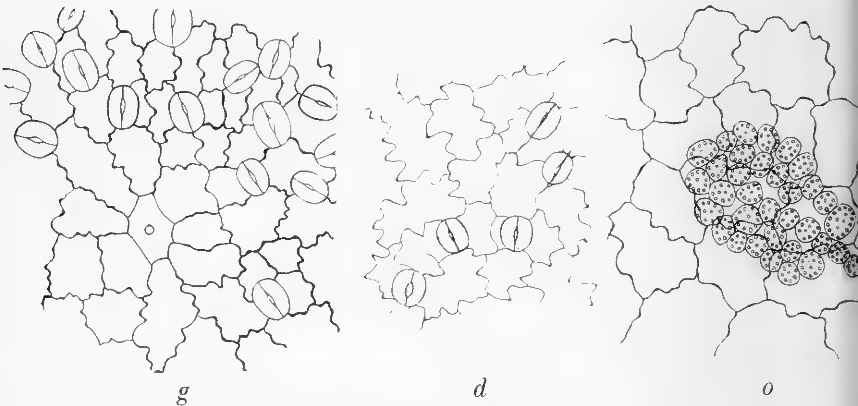

Fig. 3. The leaf.

Epidermis: *g*, lower surface (material from Greenland); *d*, lower surface, *o*, upper surface, with palisade cells added (material from Denmark).

The mesophyll shows that the leaf is a typical shade-leaf, in conformity with its usual habitat (Fig. 4).

The epidermis contains chorophyll; the cells are largest on the upper surface (Fig. 3).

The perpendicular walls are undulating with thickened outer ends (Fig. 4). This was especially pronounced on the material from Greenland, where the walls also were thicker. The stomata, which are only found on the lower surface, are somewhat projecting, oval, and of the usual structure (Fig. 3).

The following table shows the average number of stomata on $^1/_{10}$ mm^2 of 6 leaves from Denmark compared with 6 from Greenland:

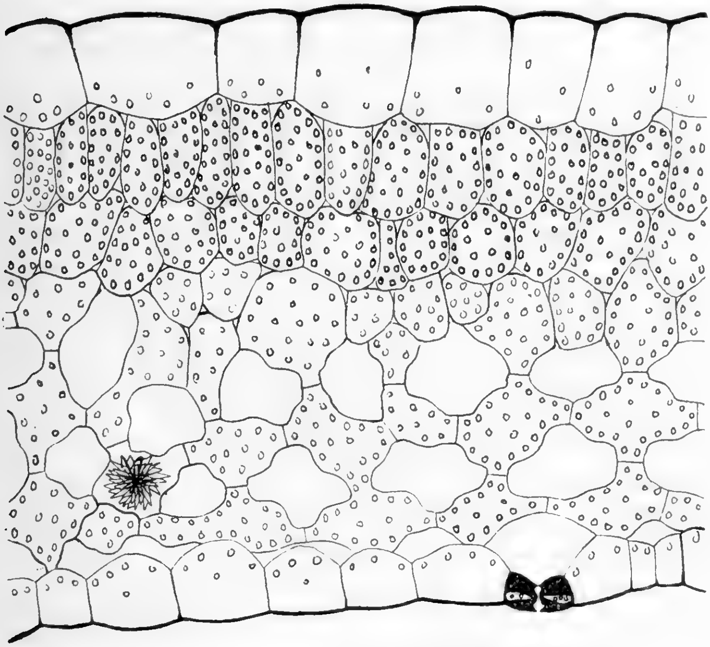

Fig. 4. Transverse section of leaf (from Denmark).

Leaf	1	2	3	4	5	6	pr. mm^2
Danish . .	49	39	51	45	39	55	463
Arctic . . .	40	44	47	40	48	45	440

On 1 mm^2 the average was about 450 stomata.

The undulation of the perpendicular cell walls of the epidermis is still more pronounced on the lower surface of the leaf than on the upper surface. Besides, the material from Greenland also showed a thickening, and larger undulations of the perpendicular epidermis walls, on the lower surface, than was the case with leaves from Denmark. The cell (see Fig. 3 *g*), which carries a glandular hair, has however straight cell walls, and the spongy tissue underneath is without intercellular spaces. The mesophyll has a pretty, regular structure rich in intercellular spaces, especially so in the spongy tissue, but also in the palisade tissue (Fig. 4).

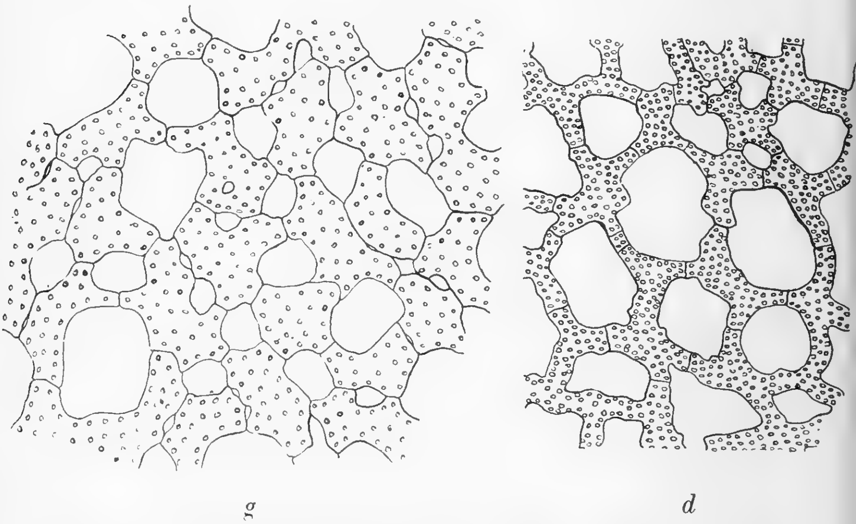

Fig. 5. The lowermost layer of spongy tissue, viewed from above; *g*, from Greenland; *d*, from Denmark.

The leaves from Denmark had, with scarcely any exception, one layer of short, broad palisade cells only, while those from Greenland had two; further, the spongy tissue of the Danish leaves had throughout a looser structure than those from the Arctic.

These relations are the opposite to what has been found by examination of other Arctic plants with regard to leaf-structure; the explanation is probably, that *Linnaea* in Greenland grows on open heaths, and consequently is not, as the Danish plant, a typical shade-plant.

The spongy tissue, generally consisting of three layers, is connected with the palisade cells by a layer of collecting cells.

The leaves from Greenland are, as is generally the case, of a smaller size than those from outside the Arctic zone.

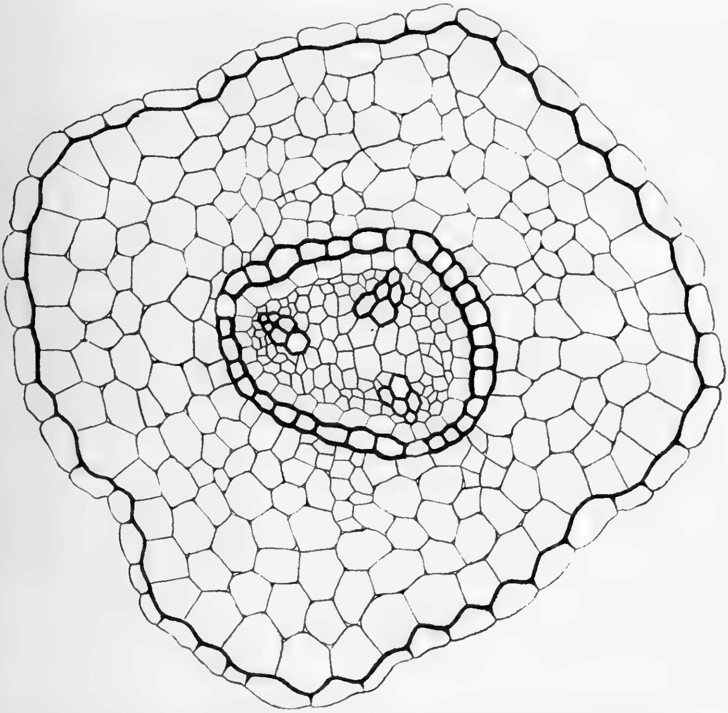

Fig. 6. Transverse section of triarch root (from Greenland).

The Root (Fig. 6). The primary root dies quickly and is replaced by the fairly numerous adventitious roots, which sprout from nodes on the rejuvenating and fructificating shoots, and ramify freely in the ground; this latter generally contains many decaying plant tissues, why mycorrhiza formations might be expected on the roots, but such have not yet been found. The epidermis of the root has thickened inner walls; the outer walls however are thin and, together with the root-hairs, decay during the second year. The exodermis, with the remainder of the epidermis, thus becomes the outermost layer; its cell walls are slightly thickened. Underneath is the starch-carrying bark, which occasionally exceeds several times in thickness the diameter of the central cylinder. Towards the centre, the bark adjoins an endodermis, the cells of which has thickened walls, those of the passage cells excepted. During the fourth year the whole of the bark is forced off, and the pericambium becomes phellogen, which forms a cork, consisting of about 10 cell layers (GIGER). The central cylinder is diarch to pentarch, and outermost is a distinctly bounded pericycle. Wood, to fill the central cylinder, is quickly formed; its anatomic structure is practically identical with that of the stem, and shows distinctly annual rings.

Summary.

When compared with material from Denmark, *Linnaea* from Greenland is distinguished by the following characteristics:

The stem has shorter internodes, giving the plant a more compact appearance.

The leaves are smaller with slighter incisions, and the perpendicular walls of the epidermis cells are thicker and have more pronounced undulations.

The mesophyll has smaller intercellular spaces and larger palisade tissues.

The Structure and Biology of Arctic Flowering Plants.

II. 4.

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1. Ericineæ (Ericaceæ, Pirolaceæ).
  1. Morphology and Biology. By Eug. Warming . . p. 1—71.
  2. The Biological Anatomy of the Leaves and of the Stems. By Henning Eiler Petersen . . . . p. 73—138.
2. Diapensiaceæ. Diapensia lapponica L. By Henning Eiler Petersen . . . . p. 139—154.
3. Empetraceæ. Empetrum nigrum L. By A. Mentz p. 155—167.
4. Saxifragaceæ.
  1. Morphology and Biology. By Eug. Warming . . p. 169—236.
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5. Hippuridaceæ, Halorrhagidaceæ and Callitrichaceæ. By Agnete Seidelin . . . . p. 295—332.
6. Ranunculaceæ. By Knud Jessen . . . . p. 333—440.
7. Lentibulariaceæ (Pinguicula). By Fr. Heide . . . . p. 441—481.

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8. Rosaceæ. By Knud Jessen . . . . p. 1—126.
9. Cornaceæ. By Carsten Olsen . . . . p. 127—150.
10. Caprifoliaceae. Linnaea borealis L. By O. Hagerup p. 151—164.

11.

Primulaceae.

By

Fr. J. Mathiesen.

1916.

For this work, entrusted to me, the necessary material has kindly been placed at my disposal by the Botanical Museum of the University in Copenhagen and by the Riksmuseum in Stockholm. I have throughout had the kind advice and guidance of Professor E. Warming, and wish to tender my hearty thanks for his great kindness and courtesy. I am also greatly indebted to Dr. C. H. Ostenfeld, Inspector at the Botanical Museum, for the willing help extended to me on several occasions.

With the exception of figs. 6 A—I and 10, which were placed at my disposal by Prof. Warming, all the others have been prepared by me. The anatomical sketches were drawn with the help of Abbe's drawing-apparatus and reduced to half-size when reproduced. The lens-combination used in drawing is given in the text for each figure, one index is the number of the Zeiss apochromatic, the other that of the compensation-eyepiece.

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— 1886 a: Om nogle arktiske Væxters Biologi. (Bihang till Kgl. Sv. Vet. Akad. Handl., Bd. 12, Afd. III.)

— 1886 b: Om Bygningen og den formodede Bestøvningsmaade af nogle grønlandske Blomster. (Oversigt over D. K. Danske Videnskabernes Selskabs Forhandlinger.)

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Primula egaliksensis Wormskj.

Lit.: Flora Danica, t. 1511. Lange, 1880, p. 71; 1887, p. 260. Warming, 1886 a, p. 24. Widmer, 1891, p. 119. Rosenvinge, 1892, p. 684. Børgesen, 1895, pp. 223, 225, 236, 237. Pax and Knuth, 1905, p. 77.

Herbarium and alcohol material from South-West Greenland collected by J. Vahl (1828), Rosenvinge (1888), Meldorph (1900), and Deichmann (1906). Also, as alcohol material, seedlings from seeds collected in Greenland, and grown in the Botanical Garden at Copenhagen (one of these is illustrated in fig. 1, a).

A perennial herb of the common Primula type (Warming 1884, pp. 33, 37 and 38; Pax in Englers bot. Jahrbücher, 1889). The vertical rhizome is very short, since the lower end dies away from year to year; it is richly covered with adventitious roots, the duration of which must also be about a year. New adventitious roots had already appeared on specimens (gathered in July) where the buds, which continue the growth of the rhizome, had as yet only developed one pair of foliage leaves. The young roots were comparatively thick at their base (1.5—2 mm), and the cortical cells were full of starch. On the other hand, the roots of the preceding summer had already begun to decay and were completely emptied of starch.

The leaves are arranged in a $\frac{2}{5}$ spiral. They vary somewhat in form and size, but with no apparent regularity in the variations, either as to arrangement or stage of development. The principal bud is placed in the axil of the uppermost foliage leaf, and, as mentioned, it had already developed several foliage leaves by the middle of the summer; as the result of further increases during the summer, a rosette of 6—8 leaves is formed. The growth of the bud ceases temporarily during the autumn, some of the leaves remaining as scale-leaves, to form a protective covering for the younger growth, which next spring will develop into ordinary foliage-leaves. These scale-leaves may be found at the base of the spring-rosette as late as July, but only in a very damaged state. Unfortunately, I had at my disposal no buds gathered during the winter, but it is probable that the bud-scales contain starch, as is the case with kindred species.

Fig. 1. *Primula egaliksensis.* *a*, Seedling from the Botanical Garden, Copenhagen, ($^3/_1$). *b*, Young plant from Igaliko ($^{27}/_7$ 1888); *x*, the two first leaves of the autumnal rosette (about $^2/_1$).

The principal bud has sometimes been found to develop its peduncle during the same year as the parent shoot, and this even on plants showing relatively poor development, so that the plant may have two inflorescences flowering about the same time. Vegetative augmentation-shoots may be formed by small leaf-rosettes developed from some of the microscopic buds, found in the axils of many of the foliage leaves (Widmer, p. 10).

I have not been able to prove the presence of dimorphic flowers in this species (see E. Warming 1886 a, p. 24). The length of the style varies only slightly, the majority of the flowers examined showing the stigma placed as in fig. 2, *a*. Self-pollination may occur, as the pollen and the stigma in the same flower seem to be fully developed at the same time. In *Flora Danica* the stigma is figured as extending a trifle above the anthers. The corolla is 5—8 mm. in diameter, the colour being white, with a yellowish ring in the throat. (Fig 2.)

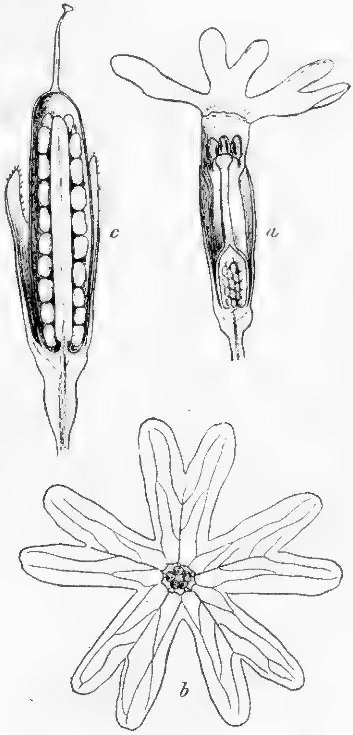

Fig. 2. *Primula egaliksensis.*
a, Longitudinal section of a flower, the stigma is seen level with the base of the anthers, ($^5/_1$). *b*, The coro'la-limb of a somewhat larger flower: in the throat the anthers are seen, ($^5/_1$). *c*, Longitudinal section of a ripe fruit, (about $^6/_1$). (Igaliko, $^{27}/_7$ 1888.)

The peduncle increases in length after flowering, as in the case of *Pr. stricta.*

Anatomy. A transverse section of the young primary root (fig. 3, *A*) shows the central cylinder to be very thin, only $\frac{1}{5}$ of the diameter of the root; the fourth layer of the cortex seems to be in process of formation. The primary root is diarch. Fig. 3, *B*, shows the central cylinder with the endodermis of a very young adventitious root. The cells of the cortex are filled with starch, except the outermost layer, which functions as an exodermis; this is also the case in the primary root. As the root gets older, the vessels increase in number, the epidermis dies away, after which the cortical cells become emptied of starch and finally perish. Crystals of a calcium salt, single as well as aggregate, are found in the bark, especially in the exodermis of the older roots.

The Rhizome. A transverse section through the lower part of this shows the severed adventitious roots and the vascular strands of the leaves, also a central group of 2—4 vascular bundles. Towards the upper end of the rhizome, where this passes over into the terminal peduncle, the number of the vascular bundles increases, but with a reduction in the size of each bundle, and at the same time several layers of the surrounding parenchyma develop into a continous sclerenchymaring. The vascular bundles differ from the normal and approximate to the hadro-centric type with sieve-tissue closing more or less distinctly round the inner side of the bundle; exceptions to this are seen in the bundles at the

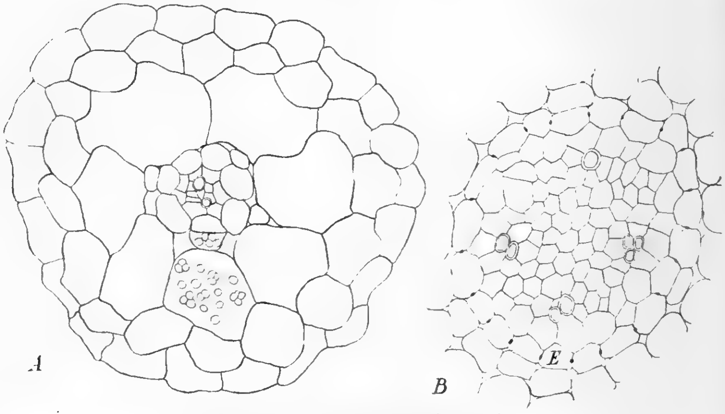

Fig. 3. *Primula egaliksensis.*

A, Tranverse section of the primary root (Seedling from the Botanical Garden, Copenhagen); (Obj. 4, Oc. 4). *B*, Transverse section of a young adventitious root, showing the central cylinder and the inner layers of the primary cortex; *E*, Endodermis with Casparian spots; (Obj. 4, Oc. 6). (Igaliko.)

apex of the rhizome which are always distinctly collateral. These bundles („steles”, v. Tieghem) are surrounded by sheaths having Casparian spots on the radial walls, and vary in shape from circular to oblong-arched. The walls of the parenchyma show pores, and its cells contained some starch (at end of July). In the proximity of the vascular bundles, the elements of the parenchyma are often arranged in fairly regular radial rows.

The Peduncle is provided with a 4—6-layered sclerenchyma-ring, which however is reduced to 3—4 layers opposite each of the vascular bundles; these latter are arranged in a regular circle. In a longitudinal section this sclerenchyma-ring appears to consist of elongated, cylindrical parenchymatous cells, densely and finely pored and with lignified walls. On the inner side of the ring, the sclerenchymatous tissue closely surrounds the leptome of the vascular bundles, thus affording some degree of protection. In the stereom, as well as in the medulla, near the vascular bundles, there are cells containing a brown substance, the nature of which, however, could not be further determined. Outside the sclerenchyma-ring the peduncle shows 4—6 layers of parenchymatous cells, lengthened axially and with large intercellular spaces communicating with the atmosphere through numerous stomates in the epidermis. Numerous chlorophyll granules are present in this parenchyma.

The pedicels attain a thickness of about 0.75 mm, and have on the whole the same anatomical structure as the peduncle.

The Leaf. The epidermal cells on the upper surface are larger and have thicker walls than those on the lower surface (fig. 4). The lateral walls are undulating, more so on the lower surface of the leaf. The outer walls show fine cuticular striations, especially near the margin of the leaf and above the midrib. The stomates are level with the surface or slightly protruding; they are surrounded by 4 to 6 cells, most often 5. BØRGESEN states that the number of stomates is nearly equal on the upper and lower surfaces of the leaf, but such is not the case in the specimens of *Pr. egaliksensis* examined by me where the number of stomates was always greater on the lower surface.

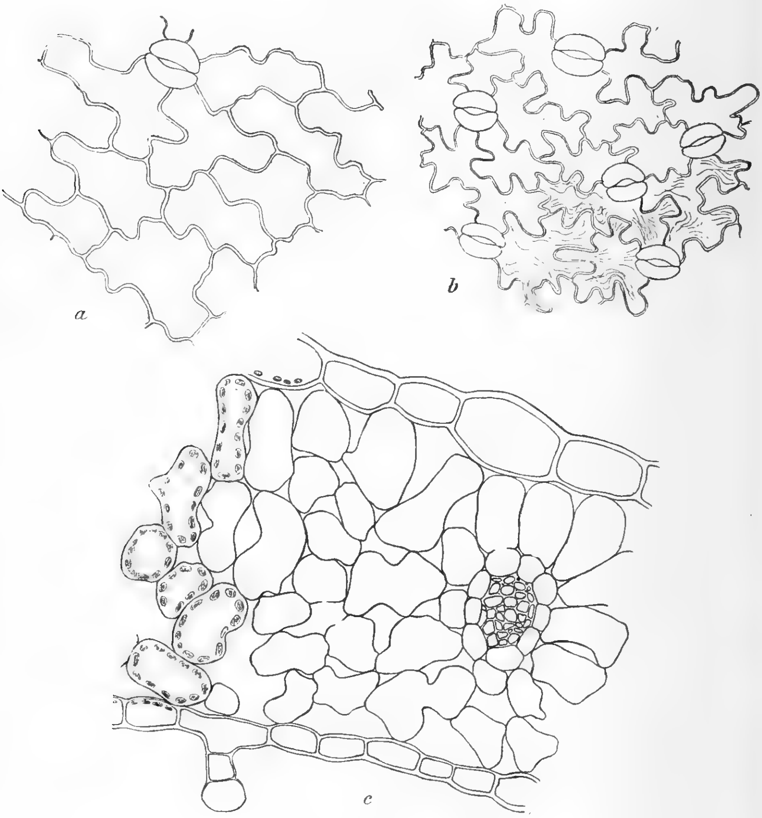

Fig. 4. *Primula egaliksensis.*
a, The epidermis from the upper surface of the leaf. *b*, The epidermis from the lower surface of the leaf. (*a* and *b*, Obj. 4, Oc. 4). *c*, Transverse section of the leaf; on the lower surface a glandular hair; (Obj. 4, Oc. 6). (Igaliko.)

The mesophyll (fig. 4, *c*) has a very lacunar structure, and palisade cells are scarcely distinguishable, though the elements of the uppermost layer above the veins, are more elongated and cylindrical; the lower layers consist of slightly ramified cells. The whole of the mesophyll is rich in chlorophyll granules, which are also found in the epidermis of the lower surface.

Hydathodes are present on the leaf-margin, opposite the stronger veins. Small glandular hairs, with a one-celled head on a one-celled stalk are found on both surfaces of the leaf, but only in small numbers. (Fig. 4, *c*.)

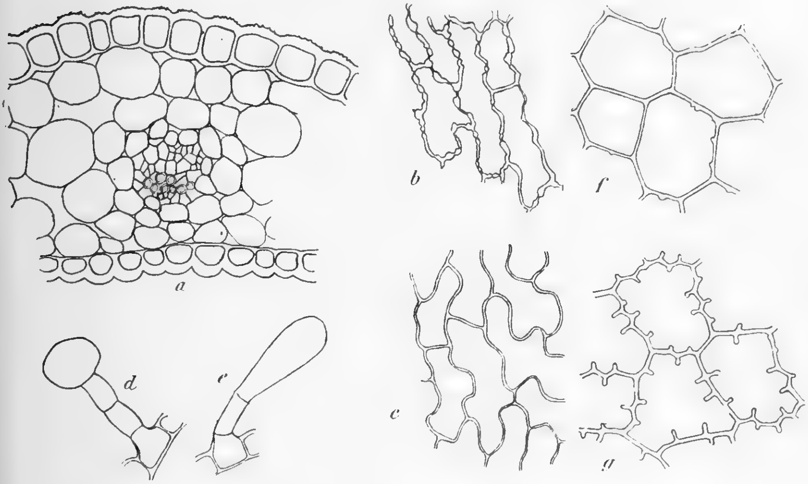

Fig. 5. *Primula egaliksensis.*

a, Transverse section of the calyx near its base. *b*, The epidermis from the inner surface of the calyx. *c*, The epidermis from the outer surface of the calyx (the apex of the lobes). (*a*, *b* and *c*, Obj. 4, Oc. 4). *d* and *e*, Forms of hairs from the margin of the calyx-lobes; (Obj. 4, Oc. 6). *f*, The epidermis from the upper surface of the corolla-limb. *g*, The epidermis from the lower surface of the corolla-limb; (Obj. 3, Oc. 12). (Igaliko.)

The Flower. The epidermis on the inner surface of the calyx, near its base, shows strongly thickened and arched cupola-like outer walls, the lateral walls being undulating and with irregular pores (fig. 5, *a* and *b*). Towards the apex the epidermal cells have more resemblance to those of the outer surface (fig. 5, *c*). Stomates appear fairly frequently on the outer surface of the calyx, being most numerous in the somewhat depressed areas between the 5 chief veins; here the outer epidermal walls show fine cuticular striations. The margins of the calyx-lobes are covered with glandular hairs, the form of which is illustrated (fig. 5, *d* and *e*); the globular or club-shaped head is always filled with a brown substance. The cells of the mesophyll are somewhat axially elongated and are amply provided with chlorophyll granules, which also occur in the epidermis of the outer surface. There is a distinct difference between the epidermal cells on the upper and lower surface of the limb of the corolla. The outer walls of the upper side are strongly arched and papillose, with cuticular striations radiating from the top of each papilla. In the throat these papillae become very large, and their contents have here a strong brown colour. On the lower surface of the limb of the corolla, the epidermal cells are somewhat cupola-shaped, the lateral walls being provided with ridges at right angles to the outer walls (fig. 5, *g*). Similar ridges are also present in the epidermis of the upper surface, but much less pronounced in character, especially near the throat (fig. 5, *f*).

Primula sibirica Jacq.

Lit.: Flora Danica, t. 188 and t. 1809. Warming, 1886 a, pp. 25, 26, 27; 1886 b, p. 21. Widmer, 1891, p. 119. Decrock, 1901, p. 98. Pax and Knuth, 1905, pp. 76, 77. Blytt, 1906, p. 569.

Alcohol material, collected by E. Warming, from Norway, 1885 (Alten, Bosekop and Kåfjord). Herbarium material from the same places and also from Hammersfest (Vahl), the shores of the White Sea (Ångström 1843), Lapponia Imandrae (Brotherus, 1885) and Kola (Brotherus, 1889).

The following observations were made in addition to what is stated by Warming and Widmer as regards the morphology of *Primula sibirica*:

The leaves in the rosette appear to be arranged in a $\frac{3}{8}$ spiral, as is the case with *Pr. egaliksensis*, but 3—5 of the embryonic leaves of the rejuvenation bud are developed as foliage-leaves during the summer. The succeeding leaves remain as scale-leaves, forming a protection for the young tissues of the bud, which in the following spring will develop into foliage-leaves, and terminate in the formation of the peduncle.

The duration of the adventitious roots is similar to that of the preceding species.

Apparently *Pr. sibirica* never developes more than one peduncle during one period of growth; at least, I have seen no specimens, which show indications of the autumnal rosette developing its peduncle during the same year as the parent-shoot.

The peduncle bears only a few flowers, and frequently only one of these attains to full development. But two subtending leaves at least are always present, and in the axil of the one which apparently bears no flower there is a microscopic rudiment of a flower-bud (fig. 6, *J*). Amongst the plants from Bosekop a few specimens were found to have four-partite flowers. The diameter of the limb of the corolla varies from 10—15 mm; the colour is a light lilac (Blytt), but according to Warming (1886 b) there is a white variety at Alten.

The biology of flower has been fully dealt with by E. Warming (1886, a, p. 27), who states as follows: "As regards the specimens from Alten, the following observations have been made: Normally developed, they are distinctly heterostylous, the figures showing the differences. According to my experience, the forms illustrated in fig. 8 (here reproduced as fig. 6) *C* and *D*, must be looked upon as the most common forms. In the long-styled flower the stigma is just in the mouth of the tube, level with the dark-yellow, wavy ring, which is present in this species as well as in *Pr. stricta* and other species. The very same differences known in other heterostylous species are again met with here. The stigma of the short-styled flower is smaller, with smaller papillae, but the pollen-grains are larger (see fig. C^1). On the

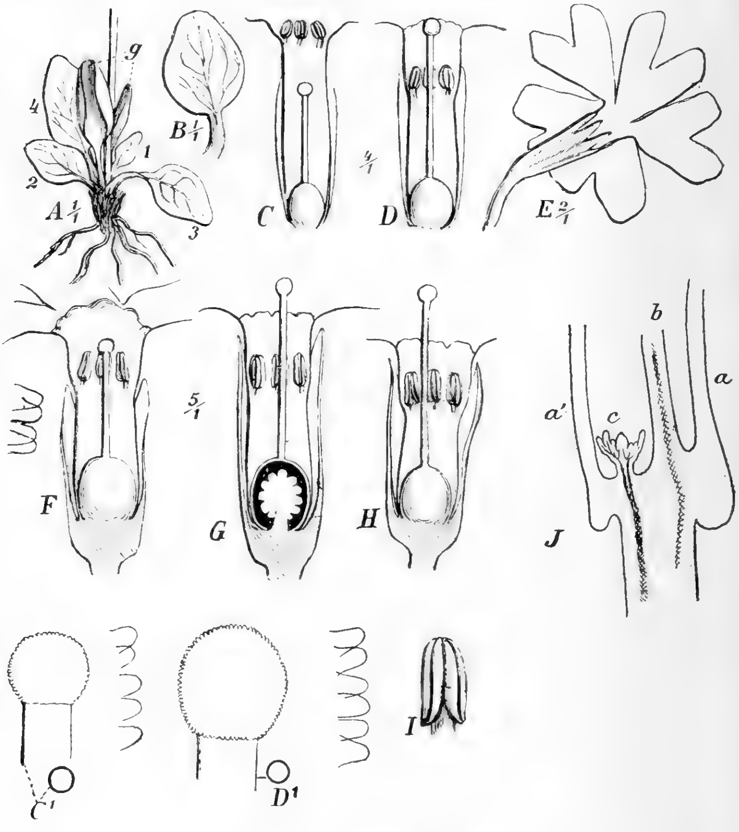

Fig. 6. *Primula sibirica.*

A, Base of plant in bloom, the foliage-leaves are marked in their order from below upwards, *1, 2, 3, 4*; the uppermost, *4*, subtends the main bud, which has already developed *2* foliage-leaves (*g*). *B*, a foliage-leaf. *C*, short-styled flower. *D*, long-styled flower. C_1 and D^1, the corresponding stigmas, pollen-grains and stigma-papillae, in the same size, respectively. *E*, a long-styled flower, seen from behind. *F*, the stigma level with the distal parts of the anthers; the stigma papillae are illustrated to the left. *G*, a long-styled flower with much protruding style. *H*, a similar one, with still longer style. *I*, anther. *J*, longitudinal section through the distal part of the peduncle ($^{10}/_1$); *a* and *a'*, 2 subtending leaves; *b*, pedicel; *c*, a rudiment of the second flower. (Alten Fjord, Norway). (*A—I* from Warming 1886.)

other hand the stigma is larger in the long-styled species, the papillae are also larger, but the pollen-grains smaller (D^1).

Flowers are, however, also found, which have a relatively much larger pistil, with a stigma reaching above the limb of the corolla, for instance fig. *G*; I found the most protruding style in the flower illustrated in fig. *H*; the pistil is of about the same length as the one in fig. *G*, but the corolla tube is noticeably shorter, causing a larger portion of the style to protrude; the anthers in fig. *H* were not yet open. I have, however, never met with a short-styled flower, the anthers of which corresponded in height with a stigma protruding to such extent. Finally, I have seen a plant at Kåfjord, with anthers and stigma at about the same level, as illustrated in fig. *F*; the calyx was here unusually short; the stigma was level with the tip of the anthers, showing its greater part above these; the anthers were open and full of pollen, and germinated pollen was found on the stigma. This was large and its papillae were in size just between those in the common long- and short-styled flowers (see fig. *F*, to

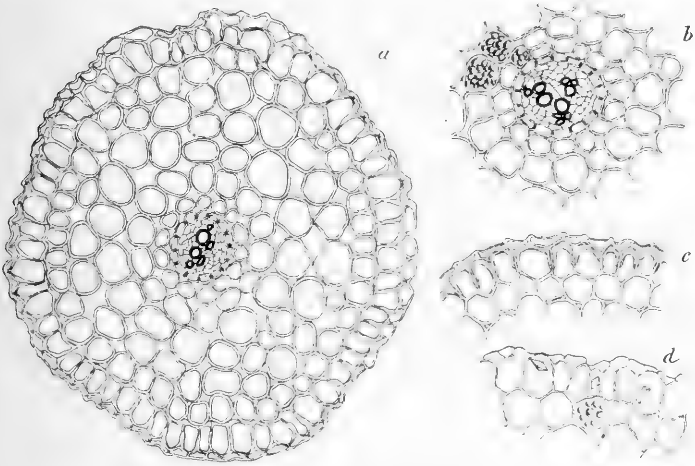

Fig. 7. *Primula sibirica.*

a, transverse section of a thin adventitious root. *b*, central cylinder with adjoining parenchyma of a 3-rayed adventitious root, some cortical cells showing contents of starch (*a* and *b*, obj. 8, oc. 6). *c*, the outer layers of the same root, greater enlargement (obj. 4, oc. 4); the section taken near the apex of the root. *d*, the epidermis and outer layers of the cortex of a root from the previous year (obj. 4, oc. 4). (Alten Fjord, Norway.)

the left). This specimen was manifestly a self-pollinator, but this species is, on the whole, as eminently suited for cross-fertilization as our large flowered and dimorphic species."

Anatomy. Two-rayed adventitious roots occur (fig. 7, *a*), but the most common number of rays is 3 or 4.. The epidermal cells perish quickly, but their outer, and especially their lateral walls are fairly resistant, so that well-preserved remains of the original outer layer may be seen even in older roots. On juvenile roots, the cortical cells have somewhat thickened walls (according to Decrock, a rather common feature of *Primula* species). Strong thickenings are especially noticeable on the outer and, in some measure, also on the lateral walls of the layer of cells, directly under the epidermis (fig. 7, *a* and *c*). These thickenings, consisting of cellulose, had disappeared in the root of the preceding year (fig. 7, *d*). The cells in the outermost layer of the primary cortex fit closely together and in close contact with the epidermis, their walls becoming somewhat cutinised with age. The young roots contain some starch in their cortical parenchyma. In the roots of the preceding year the starch was almost exhausted, probably during the spring growth, but I have found small single crystals of a calcium salt, especially in the exodermis (fig. *d*).

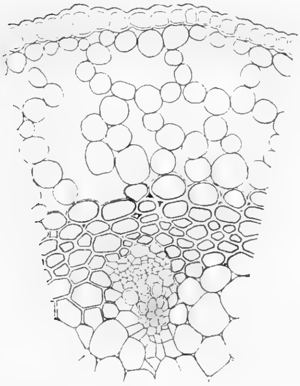

Fig. 8. *Primula sibirica.* Transverse section of a peduncle; the sector shows a vascular strand, stereome and assimilation-tissue, together with epidermis (obj. 4, oc. 4). (Alten Fjord, Norway.)

The rhizome has in all essentials the same structure as in *Pr. egaliksensis*, but both *Pr. sibirica* and the following species are characterized by having sclereids, singly or in small groups, in the medulla of the rhizome.

The transverse section of a peduncle (fig. 8) shows a structure somewhat less resistant than in the case of *Pr. egaliksensis* and *Pr. stricta.* The assimilation tissue is more lacunar, and the stereome is provided with larger and less thick-walled elements. Chlorophyll granules are present also in the epidermis.

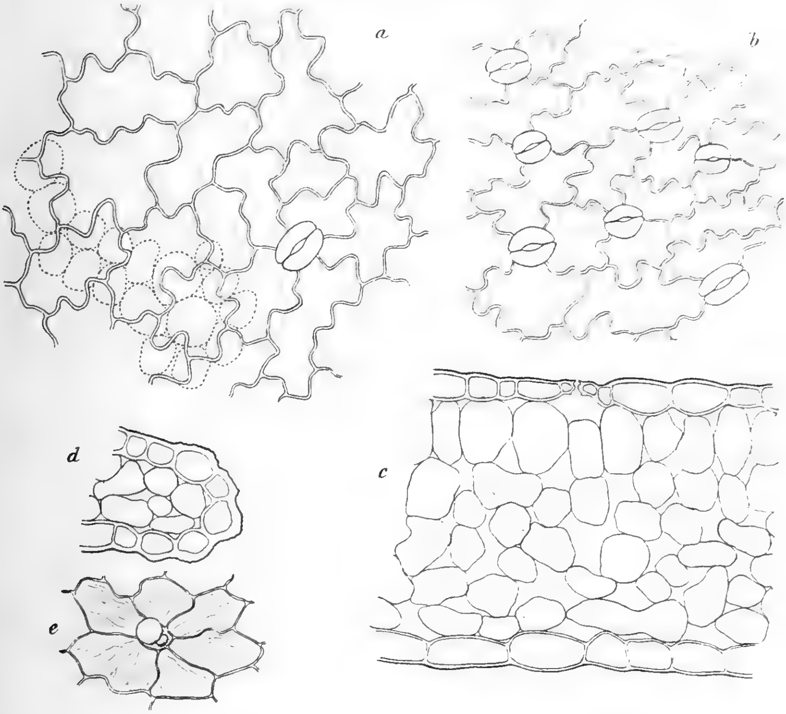

Fig. 9. *Primula sibirica.*

a, the epidermis of the upper surface of the leaf. *b*, the epidermis of the lower surface of the leaf. *c*, transverse section of the leaf. *d*, transverse section of the margin of the leaf. *e*, glandular hair from the upper surface of the leaf; the outer walls of the surrounding epidermis cells, with fine cuticular striations. (*a*, *b*, *c*, and *d*, obj. 4, oc. 4.) (Alten Fjord, Norway.)

The Leaf. The lateral walls of the epidermis on the upper surface show faint undulations, those of the lower surface being somewhat more pronounced (fig. 9, *a* and *b*). The outer walls are provided with fine cuticular striations (fig. 9, *e*) which are more strongly marked towards the margin of the leaf where the outer epidermal walls become thicker (fig. 9, *d*). Both surfaces of the leaf are provided with stomates, the lower having by far the greater number; these are level with, or slightly raised above the surface, and are surrounded by 4—6, most frequently 5, cells. Glandular hairs of the usual Primula type are distributed fairly regularly, though very scantily, over the whole surface. A palisade layer is hardly distinguishable, though the cells of the corresponding layer are almost barrel-shaped (fig. 9, *c*). The mesophyll is, on the whole, very loose in structure, its bottom layer consisting slightly branched cells. It is amply provided with chlorophyll granules, and these are also found in the epidermis of both surfaces, although only scantily in that of the upper surface. Hydathodes are present on the leaf-margin opposite the stronger veins.

As in the case of the vegetative parts, the floral organs of *Pr. sibirica* differ only slightly from the corresponding parts of *Pr. egaliksensis*. The difference is limited to the less thickened outer and, especially, lateral walls of the epidermis on the inner side of the calyx (compare *Pr. egaliksensis* in fig. 5, *a*, *b* and *c*). The hairs, most often present on the margin of the sepals, are those with club-shaped heads.

Primula stricta Hornem.

Lit.: Flora Danica, t. 1385. Warming, 1886 a, p. 21 and the following; 1886 b, p. 7. Lindman, 1887, pp. 28, 77. Widmer, 1891, p. 122. Børgesen, 1895, pp. 223, 225, 229, 236, 237. Ekstam, 1897, pp. 166, 167. Pax and Knuth, 1905, p. 86. Sylvén, 1905, p. 125. Blytt, 1906, p. 568.

Alcohol material from the north of Norway (Bosekop near Alten Fjord, Kåfjord), collected by E. Warming, June 1885. Herbarium material from the same places, and also from Iceland (Restara, 1894, St. Stefansson) and Lapponia Imandrae (A. O. Kihlmann, 1892).

According to Sylvén, *Pr. stricta* shows, during its first stage of vegetative development, a great resemblance to the closely allied species *Pr. farinosa* and *Pr. scotica*. These latter develop during the first summer a fairly dense rosette, and numerous adventitious roots arise from the base of the leaves, whereas the ramification of the main root is poor. The hibernation is effected by a winter-bud.

In the case of this species, it is not uncommon to find the same rhizome bearing several inflorescences during the summer. The rejuvenation shoot in the axil of the uppermost foliage leaf, as well as the augmentation shoots from buds in the axils of the lower leaves of the rhizome, are able to reach the flowering stage simultaneous with, or somewhat later than, the parent shoot.

The colour of the corolla is lilac with a yellowish throat-ring, the diameter of the limb being from 5—8 mm. EKSTAM (p. 116) describes *Pr. stricta* as being scented, and states (p. 167): "während nur zwei, *Polemonium pulchellum* und *Pr. stricta* (mit starkem, unangenehmen Geruch, nach Kjellman), einen unangenehmen Geruch haben". LINDMAN ascribes to *Pr. stricta* "mycket stark, frän lukt, lik den af orchisknölarna".

The morphology of the flower has been described by WARMING (1886 a), and from this the following is quoted. "The Norwegian specimens (the author is comparing the details of *Pr. stricta* Hornem. with those of *Pr. stricta* var. *groenlandica* Warm. = *Pr. farinosa* var. *δ. groenlandica* (Warm.) Pax) are slightly protrandrous or perhaps sometimes homogamous. The anthers open very early and, as far as I have been able to see, most often somewhat before the stigma is fully ripe. Amongst the very numerous Scandinavian flowers, examined by me, I have found, but only in very few cases, the stigma in the precise relative position as in those from Greenland; the rule is, that the stigma protrudes more than in the latter; in some instances the stigma is found level with the tip of the anthers (fig. 10, *E*), while in others it is as much as 1 mm. above them (fig. *I*).

In the first case self-pollination may yet be possible and comparatively easy, while in the latter, it is rendered very difficult, or well nigh impossible, the flower being in an erect position all through. This greater length of the style is not caused by growth during flowering, as, in all the many specimens of buds examined, I have always found the same relative lengths, the stigma being placed at a higher level, than in the specimens from Greenland. . . . . Only once I have found an inflorescence, the two flowers of which might

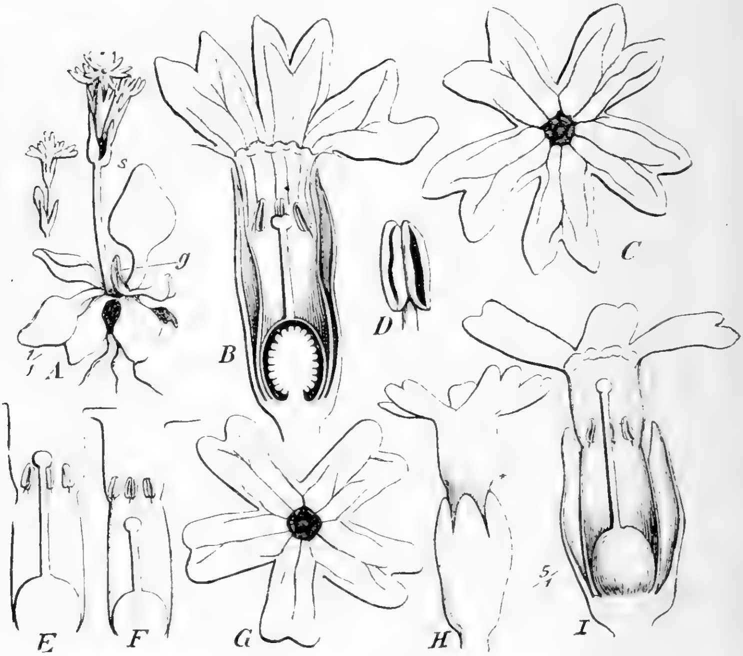

Fig. 10 *A—D*, *Primula farinosa*, var. *groenlandica*, from Greenland (Itivnek near Holsteinsborg).

A, the whole plant and an isolated inflorescence, natural size. *B*, longitudinal section of a flower. *C*, the corolla-limb seen from above; the stigma surrounded by the anthers is seen through the throat ($^{5}/_{1}$). *D*, an anther.

E—F, *Primula stricta*, from Alten Fjord, Finmark.

E and *F*, longitudinal section of two flowers. *G*, the limb of the corolla, seen from above, ($^{5}/_{1}$). *H*, stigma and anthers are at the same level at *. *I*, longitudinal section of a long-styled flower. (From Warming 1886.)

appear as being short-styled (fig. 10, *F*), and the flower illustrated in fig. *I*, when compared with this might be looked upon as the corresponding long-styled form; considering, however, that this fig. *I* depicts the longest styled flower I ever found, and that the length varies generally between that given in fig. *I* and in fig. *E*, while no flowers are found with the stigma below the anthers, I must look upon the form, illustrated in fig. *F*, as being accidental and of no great import."

To this I have only to add the following: Although the most common form amongst flowers from Norway is like that illustrated in fig. 10 *E*, yet it seems that long-styled flowers (as in fig. 10, *I*) are not so very rare. I have also found a few short-styled flowers (as in fig. 10, *F*). A difference was noted in the size of the stigma-papillae of the "long" and "short"-styled types, though this was certainly small. Flowers from Iceland all resemble the type in fig. 10, *E*.

The pedicel is lengthened a good deal after the flowering.

Anatomy. The adventitious roots are 4-rayed. The epidermis dies away quickly, and the protective function is transferred to the outermost layer of the primary cortex which becomes an exodermis, the cells of which are slightly cutinised on the outer and, to some extent, also on the lateral walls. Single crystals are frequent in the exodermal cells. Distinct Casparian spots occur on the radial walls of the fairly well-marked endodermis.

The more vigorous adventitious roots exhibit an incipient development towards the secondary type, in that the middle of the central cylinder is filled with hadromal elements, while the leptome groups increase in size; but no continuous cambium is formed, because the groups of meristematic cells situated between the protohadromal rays do not succeed in joining outside these. Young roots have the cortical cells filled with starch.

The rhizome quickly dies away from behind. A transverse section discloses the vascular bundles ("steles", v. Tieghem), circular to oblong-arched, surrounded by an endodermis, and resembling those of *Pr. egaliksensis* already described. Thick-walled and finely pitted sclereids appear both as groups in the medulla and isolated in the steles. The surrounding parenchyma has its adjacent cells arranged in radial rows, radiating from the vascular bundle; the cells are pitted and were found empty of starch (June, July).

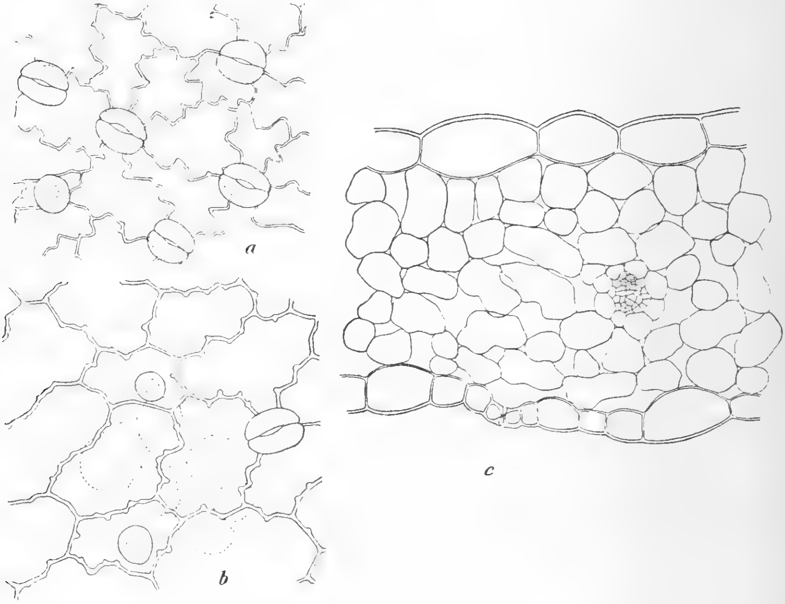

Fig. 11. *Primula stricta.*
a, the epidermis of the lower surface of the leaf. *b*, the epidermis of the upper surface. *c*, transverse section of the leaf, (*a*, *b*, and *c*, obj. 4, oc. 4). (Alten Fjord, Norway.)

The peduncle has the same structure as that of *Pr. egaliksensis.*

The Leaf (fig. 11). The lateral epidermal walls of the upper surface may be nearly straight or slightly undulating, while those of the lower surface are more strongly undulated.

The epidermal cells of both surfaces have their lateral walls strengthened by thickened bands at right angles to the surface; these originate fairly regularly from the convex side of the wall-foldings (fig. 11, *a* and *b*). Numerous cells with brown contents are found in the epidermis. Børgesen states that the number of stomates is somewhat larger on the upper than on the lower surface, but the opposite is the case in the leaves examined by me, where the larger number of stomates is on the lower surface. The stomates both on the upper and lower surfaces of the leaf, are most numerous towards the apex and near the margin. Glandular hairs occur evenly distributed, though rather scantily, over the whole surface of the leaf. As was the case with the two preceding species, the mesophyll is loose and little differentiated in structure (fig. 11, *c*). The uppermost layer consists of short, thick and often almost isodiametric cells; in the lowest layer the elements of the mesophyll become somewhat ramose and more horizontally elongated. Chlorophyll granules are plentiful throughout the mesophyll, and also in the epidermis of the lower surface, but they are few or entirely absent in that of the upper surface. Hydathodes are present on the margin of the leaf.

The floral parts are anatomically very similar to the corresponding parts of *Pr. sibirica*. The hair-covering of the calyx lobes consists principally of the type of glandular hairs illustrated in fig. 5, *e*.

Primula farinosa L., var. groenlandica (Warming) Pax.

Lit.: Lange, 1880, p. 70 (*Pr. stricta*); 1887, p. 260 (*Pr. stricta* var. *groenlandica*, Warming). E. Warming, 1886 a, p. 21 etc. (*Pr. stricta* var. *groenland.*). Rosenvinge, 1892, p. 683 (*Pr. farin.* var. *mistassinica* (Mich.) Pax). Abromeit, 1899, pp. 37—40 (*Pr. farin.* var. *mistassin.*). Pax and Knuth, 1905, p. 84.

Alcohol material from Itivnek near Holsteinborg (E. WARMING, $^{24}/_{7}$ 1884). Herbarium material from Umanak, Strømfjord, Isortok and Itivnek in Greenland.

PAX and KNUTH consider that the small *Primula* from Itivnek, described and illustrated by E. WARMING (1886, a) belongs to the species *Pr. farinosa*, but as a special variety: *δ, groenlandica* (Warm.) Pax. The Greenland plants of this species differ from *Pr. stricta* Hornem., (which latter according to the above authors does not occur in Greenland; see also ROSENVINGE), by having deeper incised corolla lobes, and by a calyx about the same length as the corolla tube, whereas in *Pr. stricta* the latter is considerably longer than the calyx (fig. 10). The relative length of the calyx tube and that of the corolla seems, however, to vary somewhat, not only in the true *Pr. stricta*, but also in the Greenland form of *Pr. farinosa.* No doubt, the plants from Itivnek have the calyx as long as the corolla tube, but, amongst about half a hundred specimens from various other places in Greenland, I found only a few flowers exhibiting similar proportions, the calyx being generally somewhat shorter. The same has been observed by ABROMEIT, who writes "die gelbe Kronröhre ragt etwa 2 mm aus den Kelch hervor". According to this author the pedicels increase greatly in length after flowering: "Die früher nur 2 mm langer Blütenstiele verlängen sich nach der Blütezeit bis zu 10 mm, und an einer alten abgestorbenen Fruchtdolde konnten gegen 24 mm lange Fruchtstiele gefunden werden". The deeply incised corolla lobes were found in all the specimens of this form, examined by me. Besides in South-West Greenland it also occurs in Labrador, thus sharing the same geographical area with *Pr. egaliksensis* (acc. to Pax and Knuth).

In vigorous specimens, the lower surface of the leaves is mealy (ABROMEIT, ROSENVINGE).

The shoot-structure closely resembles that of the nearly related species already described.

E. Warming (1886, a) gives a description of the flower biology, and states in this connection: "All flowers from Greenland, examined by me, showed homogamy, as far as could be ascertained; in a bud, near its expansion, the pollen grains were observed lying loose and fully developed in the anthers still closed, and the papillae of the stigma were as large as those in an older flower; the stigma was in all species level with the middle of the anthers (fig. 10, *B*): self-pollination is inevitable as the corolla tube is very narrow, and the anthers lie close up to the stigma; the anthers incline somewhat towards the stigma (fig. 10, *B*), and looking into the throat from above, the stigma is found to be surrounded by the five anthers (fig. 10, *C*). Cross-pollination is of course not impossible, but it seems to me, that to be effective, the tubes of the foreign pollen must develop more quickly, than those of its own pollen. I found germinating pollen grains on the stigma, while pollen yet remained in the anthers". In all the flowers examined by me, I also observed, that the position of the stigma, in relation to the stamens, was as given in fig. 10, *B*. The limb of the corolla reaches a diameter of 8 mm.

As to the anatomy, this form corresponds so closely with the species described earlier, that a few remarks will suffice.

Crystals of a calcium salt were also found in the exodermis of the root of *Pr. farinosa* var. *groenl.* The sclerenchyma of the peduncle is only slightly developed in tiny specimens such as illustrated in fig. 10, *A*, but the plants may develop much more vigorously, and in these the structure of the peduncle is like that of *Pr. egaliksensis* and *Pr. stricta.* Abromeit states, that owing to the presence of anthocyanin in the epidermis, the peduncle, especially near its apex, also the pedicels and calyces, may be dark blue-black in colour.

The Leaf. The epidermis of the upper surface exhibits slightly undulated to nearly straight lateral walls, but those of the lower surface are strongly undulated. Thickenings of the lateral walls, similar to those in fig. 11 *a* and *b*, are also present, though less pronounced. No proper palisade layer is developed, nor in *Pr. farinosa* var. *groenl.* does the corresponding layer consist of the barrel-shaped cells, already described in the previous species. The bottom layer of the mesophyll has slightly branched cells. The mesophyll is liberally provided with chlorophyll granules, and these are also present in the epidermis of the lower surface. The number of stomates is, in this species, much greater on the lower than on the upper surface of the leaf.

Primula nivalis Pallas, var. *pumila* Ledeb.

Lit.: Kjellman 1882, p. 515; 1883, p. 492. Pax and Knuth, 1905, p. 102.

Herbarium material from arctic Siberia (Pitlekaj and the island of St. Lawrence) collected July 7th and August 1st, 1879, during the Vega expedition by Fr. R. Kjellman, and by him determined as being the variety *pumila* Ledeb. The chief difference from the main type, according to this author, lies in the almost entire leaves (1882, p. 515: "Mest afvika de med hänsyn till bladen, hvilka hos hufvudformen äro tätt och hvasst sågade, hos den arctiska formen åter alldeles helbräddade. Emellertid finnas öfvergångsformer"). In size they vary greatly; and Kjellman records finding specimens (St. Lawrence and Konyam bay), which, as regards vigorous development, were quite equal to the main type, wherefore he does not think that the designation *pumila* is quite appropriate.

My material consisted of specimens with peduncles measuring in height up to 10 cm, and the leaves attained to

5 cm long and 7—10 mm broad. The inflorescences vary up to 10 flowers.

In the monograph by Pax and Knuth, *Pr. nivalis* var. *pumila* Ledeb. is considered to be identical with Kjellman's species *Pr. Tschuktschorum* (1882, p. 516, t. IX), and the name *Pr. pumila* (Ledeb.) Pax, is consequently given to both. The description although it agrees closely with *Pr. T.* Kjellman, scarcely applies to *Pr. nivalis* f. *pumila* Ledeb. according to the material at my disposal here. This latter differs distinctly from the former in having broader leaves, and a longer corolla tube in proportion to the calyx. It also has, all over, a more vigorous habit, and the inflorescence is generally fuller. The two forms have the same area of distribution viz. north-eastern Siberia and the islands in the Behring Strait.

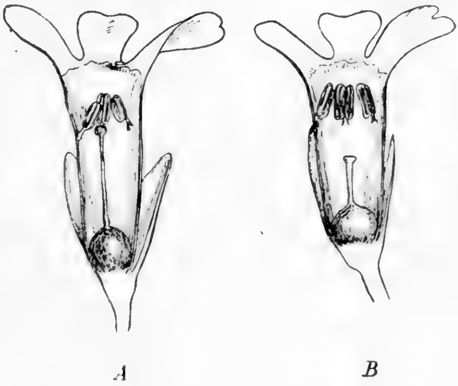

Fig. 12. *Primula nivalis* var. *pumila*.
A, longitudinal section of a flower; the stigma is level with the base of the anthers. ($^{3}/_{1}$). *B*, longitudinal section of a short-styled flower, ($^{3}/_{1}$). (Pitlekaj.)

Kjellman gives (1883, p. 492, figg. pp. 490 and 491) the following description of the hibernation bud of *Pr. nivalis* from Chuckesland: "Det är, såsom synes, en mycket kraftig bildning. Dess längd är 35, dess tvärdiameter 15 mm. Dess hölja utgöras af ett antal kraftiga, tjocka lågblad, hvilka antagligen i viss mån bidraga till de inre delarnas skydd, men som derhjämta, och kanske huvudsakligen, tjenstgöra såsom förvaringsrum för upplagsnäring. Åtminstone äro deras parenchymcellar öfverfulla of stärkelse. Innanför dessa sitta knoppskottets assimileranda blad, — de äro stora med tydligt urskiljbara delar, — och innerst sjelfa blomställningen, hvars hufvudaxel har en märkbar längd och hvars blomknopper äro fullt tydliga, ungefär 2,5 mm långa, och med alla blommans delar ganska långt utbildade . . .". In this *Primula*, the main bud also developes foliage leaves during the same summer, in which it is formed.

Flowers of type *A* (fig. 12) were found as frequently as of type *B*. The stigma in type *A* is level with the base of the anthers and self-pollination may thus readily be effected. Fig. 12, *B* shows a short-styled flower but corresponding long-styled form, which might be expected to be present, did not occur in the material examined by me. The stigma-papillae of *A* were slightly larger on the average, than those of *B*. The corolla is dark purple in colour.

Anatomy. The adventitious roots vary in thickness and in number of rays, and roots with 4, 5 and 6-rays were found. The endodermis is rather prominent, and Casparian spots are very distinct (fig. 13, *A*). The cells of the primary cortex were devoid of reserve-materials (July), and their walls showed collenchyma-like thickening. The epidermis is thin-walled and perishes quickly. The outermost layer of the primary cortex is developed as an exodermis, with the cells filled with a dark-brown substance.

The peduncle (fig. 13, *B*) differs from that of the species previously described by the absence of a sclerenchymatic ring during flowering. It appears, however, from a peduncle of the previous period of growth that the cells between, and just outside, the vascular bundles are somewhat thickened during the ripening of the fruits. Chlorophyll granules are present in the cells of the exceedingly lacunar cortex. The vessels in the strands are few and narrow (fig. 13, *B*), whereas the leptome is rather strongly developed. The parenchyma is thin-walled.

The leaf. The epidermal cells of the upper surface have straight lateral walls, or nearly so, which here and there are provided with flanged thickenings at right angles to the surface of the leaf (e. g. the two upper cells to the right, fig. 14, *a*). The outer-walls often have fine cuticular striations, especially on the epidermal cells over the midrib. The epidermis of the lower surface has undulating lateral walls, provided with thickenings similar to those already described for the upper surface; these are especially well-marked near the stomates (fig. 14, *b*). The stomates are exceedingly rare on the upper surface, whereas, on the lower surface, they are fairly numerous, from 90—110 per sq. mm; they are surrounded by 4 or 5 cells. Glandular hairs of the usual Primula type are present on both surfaces of the leaf, and they always originate from an epidermal cell much smaller than the surrounding ones (fig. 14, *a* and *b*). The

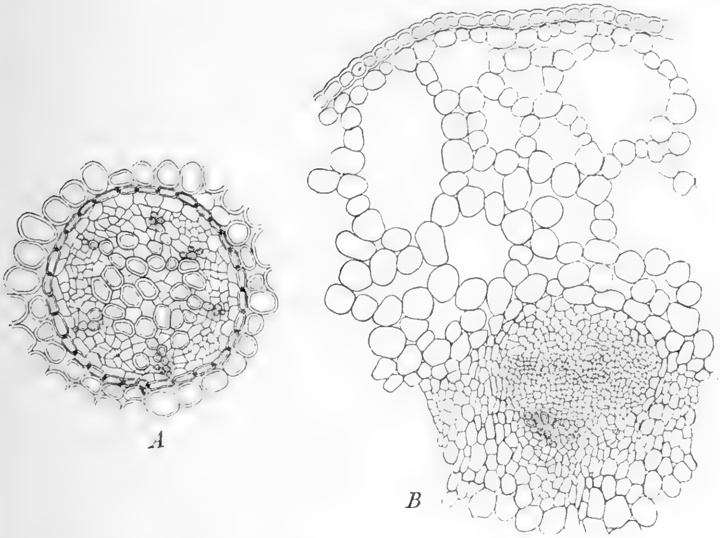

Fig. 13. *Primula nivalis* var. *pumila*.
A, the central cylinder and the adjoining tissues from a 6-rayed adventitious root; (obj. 8, oc. 6). *B*, the peduncle; the fig. shows a sector of the transverse section with a vascular bundle; (obj. 4, oc. 4). (Pitlekaj).

stomates are on a level with the surface of the leaf. Numerous cells, filled with a yellowish-brown substance, are present in the epidermis of both surfaces.

In this Primula the upper 1 or 2 layers of the mesophyll consist of elongated and closely placed cells, so that they may be described as palisades (fig. 14, *c*). Towards the lower surface, the mesophyll becomes unusually lacunar, and consists of much branched cells extended in the plane of the leaf surface.

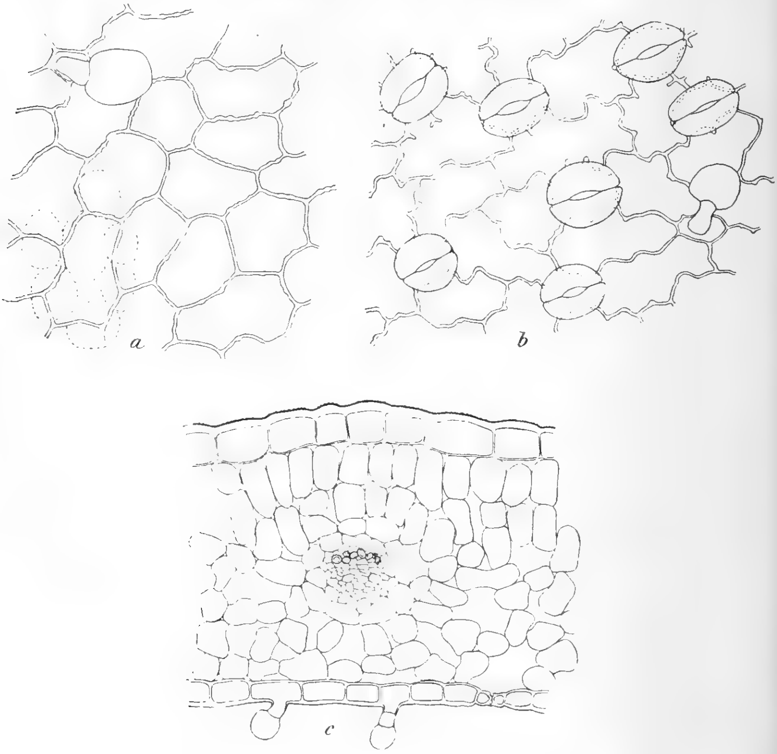

Fig. 14. *Primula nivalis* var. *pumila*.
a, the epidermis of the upper surface. *b*, the epidermis of the lower surface. *c*, transverse section of the leaf. (*a* and *b*, obj. 4, oc. 6; *c*, obj. 4, oc. 4). (Pitlekaj.)

Androsaces septentrionalis L.

Lit.: Flora Danica, t. 7. MÜLLER, 1881, p. 358. BRUNDIN, 1898, pp. 24, 25, 27. P. KNUTH, 1899, p. 307. PAX and KNUTH, 1905, p. 214. Sylvén, 1905, p. 126. Blytt, 1906, p. 566. Ostenfeld, 1910, p. 61 (var. *Gormannii*).

Plants preserved in alcohol from Öland (E. Warming $^{31}/_{5}$ 1907). Herbarium material from Arctic Siberia (the mouth of the Lena River, 1883; Dr. Bunge), and Arctic America (King Point, A. H. Lindström, June 17th and 28th, 1906). The plants from the latter habitat belonged to *A. Gormannii* Greene, formerly considered a separate species, but the only difference from *A. sept.* is the shorter pedicels; Ostenfeld therefore ranks it with the latter species, but as a special variety (*A. septentrionalis* var. *Gormannii* (Greene) Ostf.).

A rosette plant of the *Draba verna* type (Brundin, Sylvén), generally appearing as a hapaxanthic winter annual, but sometimes it succeeds in attaining to pollacanthic growth (Sylvén, one specimen from Uppsala).

According to these authors, the seeds germinate at once during the summer, and a great number of leaves are developed before winter sets in. These remain green throughout the winter, except the lowest in the rosette, hence they can resume their assimilative functions in spring, as soon as conditions permit. No special bud-scales are provided for protecting the growing-point and the embryonic leaf-tissues against desiccation during the winter. The peculiar flat form of the rosettes is caused by the upper leaves growing more on the upper than on the lower surface, so that they are deflected downwards, pressing the lower and older leaves closely towards the substratum (Brundin). During the winter the leaves assume a deep red-brown colour (ibid.).

The primary root developes into a thin, slightly branched tap-root; adventitious roots do not occur.

The growth of the shoot terminates with a 7—10 flowered peduncle; weak specimens develop only one peduncle, whereas stronger ones produce several, through development of the axillary buds of the upper foliage-leaves; on a specimen from Boganida, I have found 19 peduncles, and *A. septentrionalis* is also depicted with several peduncles both in Flora Danica and by BLYTT. These secondary axes have often some foliage-leaves developed at their base.

Like other winter annual plants, *A. septentrionalis* is, according to BRUNDIN, sometimes found flowering in the same year as it germinated.

The calyx is campanulate with 5 protruding ridges at its base, and its lobes reach somewhat above the corolla-tube. The diameter of the limb was found to be 6 mm on specimens from Öland, 3—5 mm on those from the Arctic; the limb and tube are white. In the throat of the corolla there are 5 projections, alternating with the corolla-lobes; they are sac-like expansions of the throat (fig. 15, *D*, shows part of the corolla seen from the outside). The centre of each projection is somewhat depressed (fig. 15, *A* and *E*). H. MÜLLER remarks, concerning these throat-projections in *Androsaces* species, that they are yellow and often very conspicuous, and for this reason he thinks they are of importance as nectar contrivances; they are also useful in narrowing the throat, thus preventing drops of water from finding their way into the corolla tube, and moistening the reproductive organs. The uppermost flat part of the ovary functions as a nectary, and, according to the above author, a drop of honey is here secreted on dry and warm days.

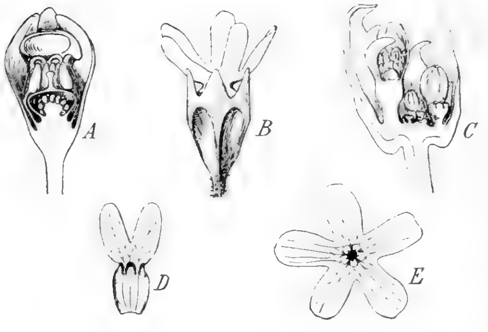

Fig. 15. *Androsaces septentrionalis.*

A, longitudinal section of flower-bud, (6/1). *B*, a recently opened flower, (5/1). *C*, a young inflorescence, developed from a bud in one of the uppermost leaf-axils of the rosette, (10/1). *D*, part of the corolla, seen from the outside; the limb is bent somewhat upwards, to show the throat-projections. *E*, the corolla, seen from above, (4/1). (Öland.)

H. **Müller** has found, by studying *A. septentrionalis* in the Alps, that visits by insects (various Diptera) are not frequent. The inflorescence, which consists of a few rather small and insignificant flowers, attracts but few visitors, hence he assumes, that the plant will often be dependent on self-pollination. The proximity of the stamens to the stigma (fig. 15, *A*) must greatly facilitate this.

Anatomy. In its anatomical structure, the root of *A. septentrionalis*, according to **Decrock**'s description (p. 121), seems to resemble closely that of *A. maxima*; no difference was found between the main and the secondary roots. The primary cortex is few layered and thin-walled, and perishes quickly, with the exception of the innermost layer, the endodermis. This consists of comparatively large cells, which, during the development of the root, divide by radial walls, so that the endodermis can keep pace with the considerable growth of the central cylinder (fig. 16, *A*); the outline of each original endodermal cell is marked by a cutinised lamella. The young root, provided with 2 hadromal rays, quickly attains the characteristics of the secondary type; the one

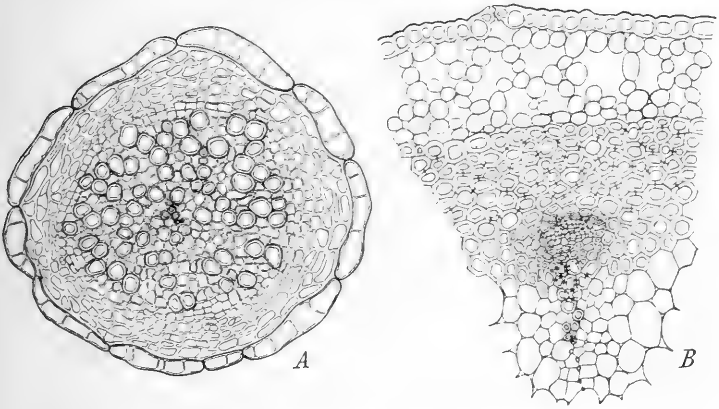

Fig. 16. *Androsaces septentrionalis.*
A, transverse section of a root-branch; (obj. 4, oc. 6). *B*, the peduncle; a sector of a transverse section with a vascular strand; (obj. 4, oc. 4). (Öland.)

depicted (fig. 16, *A*) is thus only 0.5 mm thick; the parenchymatous ground tissue, surrounding the numerous vessels, is lignified at the periphery of the hadromal part. In the leptome the sieve tubes seem to be few. but their precise determination is made difficult by the rapid thickening of their lateral walls, which in a transverse section makes them resemble the somewhat collenchyma-like parenchyma cells surrounding them. In the periphery of the root, the parenchyma cells appear to be tangentially extended and are frequently divided by thinner radial walls.

The peduncle. A lacunar tissue of axially extended cells, containing chlorophyll granules, is surrounded by a thick, strongly cuticularised epidermis, provided with stomates (fig. 16, *B*); the peduncle is therefore, in this case, an organ with assimilative functions. Inside this tissue is seen a stereome including up to 10 layers of very elongated and thick-walled parenchymatous cells, with finely pitted lateral walls. The first-formed vessels (see fig. 16, *B*, below) are placed nearly in a radial line, and have only a few ill-defined annular thickenings, so that in the fully developed peduncle, they are found quite flattened by the turgid pressure of the surrounding tissue. The ground-tissue has very thin walls, and often perishes during the ripening of the fruit, when the peduncle becomes hollow.

The pedicels, about 0.5 mm thick, are very similar in structure to the peduncle.

The leaf. The epidermis of the upper surface (fig. 17, *A*) has straight, often pitted, lateral walls, those of the lower surface being rather strongly undulated (fig. 17, *B*). The outer walls show cuticular striations, especially distinct around the hairs. Of these two kinds are present: I. glandular hairs with a one-celled stalk (less frequently two-celled) and with a unicellular head; these originate from a cell which is smaller than the surrounding epidermal cells.

II. multicellular, thickwalled and most frequently branched cover-hairs with a warty cuticle; various forms are depicted in fig. 17, *D*, *E* and *F*; *D* and *E* showing the thickness of the walls. Stomates, surrounded by 4—5 cells, are present on both surfaces of the leaf, but there are about double as many on the lower than on the upper surface, the proportion varying only slightly in plants from different habitats.

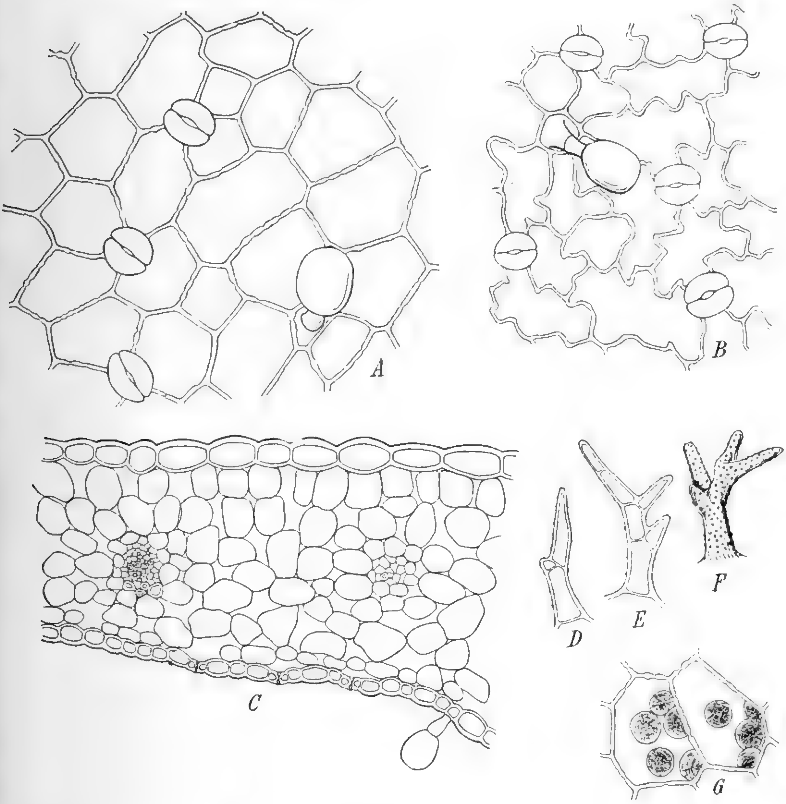

Fig. 17. *Androsaces septentrionalis.*

A, the epidermis of the upper surface of the leaf. *B*, the epidermis of the lower surface of the leaf. *C*, transverse section of the leaf; the vascular strand to the left shows collenchyma-like thickened tissue on the lower side. *D*, *E* and *F*, different forms of cover-hair; *D* and *E* are seen in optical section. *G*, epidermal cells from the upper surface of the leaf, with contents of spheroidal formations. (C, obj. 4, oc. 4; the rest, obj. 4, oc. 6.) (Öland.)

The total number of stomates per leaf is, however, on an average far greater on specimens from Öland, than on those from Arctic America and Siberia.

The apex of the leaf and of each of the 2—4 teeth in its margin, are provided on the lower surface with a group of hydathodes, from which the distal portion of the veins extends fan-shaped as a well-developed epitheme.

A transverse section (Fig. 17, *C*) discloses from 2—4 layers (the thickness of the leaf is somewhat variable) of short and broad palisade cells, which like the rest of the mesophyll are rich in chlorophyll granules. The undermost layer of the mesophyll consists of rather strongly branched cells. Frequently the epidermis of the lower surface is found loosened from the mesophyll. The vascular bundles are sometimes accompanied by cells with collenchymatous thickening (fig. 17, *C*, the vascular bundle to the left). In the epidermis of both lower and upper surfaces, though most frequently in the latter, there are cells filled with a brown substance. In all the leaves examined by me, but only in the upper surface, this contains some peculiar spheroidal and deeply brown-coloured bodies (fig. 17, *G*), which were exceedingly resistant towards solvents; they may perhaps be only a precipitate caused by evaporation, or by preservation in alcohol.

With regard to the floral parts of *A. septentrionalis*, the calyx presents a peculiar anatomical structure, so that it deserves further attention.

A transverse section (fig. 18, *A*) of one of the 5 projecting ridges of the calyx (see p. 196) shows a layer of thin-walled cells within the epidermis of the outer surface of the calyx; these cells are in close contact with each other, and also with the epidermis without any intercellular spaces. This layer (probably an aqueous tissue) is seen in fig. 18, *B*, in surface-view; its elements appear very elongated, with their ends wedged together, and they contain chlorophyll granules, like the mesophyll. The stomates are limited to the upper part of the calyx (i. e. the lobes and a narrow belt below these), and they are about equally numerous on both surfaces. The lateral walls of the epidermis are undulating, more especially on the inner surface of the calyx and also on the 5 concave depressions between the protruding parts of its outer surface; they are less strongly undulated, or nearly straight, on the protruding parts.

The limb of the corolla has papilla-like arched epidermal cells, which are most prominent on the upper surface, especially so round the throat-scales, but these, however, are not papillary. The flat polygonal cells, which cover the throat-scales, were filled with a brown substance.

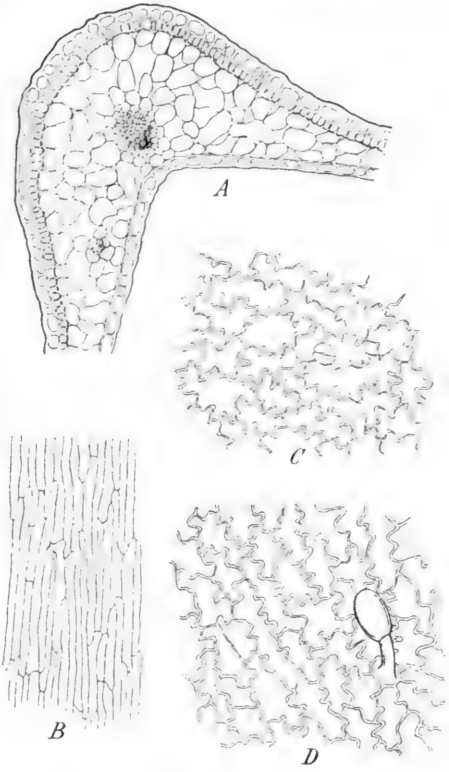

Fig. 18. *Androsaces septentrionalis.* *A*, transverse section of one of the protruding parts of the calyx; under the epidermis of the outer surface is seen a continuous layer of thin-walled cells. *B*, surface-view of this layer. *C*, the epidermis from the inner surface of the calyx. *D*, the epidermis from the outer surface. (*A*, *B*, *C* and *D*, obj. 8, oc. 6.) (Öland.)

Androsaces chamaejasme Host.

Lit.: Wydler, 1859, p. 22. Müller, 1881, pp. 358, 359. Holm, 1885, p. 44; tab. VIII. Eastwood, 1902, p. 211. Knuth 1899,

p. 307. Pax and Knuth, 1905, p. 188, etc. Ostenfeld, 1910, p. 61.

Alcohol material from Jugor Schar ($^9/_9$ 1882), collected by Th. Holm. Herbarium material from Arctic America (var. *arctica* Knuth, Herschell Island $^{13}/_7$ 1906, A. H. Lindström); Arctic Siberia (Chabarowa, August, 1894, H. Fisher; Wajgatsch, July, 1875, Fr. R. Kjellman and A. N. Lundström); also from Central Europe (the Alps, the Carpathians).

This plant developes long and short shoots alternately on the same axis (see fig. 19, *A*) and is similar to *A. lactea*, which is described by Wydler, as having the densely leaved rosettes separated by long-jointed internodes.

Fig. 19. *Androsaces chamaejasme.* *A*, a small specimen from Herschell Island, (see the text); the plant shows the withered remains of 4 peduncles, the one furthest to the left is the youngest, the middle one the oldest, ($^2/_3$). *B*, rosette with 3 rejuvenation buds, ($^2/_1$). *C*, rejuvenating shoot, where the change from long internodes to the densely leaved rosettes has taken place twice, ($^2/_1$). (*A* from Herschell Island, *B* and *C* from Wajgatsch.)

In the species here described, the peduncles are terminal (thus differing from *A. lactea*), the rejuvenescence must therefore be effected by means of axillary buds (fig. 19, *B*). During the summer in which the parent-shoot forms its peduncle, some of these buds develop into lateral shoots similar in structure to that of the parent-shoot. The length of the long-jointed internodes varies greatly, from 5 cm down to a few mm, and sometimes even less, so that the plant becomes almost cushion-like.

The rosettes are generally bent towards the ground, or even rest on this, in which case adventitious roots may develop, and facilitate the vegetative extension of the plant;

this development is however rare. The plant (from Herschell Island) depicted in fig. 19, *A*, has, however, a more erect growth, and this is the more characteristic form of specimens from this locality. There was a considerable amount of clay and sand amongst the withered leaves of the three lower rosettes (fig. 19, *A*), and it seems probable, that the plant has grown on a spot, where, under certain conditions, its vegetative organs were periodically covered by deposits, thus causing the plant to assume a more erect manner of growth, necessary for maintaining life.

The leaves do not seem to retain their assimilative function beyond one period of growth, and the leaves developed during the previous summer were nearly always withered before the following spring. The withered leaves are fairly resistant, and they may remain on the plant for several years before crumbling away.

Special bud-scales are not formed, but the young leaves, which are very hairy, especially on the margins, protect the growing point by bending across it. There are two fairly well differentiated types of axial shoots: one has a thicker elongated internode and a densely leaved rosette; the other has a thinner axis and fewer leaves in the rosette, and its growth never terminates by the development of a peduncle.

As regards the anatomy, there is a marked difference between the long-jointed internodes of these two types, which will be dealt with later.

The flower. The size of the corolla seems to vary greatly (fig. 20, *A* and *B*). I found it largest on plants from Herschell Island and from Wajgatsch, a diameter of 12 mm being attained; it was distinctly smaller (6—8 mm) on plants from other habitats. The colour is whitish-yellow, the 5 small projections narrowing the throat, having a more pronounced yellow colour. According to H. Müller, who thoroughly describes the biology, these throat-scales change their colour and become red when the flower has reached the stage of pollination. This is effected either by insects (Lepidoptera, Hymenoptera and, especially, Diptera), or by self-pollination, in the absence of these. The limb of the corolla also assumes a faint pink colour. This difference in colour between younger and older flowers is presumed to be a signal to the more intelligent insects, that the older flowers have already been cleared of honey by earlier visitors, hence they avoid the red flowers, and the result for the plant is a more intensive utilisation of the visits by insects (H. Müller).

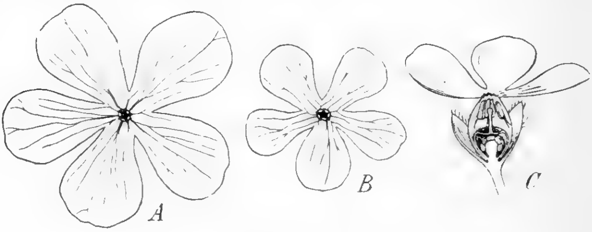

Fig. 20. *Androsaces chamaejasme.*
A and *B*, flowers seen from above; *A* from Herschell Island, *B* from Chabarowa, ($^5/_2$). *C*, flower, transverse section, ($^5/_2$).

Miss A. Eastwood mentions the change of colour in the corolla, so that it must also occur in arctic localities (Alaska).

Honey is secreted on the cup-shaped surface of the ovary (H. Müller).

Anatomy. An adventitious root, 0.5 mm in thickness, examined by me, was found to be 3-rayed, but had otherwise the same anatomical structure, as the root of *A. septentrionalis.*

The stem of *A. chamaejasme*, like that of other *Androsaces* species with a similar mode of growth [*A. lactea* (Wydler, 1859), *A. villosa* (Decrock, 1901)], shows a distinct difference as regards the structure of the naked long-shoots and the densely-leaved short-shoots.

As to the first, fig. 21 *A* illustrates a transverse section of a stem, which has carried a rosette with few leaves;

B and *C* show similar sections of the cortex and central cylinder, respectively, of a stem, where the rosette has been more densely leaved. Both have this in common, that the inner layers of the cortical parenchyma perish fairly quickly, except the endodermis which by division of its radial walls keeps pace with the growth of the central cylinder. The outer layers of the cortex acquire thickened and lignified walls, thus forming a continous sclerenchymatic ring. By comparing fig. 21, *A* with fig. 21, *B* it is apparent, that the thickness of this ring differs in the two types of shoots; in *B*, 5—6 layers take part in the forming of the stereome, while in *A*, this only consists of 1—2 layers. When the shoots have reached a certain age, the central cylinder will be found lying free within a tubular sheath, formed by the lignified and thickened cortical parenchyma, together with the persistant epidermis filled with a brown secretion.

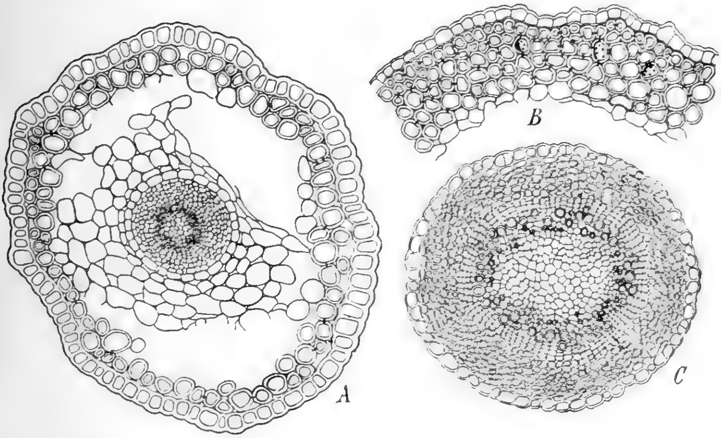

Fig. 21. *Androsaces chamaejasme.*
A, transverse section of a stem, which has borne a few-leaved rosette. *B* and *C*, respectively, the outer layers of the cortex with epidermis attached, and the centralcylinder with the endodermis of a stem with many-leaved rosette. (*A*, *B* and *C*, obj. 8, oc. 4.) (Jugor Schar.)

The cells of the cortical parenchyma are elongated axially, and the elements of the external thickened layers are finely pitted, both in the end and the lateral walls. The central cylinder has a narrow medulla, surrounded by a continuous ring of vessels (fig. 21, *A* and *C*). A circular, continuous cambium commences its functions at a very early stage of the development, forming new vessels towards the centre. Outwards it forms sieve-tissue, the walls of which soon become somewhat thickened collenchyma-like, thus resembling, in a transverse section, the thick-walled parenchyma of the many-layered pericycle; in this, thin radial walls were noticed in a few of the cells (fig. 21, *C*).

The medulla becomes larger in the stem of the rosettes, and the continuous ring of vessels and sieve-tissue, present in the long internodes, is here interrupted by the leaf-traces inserted amongst them. The sclerenchyma in the periphery is here composed of much shorter elements.

The peduncle differs from that of the previous species, by having, most frequently, a somewhat less-developed stereome. It also has, like the calyx, long cover-hairs consisting of up to 7 thin-walled cells; in appearance they are minutely warted by cutinization. Glandular hairs with a 1—2-celled head on a 1—2-celled stalk, are also present.

The leaf. The epidermis has thin, undulating lateral walls; those of the upper surface are somewhat less undulated than those on the lower surface, though there is no great difference (fig.22, *A* and *B*). Glandular hairs, with a structure similar to those on the peduncle, are evenly distributed all over the surface. The cover-hairs are most numerous near the margin of the leaf; they are hyaline, 2—5 cells long, more or less thick-walled, and their surface is closely and minutely warted by cutinization; on the lamina of the leaf these hairs are few, and the short (2-celled) form is most frequent. The variety *arctica* Knuth (Herschell Island) is, however, distinguished by being closely covered with long cover-hairs on both surfaces of the leaf. The epidermal cells from which the cover-hairs originate, are strongly arched. Stomates are present in great numbers on both surfaces. Where the leaves are pressed closely together in rosettes, the proportion between the number of stomates on the upper and lower surface is almost the same, but they are always somewhat more numerous on the lower surface. On shoots with few leaves (see fig. 19, *A*, furthest to the right), the stomates are much fewer on the upper than on the lower surface of the leaves; but, in this case the stomates are

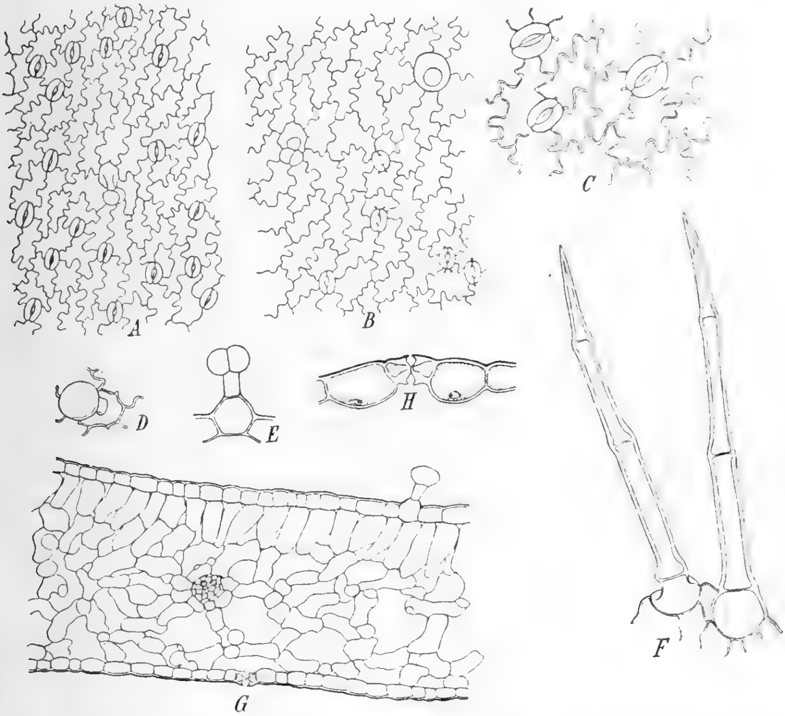

Fig. 22. *Androsaces chamaejasme.*

A, the epidermis of the lower surface of the leaf. *B*, the epidermis of the upper surface of the leaf. *C*, a piece of the epidermis, more enlarged. *D* and *E*, forms of glandular hairs. *F*, cover-hairs from the margin of the leaf, seen in optical section. *G*, transverse section of the leaf. *H*, a single stoma. (*A*, *B* and *G*, obj. 8, oc. 4; *F*, obj. 8, oc. 6; *C*, *D*, *E* and *H*, obj. 4, oc. 4.) (Jugor Schar.)

more evenly distributed as compared with the densely leaved rosettes, where they are especially numerous towards the apex of the leaf. The total number of stomates per leaf seems generally greater on plants from Central Europe, than on those from the Arctic Zone.

In fig. 22, *G*, a transverse section of the leaf is given. The outer walls of the epidermis are only slightly thickened, and the stomates are either level with the surface of the leaf, or slightly raised above this. The illustration shows only one layer of palisades, but 2 and even 3 layers may occur (see Th. Holm, Tab. VIII, fig. 4). The aërenchyma is exceedingly lacunar in structure, and its cells are strongly branched.

Dodecatheon frigidum Cham. et Schlecht.

Lit.: Kjellman, 1883, p. 517. Eastwood, 1902, p. 211. Pax and Knuth, 1905, p. 239. Ostenfeld, 1910, p. 62.

Herbarium material from Arctic America (Port Clarence, 22nd and 26th July 1879, Fr. R. Kjellman; Herschell Island $^{13}/_{6}$ 1906, A. H. Lindström).

The geographical area of *Dodecatheon frigidum* seems to be fairly limited. With the exception of a couple of records in Oregon and Utah, which Pax and Knuth consider to be doubtful, it has only been found on the shores of Berings Straits and Alaska, and on adjacent islands. According to Kjellman, it grows chiefly amongst shrubs on mountain-slopes, but it may also be found on damp plains near the beach. The shoot-structure resembles that of the *Primula* species already described. The peduncle is terminal, and the bud, which is to continue the growth of the rhizome, developes in the axil of the uppermost foliage-leaf. In the material examined by me, were some specimens with an upward branching rhizome, which showed that the buds formed in the axils of the lower foliage-leaves may also attain to full development under favourable conditions.

The rhizome is closely covered with slightly branched adventitious roots, up to about 2 mm in thickness; both have a bright, brownish colour. The rhizome attains to a considerable length (up to 5 cm) by continuous annual growth, remaining alive for several years; on one rhizome I have counted up to 3 generations of shoots, plainly defined by the remains of the old peduncles. The withered bud-scales are found at the base of the spring rosettes, which consist of long-stalked ovate foliage-leaves 2—4 cm long, 0.7—2 cm broad. About the middle of July the hibernation buds are still small.

The peduncle carries 2—3 reddish-violet flowers, drooping when in full bloom.

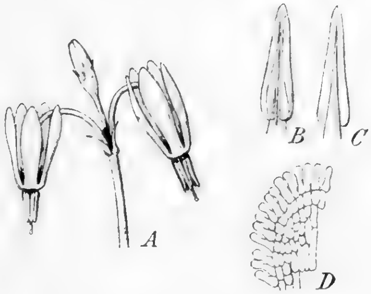

Fig. 23. *Dodecatheon frigidum.*
A, inflorescence (slightly reduced). *B*, an anther seen from the inside; the cavities of the anther are open. *C*, dorsal view of an anther, (*B* and *C*, $^3/_1$). *D*, the stigma papillae; (obj. 8, oc 4.) (Herschell Island.)

The pollination process in species of *Dodecatheon*, according to KERNER (Pflanzenleben II p. 303), is as follows: The pollen-bearing insect, in search of honey, forces the cone-like column of anthers apart with its proboscis, and during this process part of the pollen falls out and becomes attached to the visitor. On the next flower visited by the insect, some of this pollen is left on the stigma and cross-fertilization is brought about. Should such fertilization not be effected, by the non-appearance of visiting insects, autogamy will take place. The short filaments become relaxed towards the end of flowering, and cause the anthers to separate somewhat, whereby the space inside the cone of anthers filled with pollen is opened, and the slightest shake causes the mealy pollen to fall on the stigma situated vertically below the anthers, because of the inverted position of the flowers (fig. 23, *A*). This figure also shows that the style of *D. frigidum* only reaches a few mm beyond the anthers. The papillae of the stigma are fairly long (fig. 23, *D*).

Anatomy. The adventitious roots are 3—5 rayed, with the central-cylinder surrounded by a strong endodermis (fig. 24, *B*). Some cells with thin walls occur scattered in this, especially opposite the hadromal rays. The primary cortex consists of a rather thickwalled parenchyma, of 16—20 layers. The outermost layer developes into an exodermis which in tangential section (fig. 24, *D*) shows both axially extended cells and short almost isodiametrical cells; these latter are comparatively thinwalled. The middle lamella is undulated, and in older roots (these alone were at my disposal) it is cutinised all round the cells, and this was also the case with the middle lamella of the endodermis. A transverse section of the outer layers of the root is illustrated in fig. 24, *C;* the fourth cell in the exodermis, from below, is one of the above-mentioned short and thin-walled cells; these are frequently filled with a brown coloured substance, similar to that which characterises the epidermis and the

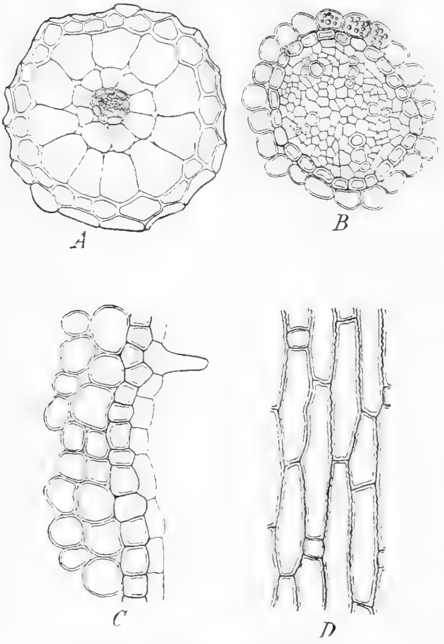

Fig. 24. *Dodecatheon frigidum.*
A, transverse section of a root-branch. *B*, the central-cylinder with endodermis and a layer of the surrounding cortical parenchyma of an adventitious root; the starch contents are shewn in some of the cells. *C*, the outer layers of the adventitious root. *D*, a tangential section of the exodermis. (*A*, *B*, *C* and *D*, obj. 4, oc. 4.) (Herschell Island.)

root-hairs. All the wall thickenings in the cortex consist of pure cellulose. It is possible, that the unthickened elements mentioned in the exo- and endodermis, have served as passage-cells for water at an earlier stage of the development of the roots, before the cutinization of the middle lamella reduced their permeability. The fact that the epidermis keeps alive and active as a water absorbing organ for a long time (I have found well preserved root-hairs nearly up to the base of the root), seems to me, at least, to confirm this supposition.

Fig. 24, *A* depicts a transverse section of a root-branch, about 0.5 mm thick; it is two-rayed and both endo- and exodermis are well developed.

The vascular bundles of the rhizome are arranged in a ring. The number varies somewhat according to the thickness of the rhizome, and I have counted up to 7 in a transverse section. In shape they vary from round to much elongated tangentially; anastomosis is frequent. They are collateral, and each is surrounded by a strand-sheath, with its cells often divided by thin radial walls. Outside the vascular-bundles, a "réseau radicifère" is formed (see DECROCK p. 183 and 196), from which the adventitious roots initiate. The ground-tissue consists of fairly thick-walled, many-pitted cells, containing some starch (July). There was an active cork-cambium directly under the epidermis, on the part of the rhizome formed the previous year; the cells of the cork contained a brown substance.

The peduncle. The stereome, so common in the Primulaceae, is very slightly developed here; it encloses a circle of 15—20 vascular bundles, and to some extent, it surrounds each single strand. A quickly perishing ground tissue is present in the middle. Outside the stereome, an assimilative parenchyma with large intercellular spaces is found. The epidermis is provided with stomates. Glandular hairs occur on the peduncle as well as on the pedicels (here particularly abundant), and on the calyx.

The leaf (fig. 25). The epidermis on both surfaces has undulating lateral walls. Stomates only occur on the lower surface, and are fairly evenly distributed, an average about 55 per sq. mm. Glandular hairs, with a unicellular, globular head on a 1-celled stalk, were present on both surfaces. The hydathodes are characteristic, each single water-pore (fig. 25, *D*) resting on a small wart-like base; they are situated on the upper surface of the leaf, near the margin and above the ends of the veins.

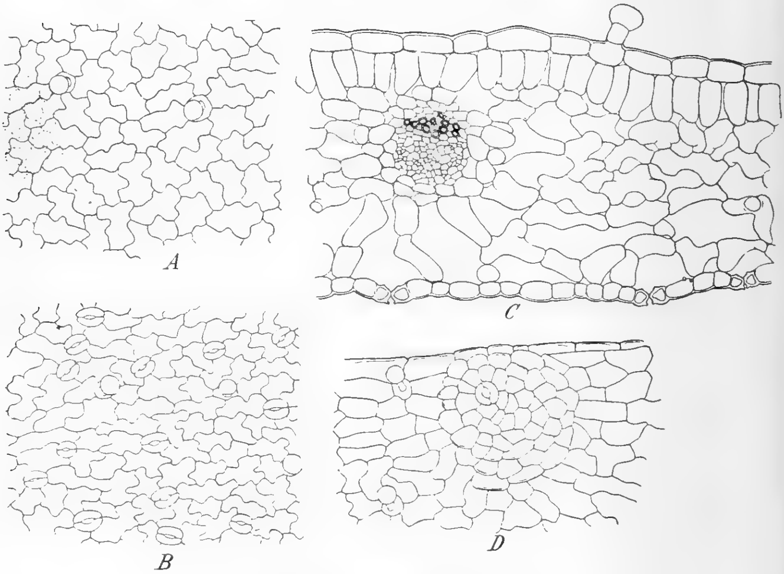

Fig. 25. *Dodecatheon frigidum.*

A, the epidermis of the upper surface; to the left the underlying palisade cells are drawn with dotted lines. *B*, the epidermis of the lower surface. *C*, transverse section of the leaf. *D*, a hydathode. (*A*, *B* and *D*, obj. 8, oc. 4; *C*, obj. 8, oc. 6.) (Herschell Island.)

The transverse section (fig. 25, *C*) shows a single layer of palisades and an aërenchyma with an exceedingly loose structure consisting of much-branched cells. Chlorophyll granules are plentiful throughout the mesophyll.

Summary.

A. **Growth forms**[1] and **shoot-formation.**

1. Chamaephytes: *Androsaces chamaejasme.*

A sedentary chamaephyte with a very persistent main root. When many leaf-rosettes are crowded together, *Androsaces chamaejasme* shows at times distinct transitions to the cushion-plant form. The adventitious roots appear very sparingly, hence vegetative propagation by root-forming rosettes can scarcely be of much importance. The foliage-leaves die in the autumn, except the innermost, partly expanded leaves. The withered leaves form a protection for the embryonic tissues of the axis, while the hair covering of the young leaves is most probably useful in the same way. The structure of the leaves is mesomorphic. The peduncle is terminal.

2. Hemicryptophytes: All the *Primula* species described above, and also *Dodecatheon frigidum.*

Perennial herbs with a quickly perishing main root, a vertical rhizome, and with leaves arranged in basal rosettes.

The rhizome of *Dodecatheon frigidum* reaches a comparatively considerable length, while the *Primulae* have only short ones, as they perish quickly from behind. The living part of the rhizome of the first four species described (viz. *Pr. egaliksensis*, *Pr. sibirica*, *Pr. stricta* and *Pr. farinosa* var. *groenlandica*) consists of a single year-growth only.

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[1] C. Raunkiær: Planterigets Livsformer og deres Betydning for Geografien. København og Kristiania, 1907.

The main bud of the *Primula* species developes in the axil of the uppermost foliage-leaf, and generally produces a few leaved rosette, almost simultaneously with the flowering of the parent shoot. During the autumn some of the leaves remain in the scale-leaf stage, and as bud-scales form a protection for the embryonic tissues in the winter-bud. In spring these tissues develop into regular foliage-leaves (the spring-rosette) and the growth of the axis terminates with the formation of the peduncle.

Buds can, however, sometimes develop in the axils of other foliage-leaves, thus forming a "rhizoma multiceps". As adventitious roots develop in abundance, and (as mentioned above) the rhizome of the Primulas quickly perishes from behind, it is possible for vegetative propagation of these species to take place. A single individual may disintegrate into a larger or smaller group by the dissolution of the parts connecting the mother rhizome with its branches, so that the latter, by the development of adventitious roots, become independent plants.

The leaves have a mesomorphic structure.

3. *Androsaces septentrionalis* appears most frequently as a hapaxanthic winter-annual. The seeds germinate in the late summer, and before the approach of winter the plant has formed a small leaf-rosette, closely pressed towards the ground, and with a strongly developed main root. Bud-scales are not present, but the tip of the axis is protected by the half-developed innermost leaves of the rosette. During the spring following, the axis completes its growth by the development of a peduncle, and in the case of robust individuals, other flowering shoots are developed in several of the axils of the foliage-leaves.

The leaves developed during the autumn, hibernate and have a somewhat xeromorphic structure and appearance (the felted hair covering). BRUNDIN states, that *Androsaces sep-*

tentrionalis, besides being a hapaxanthic winter-annual, may sometimes be seen to flower during the same year as germination has taken place (this is also the case with such plants as *Draba verna*); according to SYLVÉN it sometimes attains to pollacanthic growth. The plant seems thus to be somewhat variable as regards its growth-form. (Therophyte-Hemicryptophyte.)

B. **Flower Biology.** The nature of my material has prevented me from ascertaining, whether the inflorescence is formed during the year previous to its development, which is the case with numerous Arctic plants. According to KJELLMAN this takes place with *Pr. nivalis* (Arctic Siberia) and the same is most probably the case with the other Primula species described here, and perhaps also with *Dodecatheon frigidum.*

The *Primula* species, *Dodecatheon frigidum* and *Androsaces chamaejasme* have quite conspicuous flowers, those of *Androsaces septentrionalis* being less so. As to the colour of the corolla, this is reddish-violet to purple in *Pr. nivalis* and *Dodecatheon frigidum*, while *Pr. egaliksensis*, *Pr. sibirica*, *Pr. stricta* and *Pr. farinosa* v. *groenlandica* have a light purple to almost white corolla-limb with yellow throat-scales. The *Androsaces* species have white corollas with yellow throat-scales, but in *Andros. chamaej.* a change of colour takes place after fertilisation, the corolla then assuming a light purple colour. The uppermost flat part of the ovary serves as a nectary in the two species of *Androsaces.* The alpine Primulas, amongst others *Pr. farin.*, secrete honey from the wall of the ovary according H. MÜLLER, but whether this is the case with the Arctic species, must remain an open question for the present.

Pr. stricta has a strong unpleasant scent.

As to dimorphism of the flowers, it can be stated, that *Pr. sibirica* appears to have a characteristic dimorphic heterostyled flower, with a very perceptible difference in size between the stigma papillae and pollen granules of the short- and long-styled flowers. *Pr. egaliksensis* and *Pr. farin.* v. *groenlandica* have homomorphic flowers, the stigma being level with or slightly below the middle of the anthers. The flowers of *Pr. stricta* may perhaps generally be regarded as homomorphic, with the stigma placed a little above the anthers, but flowers are also found with the stigma raised considerably above the anthers, while others, have it situated much lower than the base of the anthers. Although I found a considerable number of flowers of *Pr. nivalis* with a very short style, the corresponding long-styled form seemed entirely lacking, and the greater part of the flowers examined had the stigma placed a trifle below the base of the anthers.

All species must be considered entomophilous; the *Androsaces* species are visited especially by Diptera (H. MÜLLER).

Failing visits by insects, self fertilisation can probably take place without difficulty in the *Androsaces* species, *Pr. egaliksensis*, *Pr. farin.* v. *groenl.* and also in those flowers of *Pr. nivalis*, where the stigma is about level with the anthers.

C. **Anatomy.** I. According to their anatomical structure, the roots of the species examined can be classed into two groups, the first representing the mesomorphic, the second the more xeromorphic type (see DECROCK).

1. The root of all the *Primula* species has a thin-walled and short-lived epidermis. Its protective function is assumed by the outermost layer of the primary cortex, the elements of which fit closely together, forming an exodermis, with the outer walls often slightly cutinised. The primary cortex is relatively an extensive tissue and, in *Pr. sibirica* and *Pr. nivalis*, its cells have somewhat thickened walls. An endodermis with Casparian spots can always be distinctly observed. The number of hadromal rays in the central

cylinder varies from 2 in the primary, and thin adventitious roots of *Pr. sibirica* to 6 (*Pr. nivalis*); 4 seems the usual number in the group Farinosae. The primary structure is retained throughout the existence of the root, though, in very strong roots of *Pr. stricta* I have found a few hadromal elements apparently of secondary origin. The primary cortex of the young roots is filled with starch, which is consumed during the spring growth. The adventitious roots of *Pr. egaliksensis*, *Pr. sibirica*, *Pr. stricta* and *Pr. farinosa* v. *groenl.* developed during the preceding summer, were found to die away; the primary cortical cells collapse and become empty, and in the case of *Pr. sibirica*, the thickenings of the cell walls disappear. In these roots of the preceding year, I have noticed diminutive crystals of a calcium salt, especially in the outer layer of the cortex; these were most frequent in *Pr. stricta.*

The anatomical structure of the root of *Dodecatheon frigidum* resembles most that of the Primulas. It differs in its characteristic exodermis and in the longevity of the epidermis. The number of hadromal rays in the adventitious roots varies from 3 to 5, but the finer lateral roots have only 2 rays. The cells of the primary cortex have somewhat thickened walls

2. In contrast to the type described above, the roots of *Androsaces* species pass quickly into the secondary stage. An active cambium ring is developed, and forms numerous vessels and wood-parenchyma toward the inside, and outwards leptome elements with somewhat collenchymatous thickened walls. The epidermis and primary cortex lying outside the endodermis, are thrown off. Through division along the radial walls, the cells of the endodermis are enabled to keep pace with the increase in thickness of the central cylinder.

II. All the species of the genus *Primula* described here are characterised by an anomalous structure of the rhizome (polystely and a "réseau radicifère"); polystely could not be proved in the case of *Dodecatheon frigidum.* These anomalies have already been thoroughly described by VAN TIEGHEM[1] and others for *Pr. nivalis*, *Pr. stricta*, *Pr. sibirica* and *Pr. farin.* Stone-cells, single or in small groups, are present in the medulla of *Pr. sibirica* and *Pr. stricta,* and the latter also has them enclosed in the individual steles. The cells of the ground-tissue are parenchymatic, coarsely pitted and contain starch. *Dodecatheon frigidum* has an active cork-cambium in the subepidermal layer of the cortex.

III. The vascular bundles of the peduncle and flower stalks are arranged in a regular circle. In most of the species they are surrounded by a sclerenchymatic ring (especially strong in *Androsaces sept.*); *Pr. nivalis* seems however to lack this stereome. A parenchymatic tissue is present outside the stereome; it consists of axially extended cells with large intercellular spaces, and is rich in chlorophyll granules. The epidermis is provided with stomates and covered with hairs of the same type as those present on the leaves of the respective species. The central ground-tissue consists of thin-walled cells, and is always homogeneous.

IV. The leaves of the *Primula* species, and those of *Dodecatheon frigidum* are provided on both surfaces, with glandular hairs of the usual Primula type (a unicellular head on a one-celled stalk). *Androsaces sept.* has in addition hairs with two-celled stalks, while in *Androsaces chamaejasme* the head of the glandular hairs may also be two-celled, the division being always effected by a central vertical wall.

The dense mealy covering, so characteristic for the

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[1] VAN TIEGHEM: Struct. de la tige d. Primevères & Groupement d. Primevères, etc.; Bull. Soc. bot. de France, 1886. VAN TIEGHEM et DOULIOT: Polystélie; Ann. sc. nat. Ser. 7, T. III, 1886. For the literature of this subject see also SOLEREDER: System. Anat. der Dicotyl.; Stuttgart, 1899.

lower surface of the leaves of many Primulas and which is known to be a resinous substance secreted from the head of the glandular hairs, is not met with, or only in a very limited degree, in the Arctic species closely related to *Pr. farinosa* (viz. *Pr. egaliksensis*, *Pr. stricta* and *Pr. sibirica*), but *Pr. farin.* v. *groenlandica* may have the leaves "mealy" on the lower surface, at least on vigorous specimens (ABROMEIT).

The leaves of the *Androsaces* species are covered with cover hairs, on the margins and the upper surface, those of *Androsaces sept.* being short and branched, while on *Androsaces chamaej.* they are long, hyaline and simple.

The lateral walls of the epidermal cells of *Pr. nivalis* and *Androsaces sept.* are straight or nearly so on the upper surface of the leaf; on the lower surface, however, they are undulating. The other *Primulae* and also *Dodecatheon frigidum* and *Androsaces chamaej.* have undulating lateral walls on both surfaces of the leaf. Fine cuticular striations were present on the outer walls of the cells of the genus *Primula* and also in the case of *Androsaces sept.*

Primula nivalis and *Dodecatheon frigidum* have stomates only on the lower surface of the leaves, but the other species are provided with stomates on both surfaces. *Pr. egaliksensis*, *Pr. sibirica*, *Pr. stricta*, *Pr. farin.* v. *groenl.* and *Androsaces sept.* have always by far the greater number on the lower surface. In *Androsaces chamaej.* the number of stomates on the upper and lower surfaces is almost the same, but only where the leaves are crowded together in dense rosettes, so that the stomates, on account of this, are mainly situated towards the apex of each leaf; where the leaves are arranged more favourably for development, as on the few-leaved shoots, then the stomates are much more numerous on the lower surface.

The stomates are level with the surface of the leaf, at times even somewhat raised above this.

The mesophyll is on the whole loose in structure. *Dodecatheon frigidum* has 1 layer, *Pr. nivalis* 1—2 and *Androsaces chamaej.* 1—3 layers of palisades. The leaves of *Androsaces sept.* vary somewhat in thickness, and show from 2—4 layers. The *Primula* species of the group Farinosae are characterised by having the uppermost layer of the mesophyll composed of somewhat irregular, ovate or barrel-shaped cells, with large intercellular spaces, so that a true palisade layer can scarcely be said to have developed. *Pr. farinosa* in the Alps shows, according to Wagner, the same peculiarity. In the case of *Androsaces chamaej.* and *Dodecatheon frigidum* the other layers of the mesophyll consist of richly branched cells, whereas in *Primula* species and *Androsaces sept.*, it is only in the lowest layer that the elements show any stellate ramification.

Chlorophyll is abundantly present throughout the mesophyll, and in special cases it was also found in the epidermis.

As is generally the case with Primulaceae, hydathodes are found at the tip of the leaves as well as on the margin opposite the stronger lateral veins.

Androsaces sept. has a small group of hydathodes at the tip of the leaves and also on the lower surface of each leaf-tooth; on *Dodecatheon frigidum* each hydathode is placed on a small, raised, wart-like base.

OM SPALTEAABNINGERNE HOS GRISELINIA LITTORALIS RAOUL OG CAMPANULA VIDALII WATS.

AF

V. A. POULSEN

Særtryk af
VIDENSK. MEDDEL. FRA DANSK NATURHIST. FOREN.
Bd. 67

Arbejder fra den botaniske Have i København. Nr. 79.

Om Spalteaabningerne hos *Griselinia littoralis* Raoul og *Campanula Vidalii* Wats.

Af

V. A. Poulsen.

(Meddelt i Mødet d. 26de Nov. 1915.)

Hertil Tab. I.

Hos en Del Planter kendes den Ejendommelighed, at Spalteaabningerne paa Bladene til et vist Tidspunkt, nemlig naar de have naaet en vis Alder, i det mindste delvis lukkes. Hvor vidt dette kan ske paa den naturligste og simpleste Maade, nemlig ved ligefrem Sammenslutning af Lukkecellerne, vides ikke; derimod kendes to andre, tilsyneladende mere vidtløftige Tilluknings- eller rettere Tilstopningsmaader: enten forstoppes selve Spalten ved et i Forgaarden udskilt, harpiks- eller voksagtigt, noget grumset Sekret [1]), eller visse Celler indenfor Spalten, altsaa i Aandehulen, vokse saaledes til, at de afspærre Baggaarden eller rettere Opisthialspalten fra Aandehulen, der herved mere eller mindre udfyldes; denne sidste Lukkemaade har man kaldt den thylloïde [2]).

Af denne haves atter tvende Former, idet den „thylloïde" Cellevækst enten kan skrive sig fra Epidermis, naar Spalteaabningens Nabo- (eventuelt Bi-)Celler træde i Virksomhed, eller fra de Aandehulen begrænsende Luftvævsceller; meget almindelige synes disse Lukningsmaader mig imidlertid ikke at være, til Trods for, at der paa forskellige Steder i Litteraturen anføres Eksempler derpaa. I de fleste Tilfælde drejer det sig, saa vidt jeg har kunnet erfare,

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[1]) Cfr. Wilhelm: Eine Eigenthümlichkeit d. Spaltöffn. d. Coniferen (Ber. d. deu. bot. Ges., I, 1883). Th. Wulff: Studien ueber verstopfte Spaltöffn. (Oesterr. bot. Ztsch., 48. Jahrg., 1898, pag. 201).

[2]) Haberlandt: Physiologische Pflanzenanatomie, IV. Aufl., 1909; p. 423, Fig. 181. Küster: Pathologische Pflanzenanatomie, 1916, p. 84.

om et Fænomen, der optræder halvt pathologisk og kun undtagelsesvis, om end just ikke sjældent. Den første Gang, det omtales i Litteraturen, er, saa vidt mig bekendt, i 1881, da Schwendener[1]) finder saadanne thylloïde Lukninger af nogle Spalteaabninger paa ældre Blade af *Camellia japonica* og *Prunus (Cerasus) Laurocerasus*; i 1887 finder Haberlandt noget lignende hos *Tradescantia viridis*; her er det Lukkecellernes Naboceller, som besörge Afspærringen (se Figuren, pag. 84 hos Küster, Pathologische Pflanzenanatomie, 1916, som er en Kopi af Billedet i Haberlandts „Funktion u. Lage des Zellkerns bei den Pfl.“, Jena, 1887). Hos *Pilea elegans* er det derimod enkelte af Bladkødets Celler, som ifølge samme Forsker[2]) lukke Spalten, og lignende har Möbius[3]) i 1887 paavist hos *Ficus* og Molisch[4]) et Par Aar efter hos *Tradescantia* og *Begonia*. I 1891 offentliggjorde Briosi et större Arbejde[5]) om Bladets Anatomi hos *Eucalyptus globulus* Lab., og heri omtaler og afbilder han ganske det samme Forhold, dog med den Forskel, at medens de Spalteaabningens Inderside afspærrende Mesofylceller hos *Pilea*, *Tradescantia*, *Ficus* ikke med Hensyn til deres Indhold afvige fra de øvrige, med hvilke de staa i Forbindelse, ere de her hos *Eucalyptus* klorofylløse og krystalførende, „il che evidentemente dimostra, che esse compiono tuttora una funzione attiva e che questa non è quella del assimilatione clorofilliana.“ Jeg kan her bemærke, at det næppe er meget hyppigt, at slige Celledannelser forekomme; jeg har hidtil trods megen Søgen[6]) dels paa Materiale fra vor botaniske Haves Væksthuse, dels paa Materiale, som er sendt mig fra Nizza, kun en enkelt Gang kunnet finde Fænomenet. Naar Briosi imidlertid i en An-

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[1]) Bau u. Mechanik d. Spaltöffnungen (Monatsber. d. kgl. Akad. d. Wiss., Berlin, 1881, p. 861, Fig. 16 a).

[2] l. c.

[3]) Beitr. z. Anat. d. Ficus-Blätter (Ber. d. Senckenb. naturf. Ges., 1887, p. 117).

[4]) Zur Kenntniss d. Thyllen (Sitzber. d. Wiener-Akad., Bd. 97, Abt. I, 1888; p. 264)

[5]) Intorno alla Anat. delle Foglie dell' Eucalyptus globulus Lab., Milano, 1891; pag. 21; Tab. 16, Figg. 1 og 2.

[6]) Da jeg ofte anvender „Folia Eucalypti“ som Paradigma ved min planteanatomiske Undervisning af en Masse farmacevtiske Elever, er det et ikke ringe Antal Præparater, som i Tidens Løb har passeret Revue for mig

mærkning) siger: „Per quanto mi sappia, nulla di simile è stato finora altrove rinvenuto“ (altsaa i 1891), kan jeg ifølge de ovenfor anførte Citater, som han for Resten ikke nævner og altsaa ikke har bemærket, ikke give ham Ret heri; Fænomenet havde været kendt i ti Aar, — i det mindste. Hos *Cephalotus* forekommer der ifølge Goebel[1] (1893) i de kandeformede Blades af ham som 2den Region betegnede Parti (paa Indersiden) Spalteaabninger (d. v. s. Vandspalter), som afspærres ved Mesofylceller, der skyde sig temmelig langt frem i den vide Spalte, — et Fænomen, som kan nævnes her i denne Sammenhæng.

Hvorvidt Geiger[2]) har Ret i at tale om Spalteaabningslukning ved Hjælp af de Celler, han i 1898 afbilder i Aandehulen hos *Pilocarpus*, skal jeg lade staa hen; vi have i al Fald ikke det samme Fænomen her, som ovenfor skildret hos de dér anførte Planter. I 1904 finde vi i en interessant Studie af Billings[3]) over *Tillandsia* derimod aabenbart et herhen hørende Eksempel, hvor Spalteaabningerne paa Grund af denne mærkelige Plantes ganske særegne biologiske Forhold bestandig holdes afspærrede indadtil af udvoksende Mesofylceller. Hermed bør ogsaa sammenlignes de meget lignende Fænomener, som omtales og afbildes af Linsbauer[1]) hos nogle Bromeliaceer; men en ganske utvivlsom thylloïd Udfyldning af Aandehulerne har Bukvič[5]) paavist hos en Del Cactaceer, (hvor denne Ejendommelighed efter hans Mening endda hører til de hyppigere Fremtoninger hos ældre Individer) og Vouk[6]) omtaler og afbilder et lignende Forhold paa nogle ejendommelige, af ham som Pneumathoder tydede Organer paa *Begonia vitifolia*'s Stængel.

I et omhyggeligt og temmelig detailleret Arbejde[7]) over Spalte-

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[1]) Pflanzenbiolog. Schilderungen, II, pag. 114 og Tab. XXIII, Fig. 10.

[2]) Beiträge z. pharmakogn. u. bot. Kenntniss der Jaborandiblätter; Diss. Zürich, 1897, p. 26.

[3]) Botan. Gaz., Vol. 38, 1904; p. 99.

[4]) Physiol. Anat. d. Epid. u. d. Durchlüftungsapp. d. Bromeliaceen, Sitzb. d. Wiener Akad., Bd. 120, I, 1911; p. 319).

[5]) Oesterr. bot Ztschr., Jahrg. 62, 1912; p. 401.

[6]) Ber. d. deutschen bot. Ges., XXX, 1912, p. 257; Tab. XI, Fig. 4.

[7]) Hryniewiecki: Anat. Studien über die Spaltöffnungen bei den Dikotylen (Bulletin de l'Acad. des Sciences de Cracovie, Sér. B, 1912, p. 585; Tab. XXVIII, Figg. 27 og 28).

aabningerne hos de tokimbladede Planter har Hryniewiecki i 1812 paavist en lignende Spalteaabningsafspærring hos *Meryta Denhamii* fra den botaniske Have i Palermo, og Rehfous[1]) noterer i en lille Artikel i 1914 samme Fænomens Forekomst hos *Euonymus* og *Catha*.

Her kan ogsaa mindes om Forholdet paa Rhizomet af *Polygonatum officinale*, hvor Aandehulerne i al Fald paa de ældre Dele opfyldes af Parenkym, saa at Spalteaabningerne ganske sættes ud af Funktion, og der opstaar smaa, lenticelagtige Vorter paa den underjordiske Stængels Overflade [cfr. Warncke: Neue Beiträge zur Kenntniss der Spaltöffnungen (Pringsheims Jahrbücher, vol. 50, 1911—12, p. 34 ff.)] samt den thylloïde Udfyldning af Aandehulen *Tradescantia pulchella* [cfr. Holden: Occlusion of the stomata in Trad. pulch. (Ann. of Bot., vol. 27, 1913, p. 369)].

Endelig have vi i 1915[2]) et Tilfælde af Aandehulens delvise thylloïde Udfyldning ved Udvækst af Spalteaabningsnaboceller hos *Hakea suaveolens*; jeg formoder, at det her omtalte Tilfælde ligesom flere af de ovenfor nævnte er mere undtagelsesvis forekommende, ti ogsaa denne Art har jeg selv hyppig undersøgt, ganske vist som Væksthusmateriale, uden endnu at have iagttaget Fænomenet. Den Interesse, der særlig knytter sig til dette Paradigma, skulle vi senere omtale.

Ved at undersøge Bladene af *Griselinia litoralis* Raoul, en stedsegrön, nyzeelandsk Busk af Cornaceernes Familie, som dyrkes i vor botaniske Haves Væksthuse, og som udmærker sig ved sine læderagtige, glatte, helrandede Blade, blev jeg opmærksom paa et Fænomen, der optraadte paa de (hidtil alle af mig undersøgte) ældre Blade, hvis friskgrönne Farve havde veget Pladsen for en lidt falmet, gullig Tone, men som dog alle endnu vare langt fra at blive afkastede og sikkerlig endnu gjorde fuld Tjeneste, et Fænomen, som for denne Arts Vedkommende synes mig hidtil ukendt og i al Fald ikke omtales af Solereder[3]) eller af hans Kilde, Sertorius[4]). Et Tværsnit af Bladpladen viser os en dorsiven-

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[1]) Bulletin de la Soc. Bot. de Genève, 2ème Sér., Vol. VI, 1914; p. 16.

[2]) Vischer: Experimentelle Beitr. z. Kenntn. d. Jugend- u. Folgeformen xerophiler Pfl. (Flora, Bd. 108, 1915, p. 13).

[3]) System. Anat. d. Dicotyledonen, 1899, p. 488.

[4]) Anat. d. Cornaceen, Diss., München, 1893, og Bull. de l'Herbier Boiss., Vol. I.

tral, udpræget xeromorf Struktur. Oversidens Epidermisceller ere noget större end Undersidens, men Kutikulaen er meget tyk og stærkt gul paa begge Flader, Ydervæggene ere som sædvanlig de tykkeste, og der findes kun Spalteaabninger paa Undersiden. Paa Bladoversiden findes en ret tykvægget, klorofylløs Hypoderm, rimeligvis et Vandvæv, af et Cellelags Tykkelse, og derunder Mesofyllet udviklet som et Palissadevæv af ret korte Celler, liggende i et eller to Lag; det temmelig vel udviklede, meget lakunøse Luftvæv, som findes derunder, bestaar af et mere tyndvægget Armparenkym, hvori Aandehulerne danne smaa, paa Fladesnit gennem Vævet kredsrunde Kamre lige indenfor Spalteaabningerne. I dette Luftvæv findes talrige, meget tyndvæggede, klorofylløse Krystalstjerneceller, hvis Vægge ofte med Alderen opløses. Sklerenkymatiske Idioblaster, som findes hos visse *Griselinia*-Arter og andre Cornaceer, forekomme ikke her. Paa Karstrængenes Beskrivelse skal jeg her ikke gaa nærmere ind; de frembyde intet af særlig Interesse og vedkomme os i al Fald ikke i denne Forbindelse; de ledsages ikke af Styrkevæv.

Spalteaabningerne, som ere af Helleborus-Typen, omgives, naar de ses paa Fladesnit af Bladet, ikke af særegne Biceller; men de fire à seks Epidermisceller, som omgive dem, springe indvendig som smaa, tyndvæggede Udposninger frem over Lukkecellernes Inderside, naturligvis dog uden at lukke for Spaltens Opisthialaabning; dette falder lettest i Öjnene paa et tyndt Bladtværsnit, og et Blik paa Figuren (Tab. I, Fig. I) viser det bedre end mange Ord. Ses Epidermis fra Indersiden paa et Fladesnit (Fig. II), faas et Billede, der ligner noget det tilsvarende af *Buxus*, saaledes som Figuren hos Chodat[1]) viser. Men nu er det, at den Ejendommelighed, som har bragt mig til at undersøge *Griselinia*bladet nærmere, viser sig saa hyppig paa de lidt ældre Blade: Disse indre Udposninger vokse til, saa at de mødes midt under Spalten; de støde her sammen i en lang Kant, og Siderne afflades ved Trykket; idet

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[1]) Principes de Botanique, 1907, p. 292, Fig. 325. Sammenlign for øvrigt hermed Forholdet hos *Preissia*, Goebel: Organographie, II. Aufl., Bd II, Bryophyten, 1915, p. 617, Fig. 573. Cfr. ogsaa Tværsnitsfiguren 8 D, pag. 20 i: Børgesen og Ove Paulsen: Om Vegetationen paa de danskvestindiske Øer. Kbhvn. 1898, samt enkelte andre i samme Arbejde. Se ogsaa mange af Figurerne hos Hryniewiecki og Rehfous (l. c.)

de nu vokse yderligere (Figg. III—IV) indefter og endogsaa efter nogen Tids Forløb dele sig ved Tværvægge i 2 til 4 Celler, opstaar der et helt lille Vævlegeme i Aandehulen, hvorved Spalteaabningen afspærres fra denne og lukkes. Dette Vævlegeme er klorofylfrit i Modsætning til det omgivende, lakunøse Mesofyl; men dette kan ikke undre, da det nedstammer fra Epidermis. Ved denne thylloïde Tilstopningsmaade sættes mange Spalteaabninger ud af Funktion, og det xeromorfe Blads Luftskifte og Transpiration nedstemmes aabenbart væsentlig. Da Planten anvender saa stort et Apparat for at naa dette Maal, tör det formodes, at en simpel Lukning af Spalten i dette og lignende Tilfælde er bleven umulig for Bladet at udføre.

Den anden Art af thylloïd Spalteaabningslukning, den, som skriver sig fra Aandehulevævets, altsaa fra det lakunøse Luftvævs Virksomhed, har jeg fundet i de noget ældre Blade af *Campanula Vidalii* Wats. Da jeg tidligere[1]) har beskrevet deres anatomiske Forhold i Anledning af deres Mælkebeholdere, skal jeg ikke gentage det her, men kun minde om, at de ere meget tykke, læderagtige og blanke; deres stærkt dorsiventralt udviklede Mesofyl er omsluttet af en især paa Oversiden meget storcellet og med en Kutikula bedækket Overhud. Spalteaabningerne ere af samme Type som hos *Griselinia*, og Tværsnittene ligne meget det, vi fandt hos denne Plante; dog ere de saavel som Overhudens andre Elementer större. Lukkecellernes Naboceller pose sig ikke frem indenfor dem, og det saakaldte Hængsel er noget tydeligere end hos *Griselinia* (Tab. I, Fig. XI). Som det ses af Figg., vokse nogle af Luftvævscellerne ind i Aandehulen og trænge ofte frem til selve Lukkecellernes Inderflade, saa at vi se Spalten lukket paa samme Maade, som fremstillet hos Haberlandt i hans fysiologiske Anatomi for *Pilea*'s Vedkommende. Den fri Endeflade af disse thylloïde, her (i Modsætning til *Griselinia*) klorofylførende Aandehuleceller er meget stærkt fortykket (Figg. XI—XI), et Forhold, som ogsaa Hryniewiecki har fundet og afbildet paa én af sine Figurer, og som tiltager med Alderen, saa at der tilsidst, især naar flere Celler have deltaget i den thylloïde Vækst, er dannet temmelig svære, lagdelte Cellulosepropper lige under (el. indenfor) Spalteaabningerne.

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[1]) Sé: V. A. Poulsen: Anatomiske Studier (Oversigt over det kgl. danske Vidensk. Selskabs Forhandlinger 1915, Nr. 2).

Som et lille Bidrag til Aandehulens Histologi har jeg tænkt mig, at disse tvende her beskrevne Tilfælde, der ikke synes mig hidtil noterede, kunde have nogen Interesse.

Universitetets botaniske Laboratorium i Januar 1916.

Figurforklaring.

Alle Figurerne ere tegnede med Abbe's Camera Clara efter Zeiss's Mikroskop, Ocul. 4 Comp. samt Obj. 3 mm Apochr., og bagefter reducerede til den halve Störrelse.

Fig. I: *Griselinia littoralis*: Tværsnit af normal Spalteaabning. Undersidens Epidermis.

— II: Samme: Fladesnit af Bladundersidens Epidermis; Indersiden vender opad. Normal Spalteaabning.

— III: Samme: Tværsn. af en Spalteaabning; de fremvoksende Biceller have lukket for Opisthialspalten.

— IV: Samme: Lignende Tilstand; Snit som Fig. II.

— V: Samme: Lignende som Fig. III; de thylloïde Celler have delt sig.

— VI: Samme: Som Fig. IV.

— VII: Samme: Som Fig. V.

— VIII: Samme: Som Fig. VII; de thylloïde Celler danne et lille Vævkompleks.

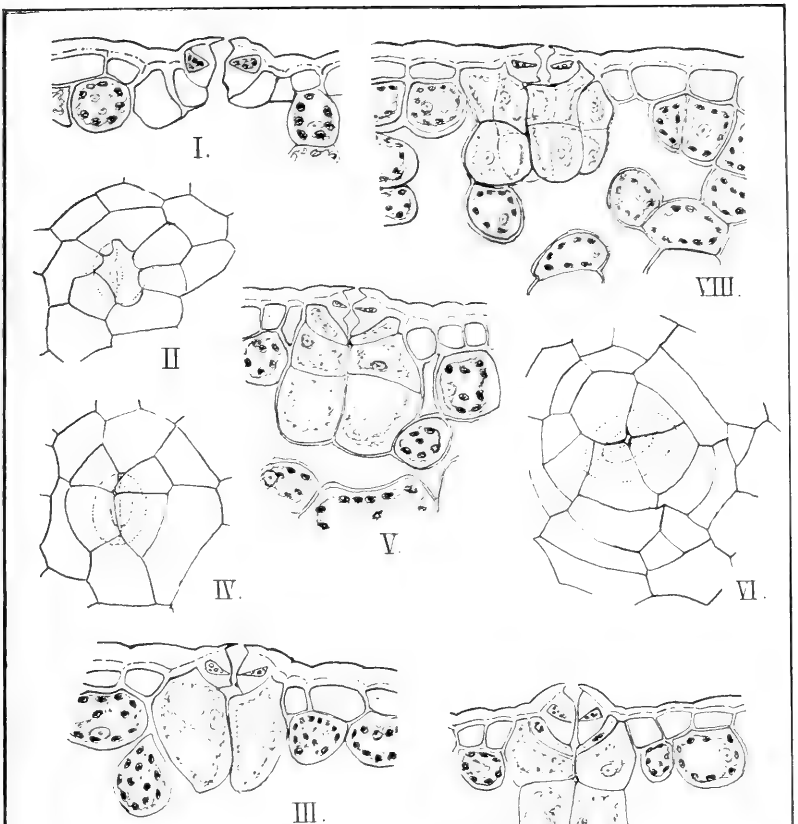
— IX: *Campanula Vidalii:* Tværsnit af Bladundersidens Overhud; Længdesnit af en Spalteaabning; Aandehulens Celler ere voksede ud og have fortykket Endevæggene.

— X: Samme: Lignende Tilstand.

— XI: Samme: Tværsnit af en Spalteaabning, indenfor hvilken en af Aandehulens Celler viser lignende Forhold som i Figg. IX og X.

3—3—16.

ANDELSBOGTRYKKERIET I ODENSE.



V. A. P. ad nat. del.

PLANTEANATOMISKE BIDRAG

AF

V. A. POULSEN

Særtryk af
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Planteanatomiske Bidrag.

Af

V. A. Poulsen.

(Meddelt i Mødet d. 16. Februar 1917.)

Hertil Tab. I og II.

Anatomiske Bemærkninger om Bladbygningen hos nogle Apocynaceer.

(Hertil Tab. I samt Textfigur 1.)

Acocanthera spectabilis (Sond.) Benth.

er en Busk eller et lille Træ fra Natal. Bladene, som her udelukkende interessere os, ere temmelig tynde, men meget stive og læderagtige, fjerribbede og helrandede. De ere udpræget xeromorft byggede; Oversidens temmelig smaa Epidermisceller have rette Sidevægge og meget tykke Ydervægge, som paa tynde Tværsnit af Bladpladen (Tab. I, Figg. 1, 2, 3) vise sig tydelig lagdelte, især ved Behandling med Kromsyre, med Kalihydrat eller med Klorzinkjod, hvilket sidste Reagens viser os deres Cellulosenatur samtidig med, at en tydelig, skarpt afsat Kutikula træder klart frem ved sin gule Farve; ved Behandling med Sudan III farvęs den smukt rød. Undersidens Epidermis er bygget ganske paa samme Maade, kun ere Cellerne her noget mindre. Bladkødets Celler ere paa Bladoversiden udviklede som et tydeligt, dobbelt Palissadelag, hvorunder der findes et Luftvæv, som er dobbelt saa tykt som Palissadevævet og ligesom dette fyldt med Klorofyl; dette Mesofyllets underste Væv begrænses af Bladundersidens Epidermis og indeholder de ikke synderlig store Aandehuler. I hele Luftvævet findes uregelmæssig fordelt en Mængde Krystalstjærner, vel sagtens i det mindste delvis af oxalsurt Kalk; umiddelbart under Palissadevævet strække Karstrængene sig; de större ledsages af Sejbast, de tyndeste ere omgivne af Parenkymskeder, som forøvrigt ikke ere særlig fremtrædende.

I alle ovenfor skildrede, anatomiske Træk er der intet særlig mærkværdigt; det er, som man kan vente sig af et dorsiventralt, xeromorft, dikotyledont Blad. Et Par Ejendommeligheder fortjene dog at fremdrages. Hypoderm og forslimede Epidermisvægge, som vi ellers ikke saa sjældent kunne træffe hos andre Apocynaceër og i det hele taget hos Xerofyter, forekomme ikke her; derimod er Kutikulaen paa Midten af hver Epidermiscelle paa Bladoversiden papilformet fremspringende (Tab. I, Fig. 2); om den, som Haberlandt i andre, lignende Tilfælde vil, skal betragtes som et Lysforstærknings-, et „Linse“-Apparat, faar staa hen; i vore Væxthuse reägere *Acocanthera*-Bladene ingenlunde tydelig paa Lysretningen. I hver enkelt af Undersidens Epidermisceller samt i enkelte, spredte af Oversidens, findes en smukt udviklet Enkeltkrystal (Tab. I, Figg. 2, 6 og 7), et Forhold, som i denne Familie, hvor det efter Halliers og Garcins Undersøgelser spiller en vis systematisk Rolle, fortjener at nævnes; det kan ligeledes anføres, at disse Celler føre Klorofyl; fem à otte blege, ofte særlig om Kærnen lejrede Korn forekomme i hver.

Men langt interessantere er Mælkecellernes Forhold, og det var det, som overhovedet bragte mig til at studere *Acocanthera*-Bladene nærmere. Medens man tidligere mente, at Mælkecellerne væsentlig holdt sig til Karstrængene og kun i ganske faa Tilfælde sendte Grene ud i Mesofyllet, hvor de da endte blindt i Cellemellemrummene, er man i den nyere Tid, da Familien i anatomisk Henseende er bleven mere detailleret undersøgt saavel af tyske som franske Forskere, bleven belært om, at Mælkecellegrene netop hos ikke saa faa Slægter strække sig ud i Bladkødet; den paagældende Litteratur herom vil man finde i Solereders systematiske Anatomi, og jeg skal ikke opholde mig derved paa dette Sted; imidlertid har jeg ikke i disse nyere Undersøgelser fundet det Fænomen omtalt, som nu skal skildres. Som det fremgaar af Tab. I, Figg. 1, 2 og 3, der fremstille Snit vinkelret paa Bladoversidens Epidermis, forlænge en Gang imellem Grene af Mælkecellerne, der i Mesofyllet have strakt sig fra Karstrængene ud i Cellemellemrummene, sig gennem Palissadernes snævre Intercellulærer lige til Epidermisindersiden, hvor de hyppigst støde til denne paa Steder, hvor tre eller fire Overhudscellers Sidevægge støde sammen og vise et tykkere, trekantet Hjörne, hvis Cellerne (paa et Fladesnit) ses fra Ydersiden (Tab. I, Fig. 12). De standse imidlertid ikke her, men bore sig ind i disse Radialvægge og naa ofte næsten helt ud til Kutikula, men heller ikke længere; Udposninger eller Papiller, der springe frem over Overhudens Niveau, dannes ikke. Af og til sker det, at Mælkecellernes Grene træffe de epidermale Radialvægge paa et Punkt imellem Hjörnerne og bore sig ind her, men dette Tilfælde er sjældnere; betragtes Overhuden paa Fladesnit, vise Tværsnittene af de i Membranerne indtrængte Mælkeceller sig som meget smaa, tæt plasma-el. saftfyldte Rum i de trekantede Cellehjörner eller som Udvidelser af de ellers lige Radialvægge; en yderst sjælden Gang har jeg truffet begge Tilfælde ved samme Cellevæg (cfr. Tab. I, Fig. 12 og 15). — Ganske lignende Indboringer kunne findes i Cellemembranerne i Bladundersidens Epidermis, men her ere de, efter hvad jeg har iagttaget, meget sjældne.

Dette ejendommelige Forhold, hvis Betydning ikke er klar, findes ikke hyppig i Planteriget, eller er i det mindste hidtil ikke angivet fra mange andre Steder; det er sikkerlig sjældent, men jeg skal dog minde om, at det findes hos *Siphocampylus* og, som jeg selv har vist, hos en Art af Slægten *Campanula*[1]), samt hos et Par nedenfor nærmere omtalte Apocynaceer.

Inden vi forlade *Acocanthera*, maa en lille Ejendommelighed, der aabenbart hænger sammen med Bladets xeromorfe Struktur, endnu omtales. Den angaar Spalteaabningerne. Disse ere af en noget anden Type end den for Familien sædvanlige og, som det fremgaar af Tab. I, Figg. 6 og 7, ere de omgivne af nogle Kredse af Biceller i radial Ordning. Deres Lukkeceller have overordentlig tykke Yder- og Indervægge, og Forgaarden, som er stor og dyb, danner et lille, vindstille Kammer ovenover den egentlige Spalte. Paa Tværsnittet viser Eisodialaabningen sig begrænset af en usædvanlig skarpt afsat Liste (kun et extremt Tilfælde af den her sædvanlig tilstedeværende, især hos visse Liliiflorer, hos *Cypripedilum* o. m. a. veludviklede, skarpe Kant, som allerede fremhæves hos de Bary),[2]) mellem hvis af Kutikulaen dannede Kanter Forgaards-

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[1] Se: V. A. Poulsen: Anatomiske Studier (Kgl. danske Vidensk. Selsk. Oversigter, 1915, Nr. 2).

[2]) Vergl. Anatomie, 1877, pag. 37 og 75; se ogsaa: Weiss: Allgem. Botanik I, Anat. d. Pflanzen, 1878, p. 384.

spalten dannes. Denne plejer at have samme aflange Form, (naar den ses paa Fladesnit), som selve den egentlige Spalte, der jo ligger dybere; men her hos *Acocanthera* er denne Eisodialspalte indskrænket til et cirkelrundt, temmelig lille Hul (Tab. I, Fig. 7), hvorved der væsentlig bidrages til Dannelsen af Vindstille i Kammeret underneden.[1] Den cirkelrunde Eisodialaabning ses paa ufarvede Glycerinpræparater med nogen Vanskelighed paa Grund af dens overordentlig tynde Rands Lighed i Lysbrydning med Glycerinen; men farves Præparatet med Jodjodkalium eller med Sudan III (i mættet alkoholisk Opløsning), træder Aabningen tydelig frem i Vand. Den omtalte Liste, der springer noget frem over Overhudens Niveau, er imidlertid ogsaa paa sin Rygside forsynet med et Fremspring (Tab. I, Figg. 4 og 5), hvilket hidtil næppe er kendt andensteds, og hvis Betydning er mig gaadefuld.

Betragtes Spalteaabningerne (paa Fladesnit) indenfra, ser man samtlige Biceller springe frem imod hverandre, dog uden at selve Spalten afspærres; deres Fremspring ses naturligvis ogsaa paa Tværsnittet. Jeg har hos *Acocanthera* ikke iagttaget Tilfælde af Spaltelukning ved Sammenslutning af disse Biceller, men ifølge egne Erfaringer, som jeg nu har[2]) fra flere Steder, tvivler jeg ikke om, at en saadan Tillukning vel maa kunne træffes paa ældre Blade, naar Omstændighederne ere dertil.

Carissa grandiflora A. D. C.

(*Arduina gr.* E. Mey.)

Erfaringen fra Studiet af *Acocanthera's* Blade, som jeg havde foretaget for Undervisningens Skyld, eftersom denne Plante er en stærk Giftplante, bragte mig til at se nærmere paa andre Apocynacé-

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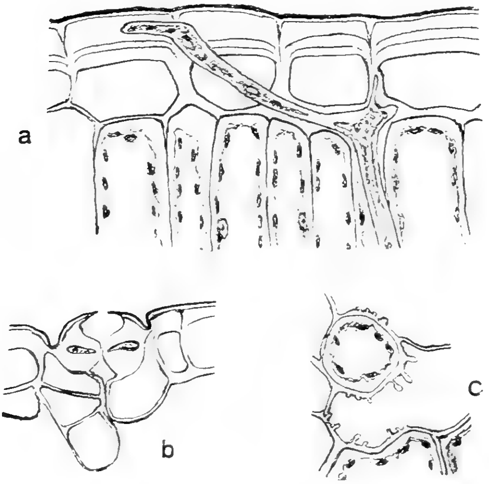
[1] Brown & Escombe (Philos. Transact., vol. 193, 1900, p. 223) have som bekendt i et vigtigt Arbejde paavist den store Betydning, som Spalteaabningerne have for den Hastighed, hvormed Bladets Vanddamp strömmer ud igennem dem; hvorledes Udströmningshastigheden forholder sig gennem Hullerne i saadanne Forgaardskamre som ovennævnte og lignende, der jo ikke saaledes som de egentlige Spalter kunne reguleres, kende vi endnu ikke.

[2] V. A. Poulsen: Spalteaabningerne hos *Griselinia litoralis* (Vidensk. Medd. fra naturh. Forening, Bd. 67, 1916; p. 137).
do. Nogle extraflorale Nektarier (Ibid., 1897, p. 356, heri om Spalteaabn. hos *Fagraea*).

blade, deriblandt paa de temmelig smaa, læderagtige, elliptisk-lancetformede og helrandede mørkegrönne Blade af *Carissa grandiflora* A. D. C. fra Natal, som dyrkes i vor botaniske Have. De ere temmelig tykke, og deres xeromorfe Struktur, som allerede viser sig ved et tykt Voxlag, er i Hovedsagen ganske som hos *Acocanthera*, med hvilken de iøvrigt i anatomisk Henseende have stor Lighed. Oversidens Epidermisceller ere dog ikke forsynede med de kutikulære Ydervægsfortykkelser; Mælkecellerne ere temmelig tykvæggede, og Palissaderne udmærke sig ved deres store Længde; navnlig gælder dette det yderste af de to Lag, hvori de forekomme, og Bladpladens dorsiventrale Bygning er saaledes særdeles udpræget; det kan dog bemærkes, at Blade, som have voxet noget mere i Skygge, have kendelig kortere Palissader; i den Henseende reagerer dette Væv aabenbart her som saa mange andre Steder ret iöjnefaldende paa Lyset. Uden iøvrigt nærmere at dvæle ved detailleret Fremstilling af Bladets Histologi, skal jeg omtale det interessanteste Bygningstræk, som *Carissa*-Bladet har tilfælles med *Acocantheras*: Mælkecellerne sende her som der tynde, stærkt saftfyldte Grene fra Hovedstammerne inde ved Karstrængene ud i Mesofyllet, hist og her lige ud til Overhuden og ind i dennes Radialvægge indtil Kutikula; dette finder Sted baade paa Bladets Over- og Underside; Figurerne (Tab. I, Figg. 9, 10, 11), som fremstille dette Forhold, trænge efter det foregaaende næppe til nöjere Forklaring.

Et eget Tilfælde, som jeg har truffet nogle Gange, men som ikke er fundet hos *Acocanthera*, findes afbildet i omstaaende Textfigur (1, a); her løber Mælkecellegrenen stærkt paa skraa ind i Epidermisvæggene og forlænger sig et lille Stykke i vandret Retning i Ydervæggen lige under Kutikula. Denne skraa Indtrængen i Sidevæggene er i det Hele taget ikke saa sjælden hos disse Apocynaceer.

En anden Ejendommelighed, som dog især træffes i gamle Blade, skal dernæst nævnes: Ved thylloid Udvæxt af Spalteaabningernes Biceller, hvorved Aandehulerne tildels eller endog aldeles udfyldes, tillukkes ligesom hos *Griselinia* (se mit ovenfor citerede Arbejde) Spalterne indenfra, og deres Funktion hører op. De thylloide Celler kunne endog dele sig (se Fig. 1 b), saa at de paa et Bladtværsnit ikke blot komme til at ligne de af mig (loc. cit. 1897) allerede for tyve Aar siden afbildede hos den javanske *Fagraea*, men ogsaa dem, jeg i 1916 beskrev hos *Griselinia*.



Textfig. 1.
a: *Carissa grandiflora*: Snit gennem Bladets Overside, vinkelret paa Fladen: en Mælkecellegren skyder sig hen under Ydervæggens Kutikula.
b: Samme: Spalteaabningen tilstoppes ved Udvæxt af Bicellerne i Aandehulen: Snit fra Bladundersiden.
c: Samme: Membranprotuberanser i Luftvævets Intercellularrum.
Tegnet med Abbe's Tegneapparat efter Zeiss: Ocul. 4 og Obj. 3 mm og formindsket.

Endnu et histologisk ejendommeligt Fænomen, som man ligeledes kan finde hos gamle Blade, der dog imidlertid ingenlunde ere ude af Funktion, skal paapeges. Man vil paa Ydersiden af Luftvævets Celler, altsaa paa Vægpartier, der direkte grænse op til de store, luftførende Intercellularer, paa flere Steder finde en Mængde smaa, klare, halvkugleformede eller tapformet fremragende, ofte temmelig tætstillede, men i enkelte Partier af Vævet ogsaa kun ganske enkeltvist forekommende Cellehindeprotuberanser (se Textfig. 1, c). Det er Dannelser, som svare til dem, der i 1873 opdagedes hos *Marattiaceer*[1]) og andre Bregner; i 1887 fandtes lignende i visse Palmepneumatophorer[2]); jeg selv opdagede Forekomsten af dem hos en *Paepalanthus*-Art[3]) i 1888; 1889 (og 1892) findes de i *Leguminos*-Frøskaller,[4]) 1892 i visse *Jordorchideers* Rodbark,[5]) 1893

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[1]) Luerssen: Botan. Ztg. 1873, p. 641. Cfr. ogsaa Mangin: Morots Journ. de Bot. 1893, Vol. 7, p. 37, (*Equisetum*) og Eva Schumann: Flora, Bd. 108, 1915, p. 211.

[2]) Jost: Bot. Ztg., Bd. 45, p. 601.

[3]) V. A. Poulsen: Vidensk. Medd. fra naturhist. Foren., 1888, p. 325.

[4]) Mattirolo e Buscaglioni: Memorie della R. Acc. delle Scienze di Torino; Ser. II, t. 42, pars I, p. 63; cfr. ogsaa Schips: Ber. d. deutschen bot. Ges. 1893.

[5]) Noack: Ber. d. Deu. Bot. Ges., X, 1892, p. 645.

i Bladenes Luftvæv hos visse *Helleborus*-Arter[1], i 1903 i Æbler.[2]) Medens jeg omtaler disse Dannelser her hos *Carissa* i de ældre Blade, skal jeg ikke undlade at anføre, at ligesom de, saa vidt jeg har kunnet se, ikke tidligere have været bemærkede her eller overhovedet hos andre Apocynaceer, ere ganske lignende intercellulære Vægprotuberanser af mig fundne i Luftvævet hos **Ligustrum lucidum** Ait. (*Lig. japonicum & coriaceum* Blume),[3]) hvor de endda ere tilstede i betydelig större Antal. Denne Plantes læderagtige, mørkegrönne, ikke ret store Blade, paa hvis anatomiske Struktur jeg her iøvrigt ikke skal gaa nærmere ind, har i Hovedsagen egentlig ganske samme Bygning som *Carissas*; Palissadevævet bestaar dog her af flere Cellelag, og Mælkeceller findes naturligvis ikke, ligesom ogsaa Forekomsten af indsænkede Kirtelhaar[4]) paa Bladoversiden o. a. m. danne en Forskel.

Efterat de to i det foregaaende behandlede Apocynacé-Arter begge havde vist mig et hidtil upaaagtet Forhold ved Mælkecellerne, har jeg undersøgt en Del andre af denne Families Medlemmer, især saadanne med læderagtige og stive Blade, fra vor botaniske Haves Væxthuse, og det viste sig da, at den paapegede histologiske Ejendommelighed ogsaa forekommer hos

Allamanda verticillata Desf.,

en kransbladet, sydamerikansk Art, hvis Skudspidsers egenartede Dække er beskrevet af Raunkiær[5]), og som jo ikke er saa fjærnt beslægtet med de tvende i det foregaaende omtalte Arter.

Bladene, som ere smalt lancetformede og helrandede, ere temmelig tynde; et Tværsnit viser os deres udpræget dorsiventrale Struktur; Palissaderne forekomme kun i ét Lag og ere ikke saa lange som hos *Carissa*, men den brachyodiske Tilslutning til Luftvævet er i det mindste paa mange Steder saare iöjnefaldende.

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[1]) Nestler: Nova Acta Leop. Carol. Acad., Bd. 61, p. 33. — Drobnig: Wurzelknollen, Diss. Rostock, 1892, p. 41.

[2]) Küster: Pathol. Anat, 1ste Ausg., p. 166.

[3]) Se: Dippel: Handbuch d. Laubholzkunde, I, 1889, p. 130. O. G. Petersen: Træer og Buske, 1916, p. 478 (den Form, jeg har undersøgt, hører sikkert til den heri under Navn af *L. japonicum* Thbg. opførte).

[4]) Cfr.: Schwendt: Zur Kenntniss der extrafl. Nekt., Diss., Göttingen, 1906; p. 23, og Tab. I, Fig. 20.

[5]) Planterigets Livsformer, 1907, pag. 32, Fig. 12 D.

Imellem Over- og Undersidens Epidermisceller er Forskellen meget betydelig; Oversidens frembyde intet særlig mærkeligt; Ydervæggene ere ikke stærkt fortykkede, men deres Kutikula er ret kraftig. Undersidens udmærke sig derimod ved deres Ydervægges centrale Udposning som en höj, söjleformet, i Spidsen lidt hovedformet opsvulmet Papil; hele Cellens Yderside er besat med stærkt fremspringende, især paa Papillen tætsiddende, grenede Kutikularlister, hvilket saavel paa Bladets Tvær- som Fladesnit giver et ganske egenartet, mikroskopisk Billede. De Söjlepapiller, som udgaa fra de nærmest omkring Spalteaabningerne liggende Celler, hælde konvergerende imod hverandre ind over Spalten. Noget lignende, maaske endda mere indviklet, ses, saa vidt mig bekendt, kun hos *Willoughbeia grandiflora* Dyer[1]). Spalteaabningerne, der kun forekomme paa Bladundersiden, frembyde intet særligt.

I disse Blade forekommer der nu mange Mælkeceller. Deres Hovedstammer følge Karstrængene, men Sidegrene skyde sig ud i Mesofyllet, og saa vel paa Bladets Over- som paa dets Underside naa de direkte ud til Epidermis. Man iagttager nu her ligesom hos de tvende ovenfor undersøgte Arter, at Enderne af disse lange, hyfeagtige Celler, der her ere forholdsvis vide og tæt mælkefyldte, bore sig ind i Radialvæggene, hyppigst i Cellehjörnerne, men ingenlunde sjældent midt paa Væggene (Tab. I, Figg. 13, 14, 16, 17); de Grene, som gaa til Oversidens Epidermis, bane sig ofte Vej paa skraa gennem Palissadevævet, og medens deres yderste Spids, der oftest støder mod Kutikula, hos *Acocanthera* og *Carissa* sædvanlig er snævrere end den øvrige Strækning, er den her hos *Allamanda* i Regelen lige saa bred som denne.

Foreløbig synes de her behandlede Tilfælde (sammen med det af mig tidligere hos *Campanula Vidalii* og af Trécul hos *Siphocampylus* opdagede) at være omtrent de eneste kendte af deres Art; en Apocynacé, som det paa Grund af dens Slægtskab med de tre ovenomhandlede ligger nær at undersøge i Henseende til dette Forhold, er *Landolphia*; de to af mig undersøgte Arter have imidlertid ikke vist sig at indeholde Mælkeceller, som trænge ind i Epidermis, og en Del andre Slægter af andre Grupper lige saa

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[1]) Hallier: Kautschuklianen, (Jahrb. d. Hamb. wiss. Anstalten, XVII, 3. Beih., 1900, p. 289).

lidt, saa at det altsaa synes, som om denne histologiske Ejendommelighed er begrænset til en enkelt Afdeling indenfor Familien. I Asclepiadaceernes meget nærstaaende Familie har jeg endnu ikke kunnet paavise Fænomenets Forekomst, trods Undersøgelse af flere Slægter. Kun kan det endnu fremhæves, at vi muligvis hos visse *Euphorbiaceer* kunne finde et lignende Forhold. Daguillon og Coupin[1]) have i 1904 paavist Mælkecellegrene, som i de extraflorale Nektarier hos *Hevea brasiliensis* trænge sig helt op imellem de secernerende Epidermispalissader (medens Parkin, der mærkelig nok samtidig [Ann. of Bot., Vol. 18, p. 217] har undersøgt de samme Nektarier, synes at have overset dette Forhold eller i hvert Fald intet angiver derom); jeg har selv undersøgt de paa Bladstilkens Overside lige ved Pladens Basis i et Antal af to eller tre siddende Nektarier hos *Hura crepitans*, første Gang i 1875 (Nat. Foren. vidensk. Medd. p. 271) og nu atter i denne Anledning; skönt de i Hovedsagen ere byggede som *Hevea*'s og findes hos en Slægtning af denne, finder jeg dog ikke med Hensyn til dette Punkt nogen Lighed med Hevea-Nektarierne: Mælkecellernes Grene strække sig lige til de secernerende Palissaders eller Prismecellers Basis, men skyde sig ikke ind imellem dem.

Bladkirtlerne hos Actinostemma Griff.

(Hertil Tab. II og Figg. 1 og 2 paa Tab. I).

Slægten *Actinostemma* er opstillet af Griffith[2]) i 1854. Han henførte den til *Cucurbitaceerne* og skriver i sin Diagnose bl. a.: „..... Folia ..... dentibus basilaribus singulis vel binis utrinque glanduliferis.....“. Hos Endlicher,[3]) hvor den er henregnet til den af senere Forfattere igen opgivne Familie *Nhandirobeae*, er denne Ejendommelighed ved Bladene, der muligen ikke er lige fremtrædende hos alle Arter, og som i hvert Fald ikke er lige stærkt udviklet hos alle Blade, og som navnlig paa de ældre bliver særdeles utydelig, slet ikke nævnt; derimod finde vi det bemærket

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[1]) Revue générale de Bot., t. XVI, p. 81.

[2]) Griffith: On Dr. Cantors collect. 24, t. 3.
do. Posthum. Papers; Notulae, pars IV, p. 601.

[3]) Endlicher: Genera pl., Suppl. IV, pars III; p. 50.

i Hookers Icones[1]) ved Omtalen af *Act. biglandulosum* Hemsl. (samlet i Yunnan af Hancock og A. Henry): „folia ..... lobis glandula parva clavata instructis“; der siges udtrykkelig, at „Kirtlerne“ „on the basal lobes of the leaves are very marked“; de findes her ogsaa paa de bredere Brakteer, som støtte de nedre Topgrene paa Hanblomsterstanden. Derimod ere de ikke nævnte i Slægtsdiagnosen hos Bentham & Hooker[2]) eller hos Engler & Prantl,[3]) ligesom heller ingen af de nævnte, udelukkende systematiske Forfattere antyde, hvad det er for en Slags Kirtler. Det er ejendommeligt, at denne Karakter heller ikke anføres for nogen af fire Arter, der nævnes i Cogniaux's store Monografi,[4]) i hvilken for øvrigt den ovennævnte *biglandulosum* ikke er nævnt, ikke en Gang som Synonym.

I vor botaniske Haves Væxthuse dyrkes en Art, *Actin. paniculatum* Max.[5]) fra Kina; den udmærker sig bl. a. ved sine ejendommelige Ammeorganer og er for den øverste Dels Vedkommende afbildet af Bois,[6]) som anbefaler den som Prydplante, for den nederste Dels af Raunkiær,[7]) der opfører den iblandt de dikotyledone Løg-Geofyter. Arten synes at spille en Rolle som en undertiden anvendt Forfalskning af visse Fritillaria-Løg, der finde Anvendelse i den kinesiske Materia medica. Denne Plantes Blade have, hvad man noget utydelig kan se paa den iøvrigt meget vellignende Tegning hos Bois, (som i sin Text siger: „la base de chaque lobe inférieure porte un ou deux glandes jaunâtres“,) lignende „Glandler“ paa sine Blade som *Act. biglandulosum*, og da jeg i en lang Række Aar fra Tid til anden har studeret den Slags Organer, har jeg, da Materialet velvilligst blev stillet til min Raadighed af Universitetets botaniske Have, benyttet Lejligheden til at studere disse her forekommende lidt nöjere, da jeg ikke kan finde dem nærmere omtalt andensteds. Man skulde navnlig vente dem

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[1]) Vol. VII, pl. 2622, 1899 (cfr. smst., pl. 2645, som supplerer foreg.).

[2]) Gen. plant., I, p. 839.

[3]) Die natürl. Pflanzenfam., IV, Abt. V, p. 13.

[4]) I Decandolle: Monographiae Phanerogamarum Prodromi continuatio, Vol. III, p. 920.

[5]) Oprindelig Mitrosicyos panicul. Max. i Primitiae florae Amurensis, p 113.

[6]) Journ. de la soc. nationale d'Horticulture de France; Février 1900.

[7]) Planterigets Livsformer, Gyldendal 1907, p. 111, Fig. 68.

beskrevne hos Yasuda,[1]) der anatomisk har undersøgt en Mængde Cucurbitaceer, ogsaa og særlig deres Blade, og som netop blandt sine Studieobjekter har *Actinostemma*; men om disse Organer har han intet. Solereder,[2]) som ogsaa nævner den anførte, japanske Forfatter, siger, at extranuptiale Nektarier i det hele taget almindelig forekomme paa Bladundersiden hos Cucurbitaceerne, men at de endnu ikke ere nærmere undersøgte, omendskönt de forlængst have været kendte af „Systematikere og Biologer“; jeg kan ikke undlade at bemærke, at de nævnte Organer dog ikke kunne kaldes saa ganske uundersøgte, da baade Delpino[3]) og jeg selv[4]) allerede for mange Aar siden ret nöje have studeret dem.

Fra 1906 foreligger der en Undersøgelse af nogle extraflorale Nektarier af Schwendt[5]); i Begyndelsen af sit Arbejde opregner han de af ham undersøgte Arter, deriblandt *Actinostemma paniculatum* Max. Alligevel foreligger der intet om denne Plante fra hans Haand, thi han skriver: „Interessante Verhältnisse zeigen unter anderen die Nektarien von Act. panic. u. Plumbago rosea, doch sind die Untersuchungen noch nicht so weit gediehen, dass sie hier veröffentlicht werden konnten.“ Det er mig ubekendt, om de senere ere blevne det, men det ses dog af dette Citat, at Forfatteren henregner dem til samme Kategori som de øvrige Organer, han har studeret, og af en ganske enkelt Yttring et Sted i hans Arbejde fremgaar det, at han med Fehlings Vædske har faaet Sukkerreaktionen frem.

I et andet Arbejde, nemlig af Aufrecht,[6]) i hvilket ogsaa nogle af de af mig tidligere studerede Nektarier ere genundersøgte, er *Actinostemma* ikke nævnt. Det samme gælder om det nyeste Arbejde om denne Organkategori af Böhmker.[7])

Paa det Materiale, som har staaet til min Raadighed, og, som

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[1]) Compar. Anat. of the Cucurb. (Journ. of the College of Sc. Univ. of Tokyo, Vol. 18; 1903).

[2]) System. Anat. der Dikot., Ergänzungsband; 1908, p. 161.

[3]) Funzione myrmecofila nel Regno vegetale [Mem. d. Reale Acc. d. Sc. dell'Istituto di Boglogna 1886; Parte prima, p. 82).

[4]) Vidensk. Medd. fra naturhist. Forening for 1875; pag. 256.

[5]) Zur Kenntniss d. extrafloralen Nektarien; Diss. Göttingen, 1906.

[6]) Beitrag zur Kenntniss extrafloraler Nektarien: Diss. Zürich, 1891.

[7]) Beiträge zur Kenntniss der floralen u. extrafloralen Nektarien, Beihefte z. bot. Ctrbl., Bd. XXXIII, Ab. I, 1917; p. 169).

ovenfor nævnt, er bestemt til *Act. paniculatum* Max., havde jeg allerede for nogle Aar siden lagt Mærke til de kirtelagtige Organer, men jeg havde lagt mine Tegninger og Optegnelser ad acta, da jeg ventede paa Schwendts Publikation. Nu ere ti Aar gaaede; jeg tillader mig nu at fremsætte mine egne Iagttagelser. Paa de spredte, fodnervede, lappede, temmelig tynde Blade ende de basale Lapper i et Antal af en eller to paa hver Side af Midtribben i en ejendommelig, blegt gulgrön, bredt afrundet, tungeformet Spids helt ulig Bladpladens andre Spidser. Dens basale Del er ofte lidt smallere, og med denne „Tungerod" gaar den over i Bladets øvrige, friskgrönne og betydelig tyndere Substans. Dette ret iöjnefaldende Legeme er „Kirtelen", og det er denne Dannelse, som har skaffet en allerede ovenfor nævnt Art Navnet *biglandulosum*, hvoraf ses, at den af tidligere Forskere har været opfattet som en Glandel, omend ingen, saa vidt jeg har kunnet se, egentlig har iagttaget nogen Sekretion (Tab. II, Figg. 1 og 2). Denne Kirtel er flad eller undertiden lidt skeformet udhulet paa Oversiden; Undersiden er hvælvet. Allerede ved stærk Lupeforstörrelse viser Undersiden sig besat med nogle meget smaa, rundagtige Pletter; et Fladesnit lagt under Mikroskopet viser dem især udbredt over Tungens basale Halvdel, paa hvilken der til Gengæld kun ses yderst faa eller aldeles ingen Spalteaabninger; disse findes i langt större Antal paa Tungerodens Underside (og i det hele taget paa den øvrige Bladunderside). Ved stærkere Forstörrelse (Figg. 3—6, Tab. II, og 1, Tab. I) og paa Præparater, der ere behandlede med Klornatron eller med Kalihydrat, ses hver saadan lille Skive eller Plet at bestaa af en elliptisk eller kredsrund, svagt udadhvælvet eller næsten plan Gruppe af tyndvæggede, plasmafyldte Celler uden Cellemellemrum, begrænset af en enkelt Række i Forhold til Skiven tangentialstrakte Celler af indbyrdes ulige Störrelse; paa forholdsvis större Skiver er det indenfor dette Grænselag liggende Cellevævs Ordning oftest temmelig uregelmæssig og Antallet af Celler ubestemt; men i de mindre eller meget smaa Skiver, hvoraf flere for Celledelingens Vedkommende synes ligesom standsede paa et tidligere Udviklingstrin, kan man (Tab. II, Figg. 3, 4, 5) erkende en vis Regelmæssighed, som minder om Cellearrangementet i mangt et skjoldformet eller skivedannet Haar, hvor Celledelingsfølgen ikke er bleven utydelig ved senere, uregelmæssige Delinger eller Forskydninger af Væggene ved uligeartet Væxt. Hvis vi betragte Tvær- eller Længdesnit vinkelrette paa den lille Bladtunges Overflade (Tab. II, Fig. 7), finde vi for det første, at selve Tungen er tykkere end den øvrige Bladplade; denne bestaar, Overhuden iberegnet, af c. syv Cellelag, hvorimod Tungens Substans er dannet af saa meget som indtil 14 à 16. Dernæst ses paa tynde Snit eller paa saadanne, der ere klarede i Kalihydrat eller Klornatron, at de nys omtalte, rundagtige Organer bestaa af tyndvæggede, polygonale, tæt plasmafyldte Celler uden Cellemellemrum og som plankonvexe, af et ejendommeligt, næsten endodermlignende Cellelag begrænsede Vævlegemer ere indsænkede i det øvrige, noget mere storcellede Væv; det begrænsende Cellelag er det samme, som danner den paa Fladesnittet synlige Cellering.

Indholdet i alle disse det indsænkede Organs Celler er det samme: en tæt Protoplasmamasse med tydelig Cellekærne. Det synes heri ikke at afvige fra Cellevævet i den øvrige, tungeformede Bladspids. Det er det samme Slags Væv, vi finde i saa mange secernerende Organer. Krystaller, Klorofyl- og Stivelsekorn eller större Oliedraaber forekomme ikke: det hele Væv farves ensartet mørkt gulbrunt med Jodjodkalium og Jodtinktur. Herved afviger det nemlig stærkt fra det assimilerende Bladvæv; thi dette farves næsten ganske sort af Jodreagenserne, og ved Anvendelsen af disse vises det ogsaa meget let, at selve Overhuden er klorofylførende. Der findes i hver Overhudscelle 5 à 7, sjældnere flere eller færre, assimilerende Klorofylkorn, som paa Fladesnit af det levende Blad vise sig betydelig blegere grönne end Kornene i Mesofyllet; men i den Overhud, som beklæder Kirteltungen, findes intet Klorofyl. Kun i Parenkymskederne omkring de fine Karstrænge, der fra Bladets Randnerver strække sig ind i Tungerne, samt i Sirørene findes der en saare finkornet Stivelse. Ved Anvendelsen af svovlsurt Jernforilte eller vandig Ferrikloridopløsning antage samtlige Celler i den tungeformede Kirtel en svag sortartig Farve: Garvesyrereaktion.

Cellevæggene i Tungens Parenkym og i de omtalte skiveformede Organer, der i Parenthes bemærket ikke staa i noget Forhold til de nævnte Karstrænge, bestaa af Cellulose. Nu vide vi fra fleres

Undersøgelser, f. Ex. Correns,[1] Elsler,[2] Schwendt,[3] Böhmker (l. c.) o. a., at det Cellelag, som begrænser det secernerende Væv indadtil, og som ofte ligesom her hos *Actinostemma* er ret fremtrædende ved sine Vægges, især Radialvæggenes optiske Udseende, i sine mikrokemiske Forhold afviger fra de andre Cellevægge og synes kutiniserede, lignificerede eller endog begge Dele samtidig.[4] Det har da Interesse at prøve dette Cellelag her med Hensyn til dette Forhold; jeg har fundet, at de ere meget resistente overfor Kalihydrat og Svovlsyre, at de farves gule af Klorzinkjod, lidt rødlige efter længere Tids Behandling med alkoholisk Sudan III-Opløsning samt (især de radiale) røde med Floroglucin-Saltsyre (ogsaa efter Præparatets Behandling med Klornatron). De ere altsaa svagt forkorkede og tydelig farvede; men det er jo iøvrigt ikke ualmindeligt, at forkorkede Cellevægge indeholde Lignin.

Spörge vi nu om disse Organers Udviklingshistorie, maa vi vende os til de yngre og yngste Blade. Det tungeformede Organ anlægges som Opsvulmninger af de basale Bladtænder allerede paa temmelig smaa Bladplader, endnu inden Mesofyllagene ere indbyrdes uddifferentierede, men dog adskillig Tid efter at Karstrængene ere anlagte. Det begynder at udpræges, naar Bladpladen er c. 3 mm lang, og opnaar hurtig sin endelige Störrelse af en Millimeter el. lidt mere; denne Længde har det paa en 6 mm's Plade, paa en 12 mm's og endnu paa en af 25 mm's Længde. Bladet, hvis Spalteaabninger ere i Færd med at anlægges, men hvis Epidermis-Sidevægge endnu ikke ere blevne bølgede (Tab. II, Fig. 11), er tæt besat med Kirtelhaar (Tab. II, Fig. 13), som først langt senere falde af. I Randen af Bladet udvikles der nogle korte, tykke, faacellede Børstehaar, hvis Endeceller ere kegleformede, i Spidsen noget afrundede, temmelig tykvæggede og (især senere) kutikularstribede; de blive siddende paa Bladet og give Randen et meget fint savtakket Udseende, naar den betragtes under Lupen.

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[1] Anat. und Entwickelungsgeschichte d. extranupt. Nekt. von Dioscorea (Sitzungsber. d. Wienerakad., Bd. 97, Abt. I, 1888).

[2] Das extrafl. Nektarium etc. bei Diospyros discolor Willd. (Sitzungsber. d. Wienerakad., Bd. 116, Abt. I, 1907).

[3] Zur Kenntn. extrafl. Nekt. Diss. Göttingen, 1906.

[4] Cfr. V. A. Poulsen: Nogle extrafl. Nektarier (Vidsk. Medd. fra nat. Foren., 1897; p. 368, Shorea).

Disse Haarformer høre op paa Overgangen til den tungeformede Ende af Fligen (eller Fligene, hvis der er flere), altsaa paa Tungeroden; allerhöjest kan nu og da et enkelt, og da oftest et kortstilket eller, som jeg har set det en sjælden Gang, siddende Kirtelhaar endnu forekomme paa den egentlige Tunges Overflade imellem de skiveformede Organer. Ogsaa Spalteaabningerne mangle paa (i al Fald största Delen af) denne Flade. Allerede paa dette yngre Stadium udpræges Tungevævets ejendommelige Beskaffenhed som Sekretionsvæv: det uddanner intet Klorofyl, Plasmaet bliver tæt, og der udvikles ingen (eller kun hist og her yderst smaa) Intercellulærer.

De ejendommelige, skiveformede Organer udvikles nu, og deres Udvikling foregaar ret hurtig: det hele, tungeformede Bladafsnit spiller aabenbart en Rolle paa det yngre Blad, thi senere, naar Bladene ere helt uddannede, skrumper det ind, bliver brunligt og visner. En Skives Anlæg begynder med, at en eneste Epidermiscelle bliver noget större og hvælver sig mere frem end Naboerne (Tab. II, Fig. 10); ganske paa samme Maade anlægges et Haar. Den saaledes fremhvælvede Initialcelle deles ved en periklin el. horizontal Væg, altsaa parallelt med Epidermisfladen, i en ydre og en indre Celle; denne sidste deles for Fremtiden kun ved antikline, ɔ: radiale Vægge, hvorved det ovenomtalte Grænselag, hvis Radial- (og tilsidst ogsaa de andre) Vægge vise Kutin- og Ligninreaktionerne, opstaar, og dette Lag hvælver sig ind i det øvrige Tungevæv; det i Begyndelsen tydelige, halvkugleformede Fremspring, som det ganske unge Organ danner over Tungeunderfladens Niveau, taber sig hurtig under den senere Udvikling, hvortil ogsaa det bidrager, at selve Tungens tilgrænsende Væv, bl. a. ved Tangentialdelinger i de umiddelbart tilstødende Epidermceller (Tab. II, Figg. 8, 9, Tab. I, Fig. 2), hæver sig op, saa at Skivens Yderflade snart kommer i Plan med Overhuden. Paa samme Maade forklarer ogsaa Schwendt visse extraflorale Nektariers Stilling og Anbringelse, og jeg har selv allerede i 1875 forklaret det samme Forhold ved Nektarierne hos *Luffa*, *Tecoma* o. a. paa lignende Maade.

Medens den indre af Skivens to Initialceller saaledes ved fortsatte radiale Delinger frembringer „Grænselaget", deles den ydre ogsaa, nemlig først ved en radial Væg, (der, saavidt jeg kan se, i

Regelen staar parallelt med Bladtungens Længderetning) (Tab. II, Fig. 11); hver af de herved dannede Celler deles nu igen paa et lidt senere Stadium (Tab. II, Figg. 5, 6, sammenholdt med Figg. 8 og 9), men de følgende Celledelinger optræde ikke altid just i samme Orden, saa at Arrangementet af Cellerne i den yngre og især i den helt udviklede Skive, ligesom ogsaa Cellernes Antal ikke overalt er ganske det samme (cfr. Tab. II, Figg. 3, 6 og Tab. I, Fig. 1). Regelmæssigheden her hos *Actinostemma* synes dog betydelig större end hos *Luffa* og (at dömme efter Elslers Figurer[1]) hos *Diospyros*, hvilket vel hænger sammen med det langt större Celleantal hos disse sidste.

Samtidig med denne de smaa, skivedannede Organers Udvikling fra en eneste Epidermiscelle gaar naturligvis Uddannelsen af det øvrige Væv, hvoraf den tungeformede Bladfligs Mesofyl bestaar; men naar jeg gör opmærksom paa, at det udvikles til et tyndvægget Parenkym, at der ikke dannes noget Palissadevæv, og at der overhovedet ikke dannes Klorofylvæv, men kun Epithem, som vi kende det fra andre Steder (secernerende Kirtelflader hos *Prunus Laurocerasus* og *Clerodendron*, Vandkirtler hos Crassulaceer, Bladtænder hos *Cucurbita* o. m. a.), hvor vi vide, at en Secretion finder Sted, behøves en nærmere Udvikling af dette Forhold næppe, da der ingen særlig Interesse knytter sig dertil; det skal blot bemærkes, at Overhudscellerne paa Tungens ofte noget hule Overside ere forholdsvis store, af indbyrdes ulige Störrelse og stærkt papilløst udhvælvede.

Spörge vi nu til Slut om, hvad hele dette ejendommelige, tungeformede Organ er for et, maa vi sikkerlig betegne det som en Kirtel. Hvad den udskiller, ved jeg ikke, da jeg aldrig har set den udskille noget som helst. Dette kan sikkert kun have sin Grund i de fra de naturlige saa forskellige Forhold, hvorunder Planten dyrkes, og, som ovenfor berørt, har Schwendt paavist Sukker i Organet; jeg maa dog göre opmærksom paa, at Prøven med Fehlings Vædske mærkelig nok ikke har villet lykkes for mig paa dette Objekt. Jeg tvivler alligevel ikke paa, at vi have extraflorale Nektarier for os eller muligvis Hydathoder; dertil er Ligheden

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[1]) Extrafl. Nect. etc. bei Diospyros discolor Willd. (Sitzungsber. d. Wienerakad., Bd. 116, Abt. I, 1907).

den Slags Organer andetsteds for stor. Hvad de smaa Skivers morfologiske Homologier angaar, da kunne de sættes lig med de secernerende Epidermisskiver hos *Prunus Laurocerasus*, *Shorea stenoptera*, *Clerodendron* o. a., og der kan, naar vi tænke paa *Diospyros*- og *Luffa*kirtlerne, ikke være Tvivl om, at vi have med indsænkede Haardannelser at göre; enkelte Gange har jeg fundet en Slags lave „Kirtelhaar" imellem dem (Tab. II, Fig. 14), som for saa vidt ere interessante, som de kunne opfattes som Mellemformer mellem „Skiverne" og de paa de unge Blade saa rigelig forekommende Kirtelhaar (Tab. II, Fig. 13), hvis nederste Celle svarer til „Mellemformens" underste Etage, der atter svarer til Grænselaget; man sammenligne Fig. 12 af et ganske ungt Skiveanlæg med (det optiske) Længdesnit af „Mellemformen" i Fig. 14, og man vil bemærke Ligheden.

Hermed mener jeg da at have gjort Rede for de ejendommelige og interessante, tungeformede Bladspidser paa *Actinostemma*bladenes Basalflige, og som en yderligere Tilföjelse til tidligere Arbejder fra min Haand angaaende trikomatiske og nektariumagtige Organer hos saa mange andre Planter haaber jeg, at dette lille Bidrag kan have sin Berettigelse.

Universitetets botan. Laboratorium i Januar 1917.

Figurforklaring.

Tab. I.

Figurerne ere alle tegnede med Abbe's Tegneapparat efter Zeiss's ocul. comp. 4, obj. apochr. 3 mm og derpaa reducerede.

Fig. 1 a: *Actinostemma paniculatum* Max. En secernerende Skive fra den tungeformede Bladtands Underside (cfr. Tab. II, Fig. 1); Fladesnit, klaret i Klornatron.

„ 2a: Samme; yngre, allerede helt indsænket Skive; Snit af Alkoholmateriale, vinkelret paa Tungens (Under-)Flade. De til Skivens Grænselag stødende Epidermceller ere tangentialdelte (cfr. Figg. 8 og 9, Tab. II). Glycerin.

Fig. 1: *Acocanthera spectabilis* (Sond.) Benth. Tyndt Tværsnit af Bladoversiden. Fra en Mælkecellestamme ses en Gren skyde sig op imellem to Epidermceller til Kutikula.
„ 2: Samme; lignende; i Epidermcellerne ses Krystaller.
„ 3: Samme; Enden af en Mælkecellegren i en Epidermisradialvæg.
„ 4: Samme; Tværsnit af en Spalteaabning.
„ 5: Samme; Længdesnit af en Spalteaabning.
„ 6: Samme; Fladesnit af Bladundersiden; Indersiden vender udad.
„ 7: Samme; en Spalteaabning set udenfra.
„ 8: *Carissa ferox* L. Samme som Figg. 1, 2 og 3.
„ 9: Samme; samme.
„ 10: Samme; samme.
„ 11: Samme; Fladesnit af Bladoversidens Epidermis, set udenfra. To Mælkecelletværsnit ses i to af Cellehjörnerne.
„ 12: *Acocanthera spect.*, ligesaa.
„ 13: *Allamanda verticillata.* Tværsnit af Bladets Overflade. En Mælkecellegren ses skyde sig imellem Palissaderne og ind i en Epidermisradialvæg, ligesom i Figg. 1, 2, 8 og 10.
„ 14, 16, 17: Fladesnit af Bladets øvre Epidermis med Tværsn. af de i selve Væggene løbende Mælkeceller.
„ 15: *Acocanthera spect.*, ligesaa.

Tab. II.

Alle Figurerne ere af *Actinostemma paniculatum* Max. Figg. 1 og 2 ere tegnede ved Abbe's Tegneapparat, Zeiss's Obj. a_2 og Ocul. Comp. 4; Fig. 7 med Ocul. 1 og obj. DD; alle de øvrige med Ocul. Comp. 4 og Obj. Apochr. 3 mm, samt bagefter reducerede.

Fig. 1 og 2: Den tungeformede Bladspids, klaret i Kalihydrat og set fra Undersiden; de ganske smaa Kredse ere Spalteaabninger, de större ere de secernerende Organer. Desuden ses Karstrængsystemet.
„ 3: Et ungt, mindre og et noget ældre, större Sekretionsorgan; Fladesnit af spiritushærdet Materiale; Cellernes plasmolyserede Indhold antydet i Kontur og Kærnernes Plads angivet.
„ 4: Yngre Sekretionsskive; Fladesnit, klaret i Klornatron; de med × mærkede Celler ere „Grænselaget“. Cfr. Fig. 6.
„ 5: Endnu yngre Stadium; uklaret Fladesnit af Alkoholmateriale.
„ 6: Lig Fig. 4.
„ 7: Tværsnit af „Tungen“ (Fig. 1) vinkelret paa Fladen gennem en Sekretionsskive; Klornatronbehandling; Cellerne i „Grænselaget“ mærkede med ×.
„ 8: Lignende Snit; Alkoholmateriale; ungt Sekretionsorgan (omtrent som Fig. 5).
„ 9: Snit gennem et andet ungt Sekretionsorgan i samme Stadium.

Fig. 10: Tyndt Længdesnit, klaret i Klornatron, gennem en ganske ung Bladtunge: en eneste Epidermiscelle indleder Anlægget af et Sekretionsorgan.

„ 11: Ganske ungt Sekretionsskiveanlæg; Fladesnit af en ung „Tunge“s Epidermis; Alkoholmateriale

„ 12: Et lidt senere Stadium; „Grænselaget“ (×) anlagt.

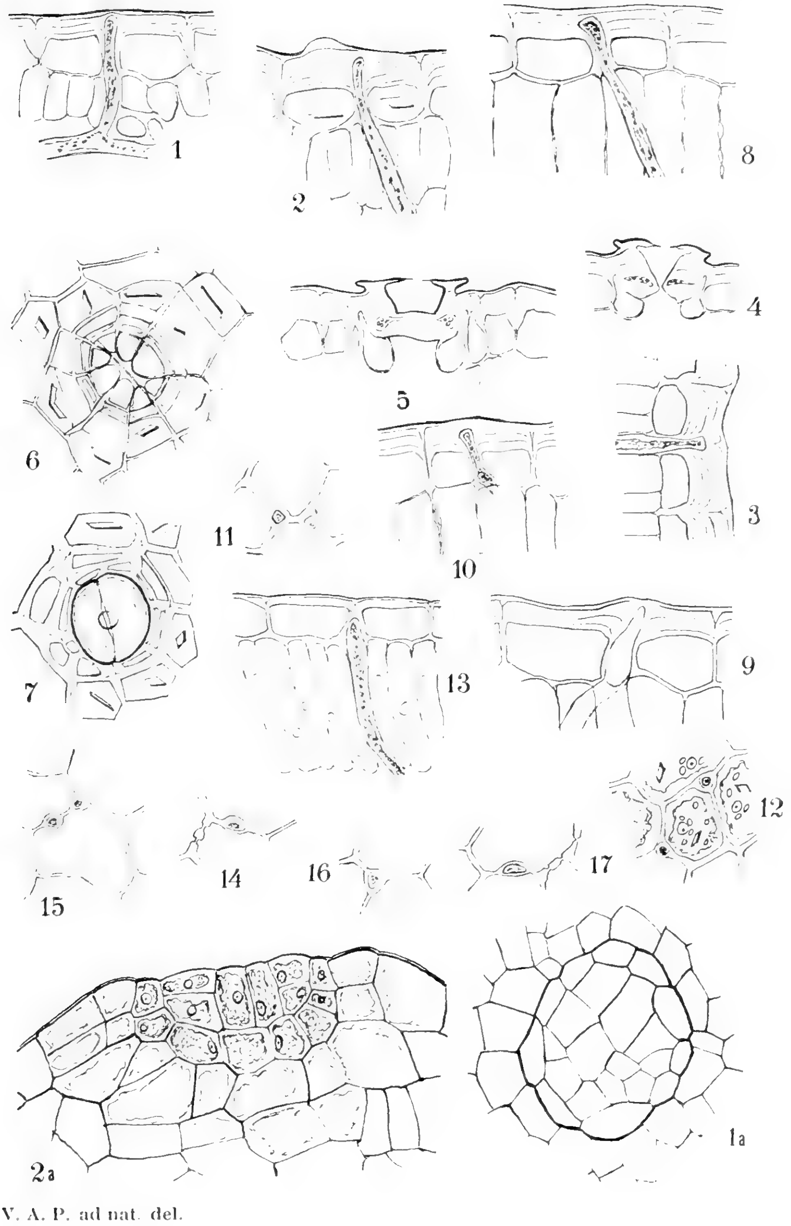
„ 13: Kirtelhaar fra Tungeroden.

„ 14: Snit vinkelret paa Tungen, klaret i Klornatron, gennem et ganske lavt Kirtelhaar; den med × mærkede Etage homolog med „Grænselaget“ i Figg. 7 og 12.

24—4—17

ANDELSBOGTRYKKERIET I ODENSE

Tab. I.



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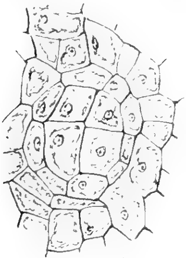

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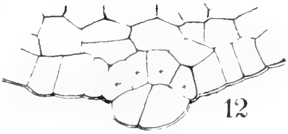

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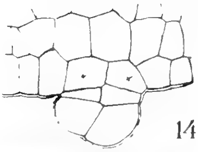

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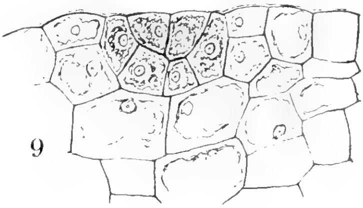

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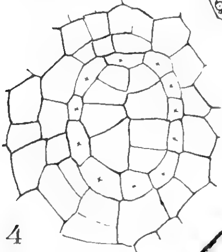

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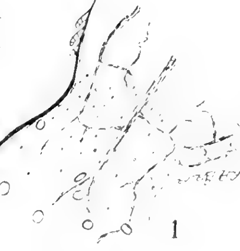

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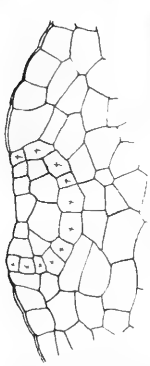

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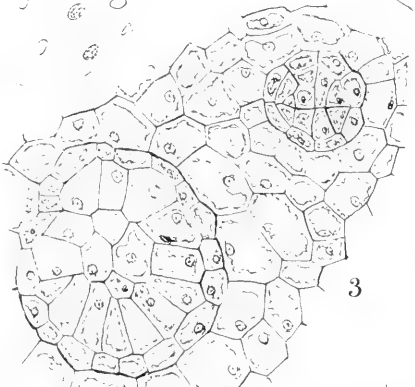

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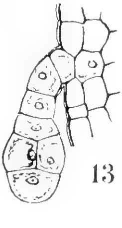

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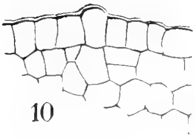

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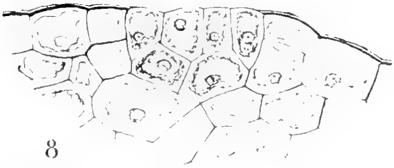

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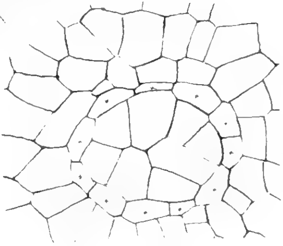

6

V. A. P. ad nat. del.

PLANTEANATOMISKE BIDRAG

II

AF

V. A. POULSEN

Særtryk af
VIDENSK. MEDDEL. FRA DANSK NATURHIST. FOREN.
Bd. 69

Arbejder fra den botaniske Have i København Nr. 83

Planteanatomiske Bidrag II.

Af

V. A. Poulsen.

Hertil Tabb. III og IV.

(Meddelt i Mødet i naturh. Forening d. 1ste Febr. 1918.

I.

Om Støtterødderne hos Acanthus ilicifolius L.

Hertil Tab. III.

Som bekendt hører den saakaldte „Mangrove"-Formation til de ejendommeligste og bedst karakteriserede tropiske Vegetationsformationer; den har været kendt siden Oldtiden, den er skildret mange Gange siden, og den er i den nyere og nyeste Tid omhyggelig studeret af velskolede Botanikere og Biologer, blandt hvilke ogsaa danske have ydet væsentlige Bidrag saavel i Almindelighed som i visse, mere specielle Henseender. Jeg skal her blot minde om Goebel's[1]), Karsten's[2]), Schimper's[3]), Warming's[4]), Børgesen og O. Paulsen's[5]), Holtermann's[6]), Areschoug's[7]), Joh.

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[1]) Pflanzenbiolog. Schilderungen, I. Theil, Abt. II: Ueber einige Eigenthümlichkeiten der südasiatischen Strandvegetation. p. 113 ff. 1889.

[2] Ueber die Mangrove-Vegetation im malayischen Archipel. Bibliotheca Botanica. Heft 22. 1891.

[3]) Botanische Mittheilungen aus den Tropen, Heft 3: Die indomalayische Strandflora. Jena. 1891.

[4]) Tropische Fragmente, II; Rhizophora Mangle; (Englers Jahrbücher, Bd. IV, 1893).
Oecology of Plants; Oxford 1909, (pag. 234 ff.).
Warming & Gräbner: Lehrbuch der ökologischen Pflanzengeographie, p. 401 (Berlin, 1915).

[5]) Om Vegetationen paa de dansk-vestindiske Øer; København, 1898.

[6] Der Einfluss des Klimas auf den Bau der Pflanzengewebe; Leipzig, 1907.

[7] Untersuchungen über den Blattbau der Mangrovepflanzen (Bibliotheca Botanica, Heft 56, 1902).

Schmidt's[1]), Guppy's[2]) samt Tansley's og Fritsch's[3]) Arbejder og Skildringer. Et af de mest ejendommelige Træk af de egentlige Mangroveplanters Naturhistorie, tilmed det, som fra først af har tildraget sig Forskernes Opmærksomhed, er de karakteristiske Støtterødder; de findes især hos Arterne af Slægten *Rhizophora*, som netop har sit Navn deraf, og som tilvisse gör et höjst ejendommeligt Indtryk paa den, der første Gang staar Ansigt til Ansigt med denne op af Havet ragende, lave Strandskov. Et Bidrag til disse *Rhizophora*rødders Anatomi har jeg leveret for flere Aar siden, og det er mig ikke bekendt, at der senere er fremkommet væsentligt nyt paa dette Omraade. Det er derfor ikke nogen Art af denne Planteslægt, som i det efterfølgende vil blive gjort til Genstand for Omtale, derimod en anden, som findes i samme Vegetation, men som paa Grund af sin betydelig ringere Störrelse og som oftest mere spredte Forekomst ikke falder saa stærkt i Öjnene, og som kun stedvis voxer i samlet Bestand, f. Ex. Kalutara, Bentotta paa Ceylon; det er nemlig den til den østlige Mangrove indskrænkede og i Amerika ganske manglende *Acanthus ilicifolus* L., hvis Udbredelse strækker sig fra Øst-Afrika til Ny-Guinea, Philippinerne og Nord-Australien. Denne *Acanthus*-Art angives i Almindelighed at være den eneste urteagtige, egentlige Mangroveplante; ved sit tidselagtige Ydre og lave Væxt er den flere Steder og navnlig i den indre Mangrove, mellem Sonneratier og Avicennier, ret fremtrædende og kan danne et lavt Buskads; hvor den voxer paa mere fugtig Grund eller i lave Pytter, faar den især fra Undersiden af de fremliggende eller skraat opstigende Grene ret talrige gröngraa, centimetertykke, bueformede Støtterødder, der ligesom de langt sværere *Rhizophora*rødder grene sig stærkt nede i det bløde Mudder. Arten er ikke hyppig afbildet; Wight (Icones, Tab. 459) har et ret tarveligt Billede af en Gren med Blomster, men uden Støtterødder, og Tansley and Fritsch (l. c., pag. 38, Fig. 13) afbilde en Gren med disse Rødder, men efter et alt andet end karakteristisk Exemplar.

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[1] Bidrag til Kundskab om Skudbygningen hos den gamle Verdens Mangrovetræer (Botanisk Tidsskrift, Bd. 26; Kbhn., 1913).

[2]) Plants, seeds and currents in the West Indies and Azores; London, Williams & Norgate, 1917.

[3]) The Flora of the Ceylon Littoral (News Phytologist, Vol. IV. 1905).

Ved sit egenartede Ydre og sin udprægede, halofytiske Levemaade, som ogsaa ved andre Forhold, er den enestaaende indenfor sin Slægt og af enkelte Forfattere i tidligere Tid gjort til Type for en selvstændig Slægt, *Dilivaria* Juss.; dog er denne ikke opretholdt af nye Forskere og bl. a. ikke af de plantegeografiske og økologiske Forfattere i den senere Litteratur.

Jeg har iagttaget Planten ved Tandjong Priok, Batavias Havneplads, samt ved en stor, i sin Tid (1895) under Rydning værende Mangrove ved Tandjong Pagar ved Singapore, og jeg maa her strax bemærke, at jeg fandt dens Grene ret svære og ikke saa lidt træagtige; samme Indtryk har jeg af Exemplarer, som dyrkedes i den botaniske Have i Buitenzorg, og af Grenstykker med Støtterødder i forskellig Udvikling, som senere med stor Liberalitet og i fortrinlig Opbevaring i Alkohol ere sendte mig fra Java af Hr. Laboratoriedirektør Hj. Jensen; jeg benytter Lejligheden til at takke for dette udmærkede Studiemateriale, der sammen med noget af mig selv i Buitenzorgerhaven indsamlet har tjent mig til disse Undersøgelser.

Støtterødderne af *Acanthus ilicifolius* have deres Udspring fra de blad- og blomsterbærende Grene; enten fra et vilkaarligt Sted paa Undersiden af de skraat opadrettede Internodier eller, hvad der forekommer mig hyppigst, fra selve Nodi, hvor der paa Axelfligenes Plads ofte findes indtil centimeterlange Torne; ovenover den ene af disse (sjældnere ovenover dem begge) udspringer en Rod. Rødderne have altsaa oftest lovbunden Stilling, hvilket ikke synes bemærket tidligere.

Det anatomiske Studium af disse Rødder synes (i Modsætning til Bladenes) mærkelig nok heller ikke at være foretaget. Det har dog sin Interesse at sé, hvorvidt de i deres Bygning stemme overéns med de tilsvarende Organer hos *Rhizophora* og *Pandanus*, om de tjene som Aanderødder eller udelukkende have mekanisk Betydning, og hvorvidt deres Stele har normal eller afvigende histologisk Struktur.

Det lidet, jeg har kunnet finde i Litteraturen om *Acanthus*-røddernes Anatomi, indskrænker sig til den kortfattede Omtale af Rodbarkcellernes Vægbygning, som Karsten giver i sit Mangrovearbejde, og som lige nævnes af Solereder[1]); dette gælder endda

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[1]) Systematische Anat. der Dicotyledonen, Ergänzbd., 1908, p. 253.

kun Jordrødderne; en egenlig Beskrivelse af Støtterødderne er næppe given, deres primære Struktur er ikke beskreven, og den anatomiske Udviklingshistorie aldrig undersøgt; dette kan komme deraf, at man har fæstet sin Opmærksomhed mere paa andre Sider af *Acanthus*rodens (og andre Mangroverødders) Naturhistorie, eller deraf, at man ikke har haft Materiale i passende Udviklingsstadier. Jeg skal tillige indrömme, at man ved Undersøgelsen af Rødderne i det sekundære Stadium, i hvilket de alle befinde sig, naar de have begyndt at udsende Grene nede i Mudderet, meget let kan oversé den anatomiske Ejendommelighed, paa hvilken jeg netop her agter at henlede Opmærksomheden, hvilket turde være Grunden til, at den hidtil er forbleven ukendt.

Et Tværsnit af den Del af Støtteroden, som er fuldt udviklet, men endnu i det primære Stadium, hvilket vil sige i en Afstand fra Rodspidsen af c. 6 à 8 cm, viser os yderst en ret smaacellet, temmelig tykvægget Epidermis, der ikke danner Rodhaar. Umiddelbart indenfor dette Lag findes en tydelig udpræget Exoderm, og derefter følger den øvrige Del af Barken, mellem hvis ydre, lidt mindre Parenkymceller, der ere forsynede med talrige, ret store Klorofylkorn og aabenbart ere i Stand til at assimilere, der findes mange Intercellularrum samt enkelte, hist og her forekommende, ret tykvæggede, porede, prosenkymatiske Elementer med lignificerede Vægge og uden levende Indhold. Den mellemste og inderste Bark bestaar af tyndvæggede, aabenbart saftrige Celler uden Klorofyl og med talrige, temmelig store Luftgange mellem sig. Saavel disse som hine Barkceller vise sig paa Længdesnittet at være langstrakt rektangulære.

Ved denne Bygning viser Rodbarken sig altsaa i Stand til Assimilation og Respiration. Den afsluttes indadtil af en meget tydelig Endoderm, hvis Radialvægge vise os de bekendte, casparyske Pletter. Den slutter som sædvanlig naturligvis tæt om den indenfor liggende Stele, som den omgiver som en smukt bølgeformet Kreds, (Tab. III, Figg. 1 og 2). Umiddelbart indenfor Endodermen findes Pericyklen som et meget tydeligt, ligeledes bølgeformet forløbende, kredsformet Lag; Stelens ledende Elementer følge dernæst fordelte i Periferien af Bindevævet, der danner en meget stor, af tyndvæggede, axialtstrakte Parenkymceller sammensat „Marv“; men ved den ejendommelige Maade, paa hvilken Hadrompartierne ere byggede, afviger denne Støtterod fra alle andre hidtil bekendte Rødder. Den er mangestraalet. Dette er ikke mærkeligt, eftersom Roden er saa tyk; der kan i Regelen tælles c. 27 à 30 Hadrompartier, men hvert af disse bestaar ikke af én eneste Karstraale, saaledes som vi ere vante til at finde, men af flere, som oftest fra 3 til 6 (Tab. III, Figg. 1, 2 og 3 samt 4); yderst sjældent er et Hadromparti kun repræsenteret af én Hadrom-„straale“. De yderste og mindste Kar ere som sædvanlig Skruekar (Tab. III, Fig. 9). Med disse temmelig stærkt tangentialstrakte Hadromstraalegrupper afvexle Leptompartierne; i dem findes ligeledes som oftest flere (3 à 4) Sivævsstrænge (Tab. III, Fig. 10), adskilte ved Bindevæv (Tab. III, Figg. 3, 4, 6, 7).

Denne primære Struktur afløses snart af den sekundære, og Tykkelsevæxten, som dog aldrig bliver betydelig, begynder. Den har til Hensigt at skabe et mekanisk virksomt Væv, idet Roden ved Udviklingen af sit sekundære Hadrom først bliver i Stand til at optræde som aktiv Støtterod. For det første uddannes det de primære Hadromstraaler nærmest omgivende Bindevæv ved Fortykning og Forvedning af Væggene til mekanisk Væv, og ved Udviklingen af et aktivt Kambium, der paa sædvanlig Vis først optræder paa Indersiden af Leptompartierne, dannes et sekundært Hadrom, og tilsidst have vi en sluttet Vedcylinder af Libriform og sekundære Kar, i hvilket de primære Hadromstraaler blive saa stærkt indlejrede, at de kun med Vanskelighed kunne skelnes. I det ved samme Kambiums Virksomhed dannede sekundære Leptom, der iøvrigt ikke giver Anledning til nogen særlig Omtale, dannes der en Del lange Sejbastceller.

Under denne sekundære Omformning af Stelen er der i Barkens yderste, lige indenfor Exodermis liggende Cellelag dannet et Par Lag Kork; hist og her udvikles der meget smukke og tydelige Lenticeller ligesom i en Stængel.

Den Del af Støtteroden, som naar ned i Jorden, udvikles til en ganske normal Rod; den er meget tyndere, udvikler Rodhaar og Sidegrene og danner selvfølgelig intet Klorofyl.

II.

Om Rhizomet hos Sanseviera guineensis Willd.

(Hertil Tab. IV, Figg. 1 og 2).

Slægten *Sanseviera* Thunb., hvoraf særlig *S. guineensis* (L.) Willd. og *S. cylindrica* Boyer ere bekendte Væxthusplanter, har været anbragt noget forskelligt i systematisk Henseende. Den førstnævnte, hvormed vi her særlig skulle beskæftige os, opfattedes af Linné som en *Aletris* (*A. hyacinthoides*, var. *guineensis*), altsaa som en Haemodoracé; Willdenow anbragte den under det Thunbergske Slægtsnavn nærmest ved *Dracaena*; Endlicher sætter den i Subordo *Aloineae* sammen med *Aloë* og *Yucca*, Lindley nævner den under Liliacé-Afdelingen Hemerocalleae, som han netop adskiller fra Aloïneer og Asparageer; Baker, Liliaceernes Monograf, anbringer den i Familien Asparagaceae, altsaa igen nær ved *Dracaena*, Baillon sætter den (under det gamle, Medikus'ske Slægtsnavn *Acyntha* fra 1786) sammen med *Liriope* Lour. (= *Ophiopogon*) og *Peliosanthes* Andr. i Gruppen Liriopeae, og i Engler og Prantl finde vi den i „Nachträge" under Dracaeneae, efterat den i den første Familiebehandling havde figureret under Ophiopogoneae, hvorhen den ogsaa var stillet af Hooker & Bentham. Uden nu at gennemgaa yderligere den systematiske Litteratur kunne vi altsaa fastslaa, at *Sanseviera* iblandt Liliiflorerne har sin Plads i Nærheden af Dracaenoideerne, hvor de nyeste Forfattere anse det for rettest at anbringe den.

I anatomisk Henseende har Slægten i Tidens Løb ikke været Genstand for saa mange Undersøgelser; i den ældre Lære- og Haandbogslitteratur er den bedst kendt paa Grund af de ejendommelige, næt-skrueformet fortykkede, aabenbart som Vandbeholdere fungerende, parenkymatiske Idioblaster i Bladets Mesofyl; de stærke Sejbaststrænge i Bladene have ogsaa været Genstand for Undersøgelser[1]), da de anvendes teknisk; men meget andet er neppe nöjere studeret og bl. a. ikke Rhizomet. I den nyere Tid er der i Wien publiceret en Del gode og detaillerede, anatomisk-systematiske Studier over forskellige Liliiflorafdelinger; deriblandt et af Zwei-

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[1]) Cfr. Wiesner: Rohstoffe des Pflanzenreichs, II, 1903; p. 397.

gelt[1]), der netop har Interesse i denne Forbindelse. Heri kunde man vente, at Rhizomets anatomiske Forhold vare behandlede; men dette er netop ikke Tilfældet, og da jeg i den Anledning har studeret dets Bygning og Væxt og fundet et Forhold, som hidtil ikke er iagttaget, har jeg ment at turde lægge Beslag paa Læserens Opmærksomhed for nogle faa Bemærkninger desangaaende.

Rhizomet, som har nogen Lighed med *Iris*'s, er temmelig kort, tykt og grenet. Det bestaar af ældre Hovedaxer, hvorfra det sidste Aars Grene som Sideskud, der i Spidsen bære de særdeles store, meget stive og solide, xeromorfe Blade og iøvrigt ere forsynede med de affaldne Blades ringformede Ar, skyde ud. Den udvendige Beklædning (Tab. IV, Fig. 1, p) er en af mange Cellelag dannet Kork, som ofte er gul eller smukt rød, en Farve, som i begge Tilfælde skyldes en Mængde Oliedraaber i de inderste Korkceller.

Efter Korken følger en af afrundede, noget tangentialtstrakte Parenkymceller sammensat Bark (Tab. IV, Fig. 1 b) med talrige Intercellularrum; uregelmæssig spredt heri findes talrige Rafideceller, hvis Krystalbundter ikke ere orienterede i nogen bestemt Retning; de ere særlig talrige i de ældre Rhizomled, og i disse ere ogsaa mange af Parenkymcellerne nætformet fortykkede, saaledes som vi ovenfor nævnte det for Bladparenkymets Vedkommende.

Indenfor denne Bark, der ikke afsluttes med nogensomhelst udpræget Endoderm, ikke en Gang (i de yngre Rhizomdele) med en tydelig Stivelseskede (omend hist og her et vist, ikke helt kontinuerligt Cellelag kan indeholde ganske faa, temmelig smaa Stivelsekorn og derved paa en Maade hævde sig som et Stivelseskede-homologon), findes Centralcylinderen (Tab. IV, Fig. 1, st) eller Stelen, der altsaa gaar ganske i eet med Barken. Dens Parenkym er ganske som Barkens, ogsaa i de ældre Rhizomstykker. I denne Stele findes de lukkede, kollaterale Karstrænge, hvis Bygning er den for Monokotyledoner sædvanlige, uregelmæssig spredte over Tværsnittet; hver Karstræng er paa Ydersiden lige udenfor Leptomet belagt med en ofte ret anselig Sejbastbelægning, som baade med Anilinsulfat, Floroglucinsaltsyre og det Mäule'ske Permanganat-

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[1] Vergleich. Anat. d. Asparagoideae, Ophiopog. etc. nebst Bemerkungen über die Beziehungen zwischen Ophiop. u. Dracaenoideen (Denkschr. d. kais Acad. d. Wiss. in Wien, Bd. 88, 1913).

reagens viser en meget tydelig Ligninreaktion. I Betragtning af, at et Rhizom er et Ammeorgan, var det mig noget paafaldende, at der ikke fandtes Stivelse i Cellerne (bortset fra de ubetydelige Spor af dette Kulhydrat, som vi omtalte ovenfor som forekommende i et Cellelag paa Grænsen mellem Bark og Stele); alle Parenkymcellerne i hele Rhizomet synes tomme og have kun et tyndt, vægstillet, temmelig kornfrit og klart Protoplasma med ikke synderlig fremtrædende Kærner. Nu viste det sig imidlertid, at Celleindholdet giver en stærk rød Reaktion med Trommerske Reagens samt en meget rigelig Osazonreaktion med saltsurt Phenylhydrazin og Natriumacetat og altsaa turde indeholde ikke ubetydelige Sukkermængder. I Monokotyledone-Rhizomer er, naar jeg bortser fra visse Gramineers, sligt, saa vidt mig bekendt, ikke tidligere paavist. I enkelte Rhizomstykker, som havde ligget nogen Tid i stærk Alkohol, var Sukkeret udkrystalliseret i Sfæritform, særlig i Barkens allerinderste Del; disse Krystaller opløstes hurtig i Vand, langsommere i Glycerin og mindede ved deres Form ganske om dem, som Bonnier[1]) allerede forlængst har paavist i visse Nektariers Parenkym.

Imidlertid er der en ganske anden Ejendommelighed, som udmærker *Sanseviera*-Rhizomet, og som, saavidt jeg véd, ikke tidligere er iagttagen hos noget Rhizom af monokotyledone Væxter. I ældre Rhizompartier, især i Axerne af første Orden og i de ældste Dele af Axerne af anden Orden, optræder der et sekundært Kambium, som dels frembringer en betydelig Parenkymmængde, dels (heri) en Del (spinklere) Karstrænge; hele denne sekundære Tilvæxt (Tab. IV, Fig. 1, k) danner paa Tværsnit en temmelig bred Zone udenom den primære Stele. Den tager sin Begyndelse ved Tangentialdelinger i Stelens yderste Periferi (Tab. IV, Fig. 2, k), indenfor det ovenfor nævnte, iøvrigt saa utydelig udprægede, inderste Barklag, som ved sit ganske vist højst mangelfulde Stivelseindhold muligen lader sig tyde som en Endoderm eller Phloeoterm. Det Cellelag, som bliver det sekundære Kambiums Initiallag, og som altsaa er Pericykellaget, er imidlertid lige saa daarlig udpræget som Endodermen; det giver sig kun tilkende ved sine Delinger; i de Tilfælde, eller paa de Steder, hvor en svag Stivelseudvikling

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[1]) Les Nectaires, (Annales des sc. nat., Bot., 6e Sér., T. VIII, 1879, p. 78; Tab. 8, Figg. 124 og 126).

antyder Endodermceller, finde vi de første kambiale Tangentialvægge umiddelbart indenfor disse, hvilket atter vil sige lige udenfor Stellens yderste Karstrænge og, saavidt jeg har bemærket, næsten aldrig samtidig i hele Pericyklens Omkreds. Det ved denne kambiale Tilvæxt dannede Parenkym udmærker sig ved de rektangulære, ofte noget radialstrakte Cellers tydelig radiære Ordning, som ogsaa de deri dannede Karstrænge udvise; i Modsætning til Karstrængene i den primære Stele have disse, noget spinklere, sekundære ingen Sejbastbelægning.

Hensigten med denne sekundære Tykkelsevæxt er gaadefuld; paa de i vor botaniske Have dyrkede Exemplarer dø Rhizomdelene bort snart, efter at de have indledet denne Kambialvirksomhed; men i Plantens Hjemstavn, det tropiske Afrika, varer deres Liv muligvis længere.

Siden det i 1915 lykkedes mig at paavise et Tilfælde af sekundær Tykkelsevæxt hos *Urginea*[1]) er der, saavidt mig bekendt, intet lignende fundet andetsteds. Derfor har jeg ment, at Offentliggörelsen af ovenstaaende ikke ganske er uden Interesse. Tilstedeværelsen af den sekundære Væxt er, hvad der vil være klart af de indledende Bemærkninger, af nogen Betydning i systematisk Henseende, for saavidt som der heri bestaar en Lighed med *Dracaenoideerne*, saaledes som ogsaa Zweigelt har hævdet, men ingen med *Ophiopogoneerne*, hvorfra det med Engler & Prantl (o. a.) vil være rigtigt at fjerne den. Muligvis forstaas Tilstedeværelsen af det sekundære Tilvæxtlag bedst rent fylogenetisk, nemlig som en (nu betydningsløs) Rest fra *Dracaena*-agtige Forfædre, hvis Stængler have været overjordiske; men förend yderligere, sammenlignende Undersøgelser, navnlig over Æggets cytologiske Forhold, hos de herved i Betragtning kommende Slægter ere foretagne, har man næppe tilstrækkeligt Materiale til en frugtbar Diskussion.

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[1]) Oversigt over det kgl. danske Vidensk. Selskabs Forh. 1915, Nr. 2, p. 181. Se heri den herhenhørende Litteratur.

III.

Det extraflorale Nektarium hos Carapa guyanensis Aubl.

(Hertil Tab. IV, Figg. 3–7).

Carapa guyanensis Aubl. er et smukt Træ af Meliaceernes Familie med meget store, finnede Blade. Det har hjemme i tropisk Amerika, i hvis Mangrover det ofte forekommer. Dog voxer det ogsaa, og maaske nok saa meget, udenfor Strandvegetationen, i „*Barringtonia*“-Formationen og længere inde; Warming[1]) anfører det heller ikke blandt den vestlige Mangroves Karakterplanter, og Spruce[2]) nævner det blandt de Træer, han traf „hele Vejen op ad Amazonfloden“. I Mangroven paa vore desværre forhenværende vestindiske Øer findes Arten ikke, derimod træffes den igen i Strandfloraen paa Senegambiens Kyst, hvis Mangrove væsentlig dannes af samme Arter som Amerikas, f. Ex. *Rhizophora Mangle* L.[3]). Af Slægten *Carapa* kendes ogsaa Arter fra den gamle Verden, nemlig de indiske Mangrovers *C. moluccensis* Lam. og *C. obovata* Bl., som imidlertid vistnok rigtigere sammenfattes i Slægten *Xylocarpus* Koenig; en Adskillelse af disse to Slægter er sikkerlig vel begrundet, og Harms, som har behandlet Familien i Engler & Prantl's „Natürliche Pflanzenfamilien“, gennemfører den ogsaa. I vor botaniske Haves Palmehus dyrkes et stort og smukt Exemplar af *Carapa guyanensis* Aubl.; det kom hertil i 1870 fra Kew Gardens, efter hvad Hr. botanisk Gartner Lange meddeler mig, og turde nu vel have en Alder af c. 50 Aar. Da jeg paa det har gjort en Iagttagelse, som ikke synes forhen kendt, skal jeg i det følgende göre Rede for den, idet jeg takker for den Beredvillighed, hvormed det ikke almindelige Materiale er stillet til min Raadighed.

De store, spredte Blade, som ikke ere forsynede med Axelflige, ere ligefinnede; saaledes maa de i al Fald betegnes i ud-

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[1]) Oecology of Plants, Oxford, 1909; p. 235.

[2]) Notes of a Botanist on the Amazon and Andes, ed. by Wallace, 1908.

[3]) Interessante Betragtninger over Strandvegetation og *Carapa* findes i et noget bredt, men höjst læseværdigt Værk af Guppy: Plants, Seeds and Currents in the West Indies and Azores, London, 1917; pag. 141.

viklet Tilstand, men Baillon[1]) har allerede forlængst paastaaet, at de anlægges uligefinnede, men at Endesmaabladet ikke udvikles normalt og tidlig gaar tilgrunde; da jeg selv har undersøgt Bladets Udviklinghistorie, kan jeg paa en Maade bekræfte dette. De unge Blade og Axedele, som netop befinde sig i Løvspring, hvilket i vort Palmehus finder Sted i Slutningen af Marts og Begyndelsen af April, naar Solen har faaet nogen Magt, ere, som Tilfældet er med mange tropiske Trævæxter, meget smukt røde. Især paa disse yngre Blade (cfr. Tab. IV, Fig. 4, som forestiller unge Blade i tre Udviklingstrin), men naturligvis ogsaa, skönt mindre tydelig, paa de ældre, kan man iagttage to extraflorale Nektarier ved Bladstilkens Grund, eet paa hver Side paa det Sted, hvor den pludselig fortykkes, inden den fæster sig til Axen; en sjælden Gang kan der optræde to Nektarier paa samme Side enten ved Siden af eller ovenover hinanden.

Plantens Knopforhold er omtalt af Raunkiær[2]); hvert Aarsskud (Tab. IV, Fig. 3) begynder med fem à sex ufuldkomne, næsten skælagtige, brede, ofte med en höjst rudimentær Bladplade forsynede Lavblade, som hvert bærer en cirkelrund eller oval Plet, et Nektarium, paa hver Side af Midtlinien. Disse Dannelser, som genfindes paa de i et Antal af sex til ti derpaa følgende, finnede Løvblade, der ere ordnede efter Skruen $^2/_5$, forekomme, som ogsaa Baillon har set, ogsaa paa „Endesmaabladet“, som er udviklet meget rudimentært, som et glat, temmelig tykt, uregelmæssig, prismatisk, eller spidst, spoleformet (Tab. IV, Fig. 4, ap), noget kødfuldt Legeme, der aldrig opnaar nogen nævneværdig Störrelse, men stanser sin Udvikling tidlig for ligeledes tidlig at skrumpe ind og forsvinde, saa at det helt udviklede, meget store Løvblad synes ligefinnet (i Regelen med 10 Par Smaablade). Det maa nu imidlertid bemærkes, at der i Spidsen af hvert af Sidesmaabladene findes et ganske lignende, med to Nektarier forsynet, sidenhen ogsaa indtörrende Apikallegeme, saa at en egentlig, selv meget rudimentær Endesmaablad-Plade i Grunden aldrig har været anlagt.

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[1]) Bull. soc. Linnéenne de Paris, p. 22; cfr. Harms i Engler & Prantl, III, 4. Abth., 1896; p. 278.

[2]) Planterigets Livsformer, Kbhvn., Gyldendal, 1907, p. 36—37. Knoppernes Forhold hos Plantens indiske Slægtning er skildret af Johs. Schmidt (Skuddene hos den gamle Verdens Mangrovetræer, 1903; p. 73).

At disse her nævnte, stillingsbundne, rundagtige Pletter[1]), som paa de yngre, pragtfuldt røde Bladstilke ere ret iöjnefaldende ved deres hvidlig-grönne Farve, ere Nektarier, erkendes let af den stærkt søde, vandklare Vædske, som de udskille i rigeligt Maal, og som især om Morgenen ses som store, klare Draaber paa de blanke Bladstilke. Den udskilte Saft er i Regelen saa rigelig, at de unge Skudender ere ganske vaade, og i sin Hjemstavn hører Planten utvivlsomt til de saakaldte myrmekofile Væxter; herom synes dog intet at være oplyst, og i den störste, sammenfattende Oversigt vi have om saadanne Planter, nemlig hos Delpino[2]), er *Carapa* aldeles ikke nævnt, ja overhovedet ingen Meliacé. At disse sukkersecernerende Kirtler ikke ere tegnede paa de ellers saa fortrinlige Afbildninger, vi have i de Candolles Monografi[3]), er mere mærkeligt, men det forklares muligvis let ved Antagelsen af, at Figurerne i Reglen i „Flora Brasiliensis“ ere udførte efter Herbariemateriale; herpaa blive Sukkerkirtlerne meget utydelige, og paa de ældre Blade, hvor deres Funktion er ophørt, og hvis Stilke ere blevne dækkede af et tyndt, mørkt Korklag, ere de i og for sig ikke helt lette at blive opmærksom paa.

Et Tværsnit af Nektariet vinkelret paa Bladfodens Yderflade viser os et skiveformet eller fladt-pudeformet Sekretionsvæv, som er noget indsænket under Bladstilkens Overflade og omgivet af en svagt ophöjet Rand. Bladfodens almindelige Epidermis bestaar af lave, paa Fladesnit polygonale Celler; ingen af dem paa den ældre Bladstilk bærer Haar; Spalteaabninger ere overmaade sparsomme; de fleste findes paa den ringformede Nektarierands ydre Skraaning. I mange af Overhudscellerne findes derimod Kalkkrystalstjerner. Den ophöjede Nektarierand fremkommer ved Epidermiscellernes Radialstrækning i en ringformet Zone umiddelbart udenfor Sekretionsvævet. Selve det secernerende Organ (Tab. IV, Fig. 5, 6) bestaar af et meget tyndvægget, smaacellet, farveløst Parenkym; dets Yderflade, der altsaa gaar i eet med Bladbasens ovenfor skildrede Overhud, er en indadtil ikke skarpt afsat Epiderm, et plasmafyldt

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[1]) Hos den indiske Slægtning (*Xylocarpus*) findes saadanne ikke; cfr. Schmidt's ovenfor citerede Arbejde.

[2]) Funzione myrmecofila del Regno vegetale, III; Memorie della Reale Accad. d. Sci. del Istituto di Bologna, 1889).

[3]) Martius's Flora Brasiliensis, Vol. XI, Tab. 64.

Epithel, som ganske ligner det underneden (el. indenfor) liggende, ligeledes plasmafyldte, sukkerproducerende Væv; i dette, der har temmelig store Cellekærner, og som farves stærkt gult med Jodjodkalium, findes ingen Intercellulærrum, og særlige Karstrænggrene, som ellers saa mange andre Steder føre til de sekretoriske Væv (f. Eks. hos *Cerasus*, *Turnera*, *Passiflora*, *Ricinus*, *Cassia*, *Hippomane*, *Viburnum Opulus* o. a.), ere her ikke tilstede. Det gaar indadtil ret jævnt over i Bladstilkens perifere Parenkym, der er betydelig mere tykvægget og rigelig udstyret med Cellemellemrum, samt i hvilket enkelte, i Retning af Bladstilkens Længdeaxe strakte, temmelig store Slimceller ere fremtrædende og paa Tværsnit af Bladstilken næsten ligne Slimgange. Betragte vi et Fladesnit af den runde, secernerende Plet, finde vi dens Epiderm dannet af ganske smaa, polygonale Celler; Spalteaabninger og Krystalstjerner findes ikke; en ejendommelig gruppevis Ordning af Cellerne, paa hvilken vi senere skulle give Forklaringen, er karakteristisk for den secernerende Overhud (Tab. IV, Fig. 7). Vende vi os igen til Tværsnittet, finde vi, at de specielle Grænselag, som skiller det secernerende Væv fra det, hvorpaa det hviler, og som flere Steder i Planteriget ellers er tydeligt, ikke alene i Nektarier, men ogsaa i andre Sekretionsorganer (*Luffa*, *Shorea*, *Dioscorea*, *Drosera* o. a.), ikke findes hos *Carapa*. Her markeres Forskellen først stærkt, naar Organet og Bladet i det hele taget bliver noget ældre, og Sekretionsperioden er forbi. Der danner sig da paa Bladstilken (og Grenene) den ovennævnte Kork, som giver disse Dele den for dem ejendommelige, mørkebrune, blanke Farve; den dannes ved Tangentialdelinger af første Cellelag under Epidermis, men gaar ved Nektarierne ind i de under Sekretionsvævet liggende dybere Cellelag, saa at hele Organet ved Korklaget isoleres fra Forbindelse med Bladstilkens øvrige, levende Væv; det secernerende Parenkym sættes ud af Funktion, dets Celler fyldes med et brungult, flobafénagtigt Indhold; Nektariets Rolle er udspillet, og medens det i Bladets yngre Faser var meget letkendeligt, ja endog iöjnefaldende, unddrager det sig nu mere og mere Opmærksomheden.

Hvad nu Udviklingshistorien angaar, anlægges Nektarierne paa de meget unge, c. 5 à 6 mm lange Blades Basis, medens de, der findes paa de ejendommelige Apicalorganer, der egentlig kan kaldes Nektariophorer, ere anlagte endnu tidligere. Jeg har særlig undersøgt de basale, og de yngste Stadier, jeg har kunnet finde (paa Grund af Materialets Kostbarhed har der været Grænser for, hvad botanisk Have har kunnet stille til Raadighed), have da paa Tværsnit vist, hvad man egentlig kan læse ud af de færdige Udviklingstrin, nemlig at Organet anlægges ganske simpelt derved, at et lille, kredsrundt Parti bevarer sin ungdommelige Karakter, medens Udviklingen skrider videre udenom det. Paa dette Stadium dele Epidermiscellerne, der paa denne kredsrunde Plet bevare Ydervæggenes oprindelige, ringe Tykkelse, medens de udenom blive noget tykkere og faa en noget sværere Kutikula, sig ved radiale (antikline) Vægge og strække sig tillige i radial Retning; derved opstaar den ovenfor omtalte, gruppevise Ordning af dem, som især ses, naar Nektarialfladen (paa Fladesnit) betragtes ovenfra. Mange af de ved Radialdelingerne opstaaede Celler tangentialdeles atter; indadtil ere de ikke alle lige lange, saa at Epidermisgrænsen imod Vævet indenfor ikke er skarp og jævn. Störstedelen af Sekretionsvævet er saaledes en Epidermaldannelse; men en Del af Vævet indenfor deltager i Organets Opbygning. Da den senere opstaaende Kork er subepidermal, er det derfor ikke underligt, at den sænker sig ind under Nektariet. Man vil paa de unge Stadier finde ikke faa Kirtelhaar paa Overhuden udenom Nektariet; de falde senere af. Det vil saaledes ses, at Udviklingshistorien ikke frembyder særlig interessante Enkeltheder.

Universitetets planteanatomiske Laboratorium i Februar 1918.

Figurforklaring.

Tab. III.

Acanthus ilicifolius L.

Samtlige Figurer ere tegnede med Camera clara og forestille Tværsnit af Støtterødder.

Figg. 1, 2 og 3: Den primære Struktur færdigdannet, c. 5 à 6 mm fra Rodspidsen, halvt skematisk; Karrene, hvis Stilling er nöjagtig angiven, fremstillede som Prikker, Protohadromelementerne ere mindst (og yderst); Leptomet er antydet ved skraverede Pletter. I Figg. 1 og 2 er Rodbarkens yderste Begrænsning, Rodens Hudlag, tegnet med; Fig. 3, som er af en lidt sværere Rod, forestiller kun et Stykke af Stelens Periferi; den yderste Kontur er her Endodermen.

Fig. 4: Et Stykke af samme Præparat, som det, hvorefter Fig. 3 er tegnet, stærkere forstörret (Zeiss's Apochr. Obj. 16 mm, Ocul. Comp. 4). Endodermens Celler ere tegnede; *e*: Endoderm; *l*: Leptom; *k*: Hadrom.

Fig. 5: To Hadromgrupper, *k*, med en mellemliggende Leptomstræng, *l*; *e*: Endoderm. 7 mm fra Rodens Spids; 5 mm; Tværmaal. (Zeiss's Apochr. Obj. 4 mm, Ocul. Comp. 4).

Fig. 6: Som forrige; én Hadromgruppe. I Endodermen, hvis casparyske Pletter endnu ikke ere dannede, findes smaa Stivelsekorn.

Fig. 7: Lidt ældre end Fig. 6; *e*: Endoderm; *pcy*: Pericykel.

Fig. 8: Noget ældre Rod; Tykkelsevæxten begynder indenfor Leptomet, *l*, med Dannelsen af et Kambium, *ca*. *e*: Endoderm; *pcy*: Pericykel; Zeiss's Obj. Apochr. 3 mm, Ocul. Comp. 4).

Fig. 9: Ganske ungt Parti, 2 mm fra Rodens Spids, 4 mm i Tvermaal. Endodermen, *e*, endnu ikke uddannet; de tykvæggede Celler, *k*, ere de stærkt farvede, men endnu ikke sammenfaldne Protohadromkar (Skruekar); Metahadromet ikke anlagt; alle disse Kar, sex Straaler ialt, udgöre ét Hadromparti; (Zeiss's Obj. Apochr. 3 mm, Ocul. Comp. 4).

Fig. 10: Samme som Fig. 8; begyndende Kambium- (*ca*) dannelse.

Tab. IV.

Fig. 1: *Sanseviera guineensis*. Tværsnit af ældre Rhizom; sekundær Tykkelsevæxt begyndt. Svagt forstörret. *st*: primær Stele; *k*: sekundært Kambium med radialt stillede Karstrænge; *b*: Bark; *p*: Periderm. — Skematisk.

Fig. 2: Samme; perifer Del af Stelen; Tværsnit. Sekundært Kambium, *k*, nylig anlagt. (Zeiss's Okular 4, Obj. Apochr. 4 mm). Figurens opadvendte Side peger udad mod Korken.

Fig. 3: *Carapa guyanensis*. Yngre, helt udsprunget Aarsskud, noget formindsket; de kredsrunde Pletter paa Bladstilkens Basis ere Nektarierne. (Tegnet af Hr. Kunstmaler A. Hou).

Fig. 4: Samme; unge Blade, svagt forstörrede; *ap*: Apicalorganerne eller Nectariophorerne.

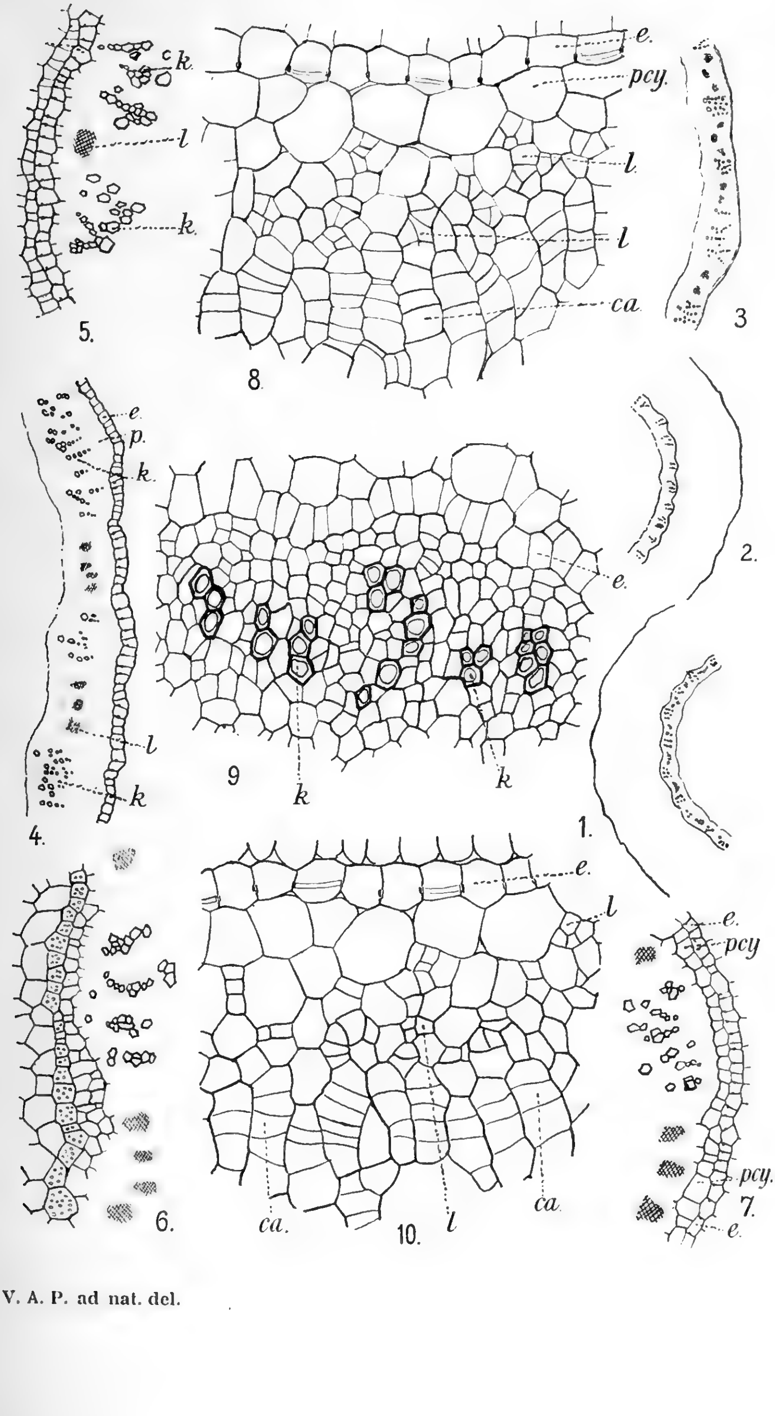
Fig. 5: Samme; Tværsnit gennem et udvoxet Nektariums Rand vinkelret paa Overfladen. De plasmafyldte Celler ere det secernerende Væv. (Zeiss's Obj. 3 mm, Okular 4 Comp.; formindsket).

Fig. 6: Samme; lignende, lidt yngre. (Samme Forstörrelse).

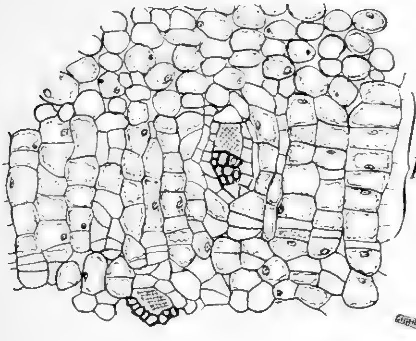
Fig. 7: Samme; den secernerende Epidermis; Fladesnit. (Samme Forst).

13—3—18.

Andelsbogtrykkeriet i Odense.



V. A. P. ad nat. del.



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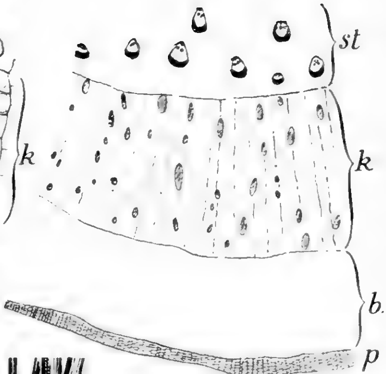

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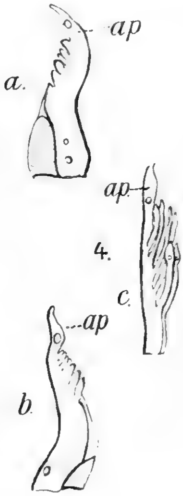

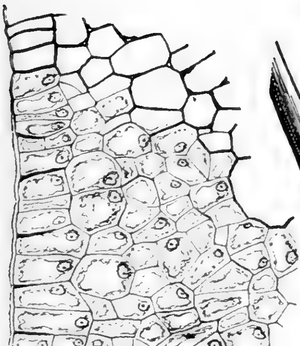

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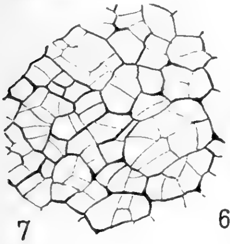

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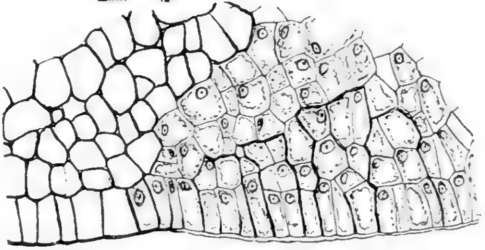

6.

V. A. P. ad nat. del.

(Særtryk af Vidensk. Medd. fra Dansk naturhist. Foren. Bd. 69.)

Arbejder fra den botaniske Have i København. Nr. 84.

Om *Synura Uvella* Stein og nogle andre Chrysomonadiner.

Af
Johs. Boye Petersen.

Hertil Tab. V.
(Meddelt i Mødet d. 15 Marts 1918.)

I nogle Aar har jeg lejlighedsvis studeret forskellige ciliebærende Organismer, især deres Ciliers finere Bygning. Det var oprindelig Hensigten, at der skulde være kommet en større Helhed ud deraf; men andre Arbejder har optaget min Tid, saa jeg foretrækker nu at publicere nogle af de Iagttagelser, jeg har gjort.

Ved Undersøgelserne anvendte jeg især den Löfflerske Beitzningsmetode i Alfr. Fischer's Modifikation (Strasburger: Praktikum 1902, Pag. 413). Denne Metode har tidligere givet meget smukke Resultater (Alfr. Fischer 1894); men Fischer's Undersøgelser er mærkeligt nok ikke bleven ført videre. De sammenfattende Skrifter, som f. Eks. Senn (i Engler und Prantl: 1900) nævner kort Fischer's Arbejder, men føjer intet nærmere til. Pascher (1914 Pag. 2) siger herom blot: „Ob die speciell von A. Fischer bei Geiszeln verschiedener Flagellaten beobachteten Strukturen (Flimmerhaarbesatz) den natürlichen Zuständen entsprechen und nicht vielleicht infolge der Präparation entstanden sind, ist nicht geklärt." Pascher finder dem altsaa ikke nærmere Omtale værd og betvivler endog, at de i Præparaterne iagttagne Strukturer virkelig svarer til de naturlige Forhold. Nu maa man indrømme, at Resultater vundne ved en Farvningsmetode som den Löfflerske altid maa behandles med megen Kritik, og man maa saa vidt muligt søge at verificere de fundne Resultater ved andre Metoder. Men Fischer's Undersøgelser synes mig saa interessante, at en Fortsættelse af dem i høj Grad var ønskelig, og at der ligger noget virkeligt til Grund for de fundne Billeder, betragter jeg som hævet over enhver Tvivl. Noget helt andet er, hvor nøje Billedet i Præparatet svarer til Virkeligheden, og hvor meget det er forandret ved Præparationen.

Samtidig med mine Ciliefarvningsforsøg har jeg ogsaa anvendt andre Undersøgelsesmetoder og derved vundet forskellige, som jeg tror, nye Resultater, især vedrørende *Synura*'s Bygning.

Jeg venter, at yderligere Undersøgelser af de finere Ciliestrukturer vil kunne give gode Bidrag til Opfattelsen af Flagellaternes Systematik, ligesom et Studium af Sværmesporers Cilier maaske kan kaste nyt Lys over Slægtskabsforholdene mellem de eencellede og de flercellede Alger.

I: **Hylsteret hos Synura.**

Hylsteret hos *Synura* har der fra gammel Tid været noget vist gaadefuldt ved, og de forskellige Forskere har haft ret afvigende Meninger om dets Natur, ligesom dets Struktur ogsaa har været beskrevet paa flere Maader. Allerede Fresenius[1]) gør opmærksom paa, at det har et kornet Udseende og mener, at dette skyldes en tæt Besætning af fine Slimkorn. Stein udtaler herimod, at det kornede Udseende skyldes en Mængde fine Spidser eller Pigge, hvormed Hylsteret er tæt besat. Paa Stein's bekendte Afbildninger af *Synura* ses disse Pigge med stor Tydelighed. Klebs (1892, Pag. 400) fremhæver atter Hylsterets kornede Udseende og mener nærmest som Fresenius, at der virkelig findes Korn paa dets Overflade, og de længere Spidser, som Stein har set, erklærer han for at være Bakterier, der har sat sig fast paa Hylsteret. Noget lignende er ogsaa iagttaget af Scherffel (1904, Pag. 441). Han er imidlertid kommet paa den Tanke, at Hylsterets kornede Udseende skyldes noget helt andet end Pigge eller paalejrede Smaakorn. Han mener nemlig at have iagttaget, at det er sammensat af smaa Plader, ganske som det tidligere er iagttaget hos *Mallomonas* af Imhof. Scherffel tør dog ikke udtale sig med Sikkerhed herom.

I 1903 opstillede Lemmermann en ny Art *Synura*, som han kaldte *S. reticulata* paa Basis af en Nettegning, som han har set

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[1]) 1858, cit. hos Stein 1878, Pag. 151.

paa Hylsteret hos en *Synura*. Han ledsager ikke sin Beskrivelse med Figurer, og Iagttagelsen synes i det hele at være gjort i Hast. Awerinzew (1912, Pag. 6) udtaler imidlertid den Anskuelse, at Lemmermann's *S. reticulata* blot er en *S. uvella*, idet han hos denne ved Hjælp af Indtørringspræparater finder, at Hylsteret „hexagonale Verdickungen besitzt, welche im ganzen netzartig auftreten, dabei sind die die Oberfläche der Hülle bedeckenden kleinen Stacheln immer nur in den Knotenpunkten dieses Netzes eingelagert.“ Det Mikrofotografi, som skal dokumentere Sagen, er desværre meget utydeligt. Endelig udtaler Pascher sig i sine forskellige Arbejder om Hylsteret hos *Synura*. Han anser det simpelt hen som usammensat i Modsætning til *Mallomonas*'s Hylster[1]); men han er dog tilbøjelig til at indrømme, at man ikke har fuld Klarhed paa dets Bygning (Pascher 1912, Pag. 154).

De ældre Undersøgere (Stein, Bütschli) anser nærmest Hylsteret for at være en Cuticulardannelse, en Slags Periplast. Klebs derimod opfatter det som et ægte Hylster, og deri har han ikke senere mødt Modsigelse.

Hylsterets kemiske Natur har ikke været Genstand for nogen som helst Undersøgelse, saa vidt jeg ved.

Allerede i 1910 havde jeg *Synura* til Undersøgelse og fremstillede dengang 2 Præparater af den ved Hjælp af den Löfflerske Beitzningsmetode (i Fischer's Modifikation, se Strasburger: Praktikum 1902, Pag. 413). I disse Præparater viste der sig dels smukke Cilier, som senere skal omtales, og dels bekræftedes ganske Scherffel's Formodning om, at Hylsteret var opbygget af Plader. Disse maa dog nærmest betegnes som Skæl, idet de ligger taglagt med den frie Rand vendt mod Koloniens Periferi. De sidder i tydelig Skruestilling lignende Skællene paa en Grankogle; men undertiden er Stillingen dog forstyrret ved Indtørringen (Tavle V, Fig. 1). De var meget løst sammenhængende, saa ved Indtørringen paa Dækglasset var Hylsteret paa mange Individer helt faldet fra hinanden, og løse Skæl laa spredte rundt om i Præparatet. Man havde da her den bedste Lejlighed til at iagttage de enkelte Skæls Form, der viste sig at være omtrent elliptisk eller svagt omvendt ægdannet, idet den butte Ende vendte udad. Paa

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[1]) Pascher 1917, Pag. 22.

hvert af dem saas en Linie, som begyndte ved Skællets øverste Punkt paa dets Rand og afskar et omtrent aflangt-liniedannet Felt paa Skællets Midte uden dog at naa dets nederste Rand. Hvorvidt dette Felt er en Fortykkelse paa Skællet eller en Fure paa det, har jeg ikke kunnet afgøre (Tavle V, Fig. 2).

Ser man paa friske eller i Formalin opbevarede *Synura*celler, navnlig dersom man farver Hylsteret f. Eks. med Hæmateïn-Vesuvin eller Rutheniumrødt, ser man tydeligt i Kanten en fin Savtakning, der skyldes Skællenes frie Rande. Fortil findes en tydelig Pore[1]) for Cilierne, og paa den opadvendende Flade ses en svag netlignende Tegning; men det er dog vanskeligt her med Sikkerhed at erkende Skælstrukturen (Tavle V, Fig. 3).

Det er aabenbart denne Tegning, som Lemmermann først har set, og troet, at den var ejendommelig for de Synuraer, han netop havde for sig. Awerinzew er saa kommet til et nøjagtigere Resultat ved Anvendelsen af sin Indtørringsmetode. Denne har jeg ogsaa prøvet. Den giver noget, men Billedet vinder i høj Grad i Tydelighed ved, at Indtørringspræparaterne behandles efter den Löfflerske Opskrift.[2])

Det er allerede af Klebs (1892, Pag. 398) omtalt, at *Synura*'s Celler kan forandre Form, og heri Hylsteret iberegnet. Den af Klebs tegnede Celle (1892, Tavle XVIII, Fig. 8 a, b) ligner i Form ikke særlig meget de normale Synuraceller, idet den sædvanlige stilkformede bageste Del af Cellen næsten helt mangler. Sandsynligvis har Klebs tegnet enkelte fritsvømmende Celler eller Celler i Kolonier bestaaende af meget faa Celler, og saadanne Kolonier omtaler Klebs, at han har set.

Jeg har selv iagttaget lignende faacellede Kolonier, og her var Cellerne altid rundagtige og manglede næsten Stilk. Jeg har set Celler, der var endnu mere afrundede end de af Klebs tegnede. For yderligere at konstatere Sagen prøvede jeg at give et Dækglas, under hvilket der befandt sig en Del store *Synura*kolonier med „langstilkede" Celler, et let Slag. Herved knustes Kolonierne; de fleste af Cellerne dræbtes; men enkelte af dem blev dog i Live og vedblev at svømme livligt omkring. Disse Celler antog

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[1]) Pascher 1917, Pag. 22, omtaler 2 Porer.

[2]) Jeg mener altsaa, at *Synura reticulata* Lemm. bør regnes som *species excludenda*.

straks en mere afrundet Form. Man maa da antage, at der er en ret betydelig Bevægelighed mellem Skællene i Hylsteret.

Angaaende dettes kemiske Natur kan jeg meddele, at det i al Fald ikke bestaar af ren Cellulose, idet Chlorzinkjod slet ikke farver det. Af samme Grund er det ogsaa udelukket, at det kan være af Æggehvidestof. Derimod antager det med Rutheniumrødt en intensiv rød Farve. Varm, stærk Svovlsyre opløser det helt, medens Jod og Svovlsyre farver det brunt.

II. **Svingtraadene hos Synura Uvella.**

I den foreliggende Litteratur finder man meget lidt om Cilierne hos *Synura*. I Almindelighed meddeler Forfatterne blot, at den har to omtrent lige lange Cilier, og i Almindelighed afbildes de strakt lige fremad som Cilierne hos en *Chlamydomonas*[1]). Ser man imidlertid med et godt Mikroskop paa en levende *Synura*-koloni, vil det være paafaldende, at man paa hver Celle i Almindelighed kun ser een Cilie strakt ud i radial Retning fra Kolonien. Kun en Gang imellem opdager man den anden Cilie, der normalt svinger parallelt med Koloniens Overflade eller slynger sig ind omkring den Celle, den hører til.

Scherffel omtaler (1904, Pag. 441) en ny „Mallomonas“form, der ingen Børster har paa Hylsteret, men to Cilier, og han beskriver, hvorledes de to Cilier bruges paa forskellig Maade. Den ene strækkes lige fremad, medens den anden føres ned langs Cellen og bagud under Bevægelsen. De to Cilier er heller ikke lige lange, idet den fremadrettede er den længste. Jeg er ganske overbevist om, at Scherffel's „*Mallomonas*“ ikke er andet end enkelte, fritsvømmende Celler af *Synura*, som den, vel at mærke, levede sammen med. Jeg har nemlig set saadanne isolerede *Synura*-celler (se ovenfor Pag. 348) svømme rundt netop paa samme Maade som af S. beskrevet.

Vi kan da nu allerede slaa fast, at de to Cilier hos *Synura* er af forskellig Natur og Virkemaade.

I de Præparater af *Synura*, som jeg fremstillede ved Hjælp af

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[1]) Se f. Eks. Pascher 1912, Tavle 9, Fig. 28.
I samme Arbejde omtaler Pascher, at han har iagttaget, hvorledes Cilierne trækkes ind hos Sværmerne. Ved denne Lejlighed mente han ogsaa at kunne se en solidere Midtstreng i Svingtraaden.

den Löfflerske Beitzningsmetode, frembød dens Cilier et overraskende Skue (Tavle V, Fig. 4). Den ene Cilie viste sig at være en „Piskecilie“ af samme Type som hos *Polytoma* (Fischer 1894), medens den anden er en Fjercilie, nærmest lignende den, der er fundet hos *Monas Guttula*.

Piskecilien har et nedre, tykkere Parti, der paa et bestemt Sted afsmalnes til en lang, tynd Pisk. Grænsen mellem „Pisken“ og „Skaftet“ er ikke saa skarp, som Fischer (1894) angiver for *Polytoma*. I mange Tilfælde er „Pisken“ knækket af, navnlig i Præparater, hvor Cellerne er dræbte med Osmiumsyre. I disse Præparater ses begge Cilierne paa næsten alle Cellerne; men i de almindelige Præparater, hvor Synuraerne ikke er dræbte inden Indtørringen, ses Piskecilien kun paa nogle faa af dem, idet det er den, der i levende Tilstand bevæges ind omkring Cellen. Ved Indtørringen vil den da i Reglen komme til at ligge inde under eller oven paa denne, saa at den ikke kan ses. Af samme Grund viser Piskecilien sig gerne betydelig kortere, end Fjercilien, til trods for at dens tykke Del i Længde dog ikke staar synderlig tilbage for denne. Hvorledes jeg har kunnet overbevise mig herom, skal jeg senere gøre Rede for.

Fjercilien viser sig som en tyk Traad, besat med en Mængde fine Haar paa begge Sider, saa at den kommer til at ligne en Fjer. I Præparaterne ser det ud, som om de fine Haar sidder i to Rækker; men dette er dog maaske blot en Følge af Indtørringen. Jeg anser det for det mest sandsynlige, at de sidder alsidigt; men det er ikke lykkedes mig at se dem anderledes end i indtørret Tilstand. De viser sig gerne at sidde parallelt indbyrdes, men med noget forskellig Vinkel med Cilien. Man kan maaske deraf have Lov at slutte, at de kan lægge sig ind til denne og atter spredes, og at disse Bevægelser foregaar samtidigt med dem alle.

Kun paa afkastede Cilier ser man undertiden, at de sidder ganske forpjusket ud i alle Retninger (Tavle V, Fig. 5). Det er da sandsynligt, at Haarene i Dødsøjeblikket har bevæget sig ganske uregelmæssigt. I andre Tilfælde finder man afkastede Cilier smukt indrullede som Euglenacilier (Fischer 1894, Pag. —, Tavle XI, Fig. 7—14), (Tavle V, Fig. 6).

En Del levende Eksemplarer af *Synura* undersøgtes ved Mørkgrundsbelysning ved Hjælp af en Paraboloïdkondensor fra Zeiss. Man saa her Cilierne i livlig Bevægelse uden omkring Kolonien. Fjercilierne var strakt lige ud, radiært fra Kolonien og stod nogenlunde roligt; men ud ad dem gik en livlig Bevægelse som af fine Bølger. Selve Cilierne bølgede sig og viste sig altsaa meget flexile i Modsætning til f. Eks. Eudorina's Cilier, der er stivere og aldrig viser sig bølgede; men formentlig har de fine Sidehaar forøget Indtrykket af Bølgebevægelsen. Selve Haarene kunde forøvrigt ikke skelnes. Piskecilien saas strakt ud i tangential Retning og ligeledes i livlig Bevægelse, men ofte forsvandt den, idet den svingede ind omkring Cellen. Heller ikke kunde man se nogen Tykkelsesforskel mellem en nedre og en øvre Del af Piskecilien, muligvis fordi den fine Pisketraad slet ikke kunde ses.

Som Lyskilde anvendtes en lille elektrisk Buelampe. Det stærke Lys, der samledes paa Præparatets Draabe, medførte ofte en saa stærk Varme, at Algerne dræbtes deraf. Man saa da, hvorledes hver Celle strakte sine to Cilier lige fremad, hvorefter de med et brat Knæk afkastedes. Det viste sig nu, at de to Cilier var omtrent lige lange; dog var Fjercilien kendeligt den længste.

I Afsnittet om Hylsteret hos *Synura* er det allerede omtalt, hvorledes det lykkedes ved et let Slag paa Dækglasset at faa enkelte Celler isolerede af Kolonierne, saa at man kunde se dem svømme omkring enkeltvis. Som Tavle V, Fig. 7 viser, bevægede Cellen sig da i en Cirkel med den brede Ende med Cilierne forrest. Fjercilien er strakt lige frem fra Cellen, medens Piskecilien sidder paa den Side af Cellen, der vender bort fra Cirkelbevægelsens Centrum.

Fjercilien frembringer aabenbart et Træk fremad i Cellen, Piskecilien derimod et Tryk i en Retning modsat den, ud i hvilken Cilien er strakt. Resultanten vil da blive en Kraft, der virker skraat til den ene Side paa Cellens forreste Ende, og dens Virkning vil vise sig som en Cirkelbevægelse af Cellen.

En levende Koloni bevæger sig gerne livligt fremad, og ofte i en bestemt Retning. Dog standser den af og til, gaar maaske lidt til den ene eller den anden Side, men fortsætter atter i samme Retning. Imidlertid drejer den sig samtidig rundt, snart til den ene, snart til den anden Side, saa det ser ud, som den trillede af Sted. Hvorledes Cilierne nu bevirker denne Bevægelse, er det vanskeligt at forestille sig i sine Enkeltheder. Idet man maa antage, at de enkelte Individer i Kolonien udfører deres Bevægelser ganske uafhængigt af de andre, maa Fjercilierne, der, som nævnt, alle virker med en Kraft bort fra Koloniens Centrum, komme til at modvirke hinanden til en vis Grad.

Hvorvidt Piskecilierne er i Stand til at forandre deres Virkeretning eller de altid svinger ud til en bestemt Side fra hver Celle, er foreløbig uoplyst, ligesom Ciliernes hele Virkemaade trænger til nøjere Efterforskning.

For at faa nærmere Klarhed over *Synura*cellens cytologiske Bygning og Ciliernes Insertion, fixerede jeg en Del Materiale med Flemming's Vædske. Efter Afvanding bragtes det i Benzol og indsmeltedes i Paraffin, hvorefter jeg skar Snit deraf paa ca. 3 μ. Tykkelse. Disse behandledes efter den Heidenhainske Metode med 4 pCt. Jærnalun i 24 Timer, med Hæmatoxylin ligeledes i 24 Timer, hvorefter der differentieredes med en ca. 1 pCt. Jærnalunopløsning. Jeg fik da ret smukke Billeder frem, som Tavle V, Fig. 8, 9 viser. Hylsteret farves slet ikke ved denne Behandling, hvorfor det næsten ikke ses i Præparaterne. Paa Figurerne er kun Protoplasmalegemet tegnet. Heri ses tydeligt de to vægstillede Kromatoforer. I Midten af Cellen findes en Kærne, som indeholder et stort, stærkt farvet Legeme (Nucleolus?), men ellers er klar og gennemsigtig. Kærnehinden er ikke meget tydelig. Kærnen er omgivet af et kornet Plasmaparti, som kun delvis udfylder Rummet mellem Kromatoforerne. Det findes væsentlig ved den øvre Ende af Cellen, medens den nedre Del af denne er udfyldt af et stort Hulrum, som er omgivet med et tyndt Protoplasmalag. Det kornede Plasma omkring Kærnen sender ofte Forlængelser ned gennem Hulrummet[1]).

Paa Tværsnit af Cellen (Tavle V, Fig. 9) ses det, at Kromatoforerne omtrent dækker Væggens hele Omkreds. Dersom Snittet er faldet gennem den øverste Del af Cellen, ses Kærnen med det kornede Plasma uden om (Fig. 9 b). Paa et Snit gennem den nedre Del af Cellen ses kun Kromatoforerne, samt Hulrummet og en Smule Protoplasma uden om det (Fig. 9 a).

Paa Spidsen af Cellen ses en mørkfarvet Fibril, der strækker

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[1]) Dette Hulrum har i den levende Celle været udfyldt med Leucosin (Klebs 1892, Pag. 395), som imidlertid er opløst under Behandlingen.

sig ind i det kornede Plasma mod Kærnen, uden at jeg dog kunde se den nøjere Forbindelse mellem dem. Den anden Ende af Fibrillen strækker sig uden for Cellen og gaar over i en Cilie, hvilket tydeligt var at se paa flere Eksemplarer. Derimod kunde jeg ikke paa nogen Celle skelne begge Cilierne; men jeg antager, at de begge udspringer fra den samme Fibril, der vel maa betegnes som en Rhizoplast.

Paa enkelte Celler saas ved Grunden af Cilien et lille mørkt Legeme, muligvis et Basalkorn; men det kunde ikke ses altid.

III. **Svingtraadene hos nogle andre Chrysomonadineæ.**

I de Ciliefarvningspræparater, som jeg fremstillede for at faa farvet Cilierne hos *Synura*, fandtes ogsaa andre Flagellater, af hvilke jeg her kort skal omtale to andre Chrysomonadiner, nemlig *Uroglena volvox* og *Dinobryon Sertularia*.

Angaaende *Uroglena volvox* (Tavle V, Fig. 10) er at bemærke, at man naturligvis ikke saa noget til den Skælbeklædning, som er ejendommelig for *Synura*, og Geléen, som omslutter Cellerne, farvedes ved Behandlingen, saa at Ciliernes Struktur fremtraadte knap saa skarpt som hos *Synura*. Paa den lange Cilie saa man dog tydeligt fine Haar i to (tilsyneladende?) Rækker som hos denne. Paa den korte Cilie var der derimod ingen særlig Struktur at opdage, hverken Sidehaar eller Pisketraad.

Cilierne hos *Dinobryon Sertularia* viste sig meget at ligne dem hos *Uroglena*. Den lange Cilie er en Fjercilie af samme Type som hos denne, og den korte Cilie synes at være af en simpel Bygning. Paa Tavle V, Fig. 11 ses kun den lange Cilie, og man bemærker, at den Del af den, der rager udenfor Hylsteret er meget tyk, medens den Del af den, som er indenfor Hylsteret, er knap halvt saa tyk. Det er aabenbart Beitzen, der har bragt den fremragende Del til at bulne ud (jvf. Fischer 1894, Pag. 192), medens Hylsteret har kunnet beskytte den inderste Del af Cilien mod Beitzens Indvirkning. Her ser man heller ikke noget til Sidehaar. Disse er hos *Dinobryon* endnu finere end hos *Synura* og *Uroglena* og i mange Tilfælde vanskelige at faa Øje paa. Naar der paa Figuren ikke ses Haar hen imod Ciliens Spids, betyder det ikke, at de ikke findes, men at de har lagt sig tæt ind til Cilien og derfor ikke kan ses.

Universitetets botaniske Laboratorium i Marts 1918.

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Figurforklaring.

Tavle V.

Fig. 1. Celle af *Synura* fra et Beitzningspræparat, visende Hylsterets Skæl og deres Anordning. (1280 Gange).

Fig. 2. 4 Skæl af samme. (2560 Gange).

Fig. 3. Celle af *Synura* konserveret i Formalin; behandlet med Alkohol og farvet med Hæmateïn-Vesuvin. Hylsteret ses i optisk Snit. (1280 G.).

Fig. 4. Cilier af *Synura* fra Beitzningspræparat. Cellerne ikke dræbte før Indtørringen paa Dækglas. (1280 G.).

Fig. 5. Afkastet Cilie af samme (1800 G.).

Fig. 6. Afkastede, mere eller mindre indrullede Cilier af samme. (1800 G.).

Fig. 7. Skematisk Figur, visende Ciliernes Stilling paa en isoleret, fritsvømmende Celle. Pilen angiver Bevægelsesretningen.

Fig. 8. Celle af *Synura*; fixeret med Flemming's Vædske; farvet med Heidenhain's Jærnhæmatoxylin. Hylsteret ikke tegnet med. (1800 G.).

Fig. 9. Celler af samme i Tværsnit. Samme Behandlingsmaade. (1800 G.).

Fig. 10. Celle af *Uroglena Volvox* med Cilier. Beitzningspræparat. (1200 G.).

Fig. 11. Celle af *Dinobryon Sertularia*. Beitzningspræparat. (1200 G.).

Explication des figures.

Planche V.

Fig. 1. Cellule de *Synura* provenant d'une préparation à mordançage, montrant les écailles de la membrane et la manière dont elles sont disposées. (1280/1).

Fig. 2. Quatre écailles de membrane de *Synura*. (2560/1).

Fig. 3. Cellule de *Synura*, conservée dans la formaline, traitée à l'alcool et colorée avec l'hématéïne-vésuvine. Section optique de la membrane. (1280/1).

Fig. 4. Cils de *Synura* enlevés à une préparation à mordançage. Les cellules n'étaient pas tuées avant dessiccation sur couvre-objet. (1280/1).

Fig. 5. Cil détaché de *Synura*. (1800/1).

Fig. 6. Cils détachés de *Synura*, plus ou moins enroulés en spirale. (1800/1).

Fig. 7. Figure schématique montrant la disposition des cils sur une cellule isolée flottante. La flèche indique la direction du mouvement.

Fig. 8. Cellule de *Synura*. Fixée à l'aide de liqueur Flemming; colorée à l'hématoxyline ferrique de Heidenhain. La membrane n'est pas représentée dans la figure. (1800/1).

Fig. 9. Cellules du même, section transversale. Même mode de traitement. (1800/1).

Fig. 10. Cellule de l'*Uroglena volvox*, munie de cils. Préparation à mordançage. (1200/1).

Fig. 11. Cellule du *Dinobryon Sertularia*. Préparation à mordançage. (1200/1)

Résumé

En raison des résultats si intéressants qu'ont fournis les recherches d'Alfred Fischer (1894), il est regrettable qu'elles n'aient pas été continuées par lui, ni jusqu'à présent reprises par d'autres chercheurs.

I. La *Membrane* chez *Synura*. En employant la méthode de *Loeffler*, telle qu'elle a été modifiée par A. Fischer, nous avons pu démontrer que dans le genre de Synura la membrane ou coque se compose de corpuscules écailleux (Planche V, fig. 1) disposés en vis comme les écailles d'une pomme de sapin, structure qui dans une certaine mesure permet à la membrane de changer de forme. Les courts piquants ou soies dont elle paraît hérissée ne sont en réalité que les pointes libres des écailles. (Planche V, fig. 3).

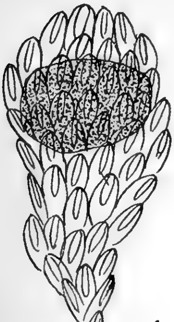
II. Les cils du Synura apparaissent dans les préparations à mordançage comme étant de deux sortes bien distinctes: l'une en forme de fouet, l'autre un cil vibratile penné montrant deux séries opposées de petits cils secondaires, de manière à simuler une plume; il est à présumer cependant, que ceux-ci partent de tous les côtés du cil primaire. Le cil flagelliforme possède une espèce de manche constituée par la partie basilaire épaisse, qui s'amincit assez brusquement en un long filament (Planche V, fig. 4). — Dans une colonie vivante, les cils pennés s'étendent dans la direction radiaire, tandis que les cils flagelliformes oscillent par la tangente ou bien vers l'intérieur de la colonie. Le mouvement du cil penné a pour effet de tirer la cellule dans la direction où le cil s'est étendu; le cil flagelliforme, de son côté, tend à exercer une pression sur son point d'insertion. (Planche V, fig. 7).

En fixant des colonies de Synura dans la liqueur de Flemming, puis colorant par la méthode à l'hématoxyline ferrique de Heidenhain, on a vu se produire de belles colorations de l'intérieur de la cellule (Planche V, fig. 8, 9). Au centre de la cellule se distingue un noyau clair et transparent, renfermant un gros corpuscule fortement coloré (un nucléole?); la membrane nucléique est peu distinct. Le noyau est entouré d'une partie cytoplasmique granuleux, laquelle ne remplit que partiellement l'espace qui sépare les chromatophores. Elle se trouve principalement vers le bout supérieur de la cellule, la partie inférieure de celle-ci étant occupée par une grande cavité, laquelle a été chargée de leucosine, qui cependant s'est dissoute au cours de la préparation. A l'extrémité supérieure de la cellule on aperçoit une fibrille, filet protoplasmique de couleur sombre, qui s'étend dans le cytoplasme granuleux vers le noyau, sans toutefois qu'on ait pu constater s'il se relie à ce dernier. A l'autre bout de la fibrille les cils se trouvent fixés. Ce filet protoplasmique est probablement un rhizoplaste.

III. Les *cils* de certaines autres *Chrysomonadineae.* L'*Uroglena Volvox* est doué, on le sait, de deux cils de longueur très inégale. Dans les préparations à mordançage, le cil court ne présentait pas de structure particulière; l'autre cil, au contraire, s'est révélé être un cil penné de même structure que chez Synura (Planche V, fig. 10). Le *Dinobryon Sertularia*, lui aussi, offre deux cils d'inégale longueur, dont le plus long est un cil penné du même type que celui des deux genres précédents, tandis que l'autre n'a pas montré de structure différenciée. (Planche V, fig. 11).

3—4—18.

Andelsbogtrykkeriet i Odense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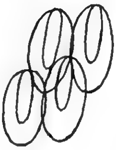
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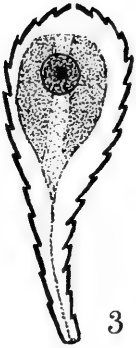
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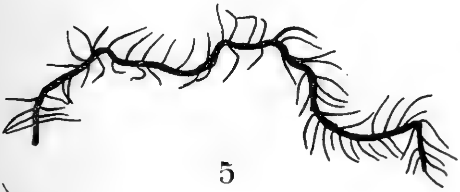
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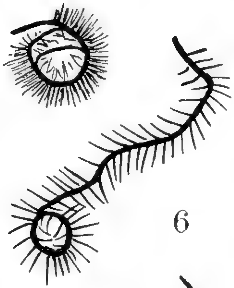
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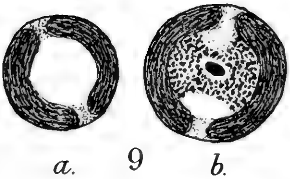


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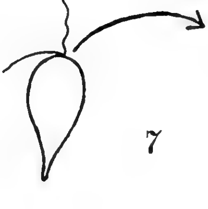
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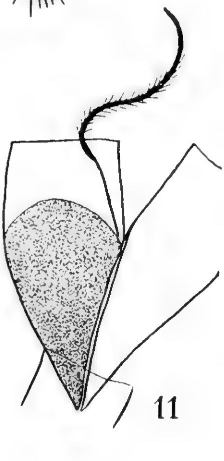
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Boye Petersen del.

MOSSES AND LICHENS

COLLECTED IN THE FORMER DANISH WEST INDIES

BY

F. BØRGESEN AND C. RAUNKIÆR

Særtryk af
DANSK BOTANISK ARKIV
Bd. 2, Nr. 9

Arbejder fra den botaniske Have i København Nr. 85

Mosses and Lichens
collected in the former Danish West Indies

By

F. Børgesen and **C. Raunkiær.**

In the years 1905-6 we visited the Danish West-Indies, and from that tour dates the greater part of the material which this list contains. As to the rest of the material most of it is due to F. Børgesen's travellings, respectively in 1892-93 and 1895-96. Finally the list contains some specimens collected by Eggers, O. Paulsen and C. H. Ostenfeld. The whole of the material is in the Botanical Museum University of Copenhagen.

Our warmest thanks are due to the Professors V. F. Brotherus and E. Wainio (Helsingfors), who were kind enough to determine the whole of the material, respectively the mosses and the lichens.

The lichens have been included in Wainio's "Additamenta ad Lichenographiam Antillarum illustrandam" (Annales Academiae Scientiarum Fennicae. Ser. A. Tom. VI. Helsingforsiae 1915). The names of those species collected by us and mentioned in Wainio's paper as new are, in the present list, printed in large type. The mosses, on the other hand, have never been published before. Therefore, by the permission of Professor Brotherus, the new species, there are only two of them, are here accompanied by his descriptions.

The greater part of our collections were chiefly got in St. Jan, the central part of St. Thomas, and the western part of St. Croix. Some of the localities were visited by us together; but, as the chief aim of our investigations in the West-Indies was of a different nature, we had, each of us by himself, opportunities of making collections in places where the other did not go. And, even if we went to the same places it often was at a different time of the year. Still, of course, one must not expect on account of this that the flora of mosses and lichens have been even moderately explored. A beginning is made, that is all. This is shown, too, as far as the mosses are concerned, by a comparison of our list of mosses with the one made by ELIZABETH GERTRUDE BRITTON[1], based upon collections in 1913. The two lists contain about the same number of species, Miss Britton's 23, ours 24, all of them collected in the Danish West-Indies; but 9 species only are common to both lists, which shows that not even a fourth part of the collected species are common to both lists, these pointly containing the 38 species of mosses now known in St. Croix, St. Thomas, and St. Jan. Four of these 38 species have, up till now, never been found elsewhere, except in the above-mentioned islands, namely: *Hyophila uliginosa* E. G. Britton, *Phascum sessile* E. G. Britton, *Trichostomum perviride* Brotherus, and *Bryum* (Apalodictyon) *Raunkiærii* Brotherus.

Even if the number of species of mosses undoubtedly, in the course of time, will increase greatly, the fact remains that the former Danish West-Indies are as deficient in species as they are destitute of areas covered with mosses. Larger patches of ground covered densely with moss are found only on the higher lands, e. g. Makumbo at St. Jan.

The lichenflora is far richer in species, our list containing 156 species, of which 59 are described as new in the above-quoted work of Wainio. All these species have so far, been found only in the Danish West Indies. Many of the new species live on stones and cliffs in places sprayed by the surf, and one of us, Børgesen, had opportunity of making collections here. Most of the species from this locality have never been described before.

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[1] ELIZABETH GERTRUDE BRITTON. West-Indian Mosses. II. Mosses of the Danish West Indies and Virgin-Islands. (Bull. of the Torr. Botan. Club 42. 1915.)

I. Mosses

Determined by **V. F. Brotherus.**

Leucobryaceae.

Octoblepharum albidum (L.) Hedw. St. Thomas: Signalhill (Eggers); St. Jan: America Hill (Raunkiær 340, 350); Esperance (Børgesen); Makumbo (Raunkiær 344).

Fissidentaceae.

Fissidens Kegelianus C. Müll. St. Thomas: St. Peter (Børgesen); Crown (Raunkiær 331).

Calymperaceae.

Syrrhopodon breviligulatus C. Müll. St. Jan: Bordeaux (Raunkiær 358).

Calymperes disciforme C. Müll. St. Croix: Caledonia Valley (Børgesen); St. Thomas (Eggers).

Pottiaceae.

Weisia edentula Sull. St. Croix: Canebay (Børgesen); Kingshill (Raunkiær 334); St. Jan: Foygut (Børgesen); Bordeaux (Børgesen; Raunkiær 343, 372); Rustenborg (Børgesen).

Trichostomum perviride Broth. n. sp. Dioicum; caespitosum, caespitibus densiusculis, rigidis, viridibus, haud nitidis; caulis c. 1.5 cm altus, erectus vel adscendens, infima basi parce fusco-radiculosus, dense foliosus, superne plerumque furcatus; folia sicca circinato-crispula, marginibus involutis, humida patentia, stricta, canaliculato-concava, e basi brevi, ovali late lineari-lanceolata, acutiuscula, saepius hyalino-mucronata, rarius obtusiuscula, mutica, marginibus anguste involutis, integris, nervo crassiusculo, continuo vel breviter excedente, dorso laevi, cellulis minutissimis, subquadratis, papillosis, obscuris, basilaribus majoribus, breviter rectangularibus, hyalinis, laevissimis. Caetera ignota.

St. Thomas, Crown, ad terram (Raunkiær 367). Species T. jamaicensi (Mitt.) Broth. affinis, sed foliorum forma facillime dignoscenda.

Hyophila Tortula (Schwaegr.) Hamp. St. Croix: Canaan (Børgesen); Jolly Hill (Raunkiær 365, 371).

Barbula hymenostylioides Broth. St. Croix: Crequis (Børgesen).

Barbula Crügeri Sond. var. laevinervis Broth. n. var. Compacte caespitosa; folia subcucullata, nervo dorso laevi. St. Jan: Hope (Børgesen).

Tortula agraria Sw. St. Croix: Prosperity (Børgesen); Caledonia Valley (Raunkiær 571); Jolly Hill (Raunkiær 564); Northside (Børgesen). St. Thomas: Løvenlund (Raunkiær 563, 568). St. Jan: America Hill (Børgesen, Raunkiær 376).

Bryaceae.

Bryum (Apalodictyon) Raunkiaerii Broth. n. sp. Dioicum; caespitosum, caespitibus laxis, faciliter dilabentibus, mollibus, pallide viridibus, haud nitidis; caulis usque ad 2 cm altus, erectus, infima basi parce radiculosus, laxissime foliosus, simplex vel parce ramosus; folia sicca et humida patula, haud decurrentia, cymbiformi-concava, elongate oblonga, obtusa, marginibus erectis, integris vel apice plus minusve distincte obtuse serrulatis, elimbata, nervo tenui, rubello, infra apicem folii evanido, cellulis laxe oblongo-hexagonis, teneris, parce chlorophyllosis, basilaribus elongate rectangularibus. Caetera ignota.

St. Croix, Caledonia, ad rupes pr. cataractam (Raunkiær 572).

Species pulcherrima, statura robusta, colore foliisque remotis, patulis oculo nudo jam dignoscenda.

Bryum Crügeri Hamp. St. Croix: Caledonia Valley (Børgesen).

Bartramiaceae.

Philonotis ligulatula (C. Müll.) Par. St. Thomas: Crown (Raunkiær 363).

Philonotis tenella (C. Müll.) Besch. St. Thomas: Løvenlund (Raunkiær 567).

Erpodiaceae.

Erpodium domingense (Spreng.) C. Müll. St. Thomas: Løvenlund Gut (Raunkiær 366, 368).

Leskeaceae.

Thuidium involvens (Hedw.) Mitt. St. Jan: Debt (Raunkiær 335); Esperance (Raunkiær 348).

Thuidium minutulum (Hedw.) Bryol. eur. St. Jan: Makumbo (Raunkiær 375).

Entodontaceae.

Stereophyllum leucostegium (Brid.) Mitt. St. Thomas: Magensbay (Børgesen).

Hypnaceae.

Microthamnium thelistegum (C. Müll.) Mitt. St. Jan: Makumbo (Raunkiær 347).

Taxithelium planum (Brid.) Mitt. St. Jan: Bordeaux (Raunkiær 339, 345, 351, 354, 364, 576); Debt (Raunkiær 338, 356, 359); Susannaberg (Børgesen); Makumbo (Børgesen; Raunkiær 574, 575); Esperance (Børgesen; Raunkiær 374); America Hill (Raunkiær cfr. Octoblepharum albidum 340, 350).

Vesicularia vesicularis (Schwaegr.) Broth. var. Poeppigiana (Hamp.) Broth. St. Croix: Crequis (Børgesen); Mount Stewart (Børgesen).

Vesicularia leucoclada (Schimp.) Broth. St. Croix: Mount Stewart Gut (Raunkiær 369, 370).

Sematophyllaceae.

Rhaphidostegium caespitosum (Sw.) Jaeg. St. Thomas: St. Peter (Børgesen).

Rhaphidostegium admixtum (Sull.) Broth. St. Jan: Esperance (Børgesen); Debt (Raunkiær 332, 346); Bordeaux (Børgesen); America Hill (Børgesen; Raunkiær 341, 352).

II. Lichens

Determined by **E. Wainio.**

I. Discolichenes.

A. Cyclocarpeae.

Trib. Parmelieae.

Eumitria Antillarum Wain. St. Thomas: Signalhill (Eggers).

Ramalina gracilis (Pers.) Nyl.* R. Antillarum Wain. St. Thomas: Crown (Raunkiær 435); Mt. St. Peter (Børgesen), Highest Ridge (Eggers).

Ramalina complanata (Sw.) Ach. St. Croix: Judith Fancy (Børgesen); St. Thomas: Signalhill (Eggers).

Parmelia (Amphigymnia) peresta Krempelh. var. flavogranulosa Wain. St. Croix: Mount Stewart (Raunkiær 433).

Parmelia dominicana Wain. St. Thomas: Magensbay Estate (Børgesen), Ma Folie (Biese).

Parmelia crinita Ach. St. Thomas: Signalhill (Eggers), Highest Ridge (Eggers).

Parmelia Sancta Crucis Wain. St. Croix: Fair Plane (Børgesen).

Parmelia latissima Fée. var. cristifera (Tayl.) Hue. St. Croix: Mt. Eagle (Børgesen). St. Thomas: Signalhill (Eggers).

Parmelia subcrinita Nyl. (Syn. P Mauriensis Hue). St. Thomas: Crown (Eggers) et alibi (Hornbeck, Børgesen).

Parmelia coralloidea (Mey. & Flot.) Wain. St. Thomas: Signalhill (Eggers), Mt. St. Peter (Børgesen), Crown (Raunkiær 415), s. l. (O. Paulsen); St. Jan: Bordeaux (Raunkiær 462, Børgesen).

Parmelia sulphurata Nees et Flot. St. Thomas: s. l. (Ove Paulsen); St. Jan: Makumbo (Raunkiær 442), Bordeaux et prope Susannaberg (Børgesen).

Parmelia (stirps Cyclocheila) tropica Wain. St. Croix: (Ove Paulsen).

Parmelia martinicana Nyl. St. Croix: Krausses Lagoon (Raunkiær 547); Fair Plane et Judith Fancy (Børgesen).

Parmelia Raunkiæri Wain. St. Croix: Cane Bay (Raunkiær 461); Judith Fancy (Børgesen).

Parmelia granatensis Nyl. St. Croix: Krausses Lagoon (Raunkiær 545).

Parmelia (Xanthoparmelia) lusitana Nyl. St. Thomas: Crown (Raunkiær 424); St. Jan: Cruz Bay (Børgesen). Var. decipiens Wain.; Buck Island pr. St. Thomas (Børgesen); St. Jan: Cruz Bay (Børgesen).

Trib. Lecanoreae.

Lecanora subtilissima Wain. St. Jan: Reef Bay (Børgesen).

Lecanora cinereo-carnea (Eschw.) Wain. St. Croix: Sandy Point et Cane Bay (Raunkiær 550, 407); St. Jan: Reef Bay (Børgesen).

Lecanora prosecha Ach. var. rubescens Wain. St. Croix: Crequis et Caledonia Valley (Børgesen).

Trib. Pertusariceae.

Pertusaria coccopoda Wain. St. Thomas: Mt. St. Peter (Børgesen); St. Jan: Foygut bay, America Hill (Børgesen).

Pertusaria xanthodes Müll. Arg. var. biformis Wain. St. Croix: Cane Bay (Raunkiær 467), Mt. Eagle (Børgesen). Var. stramineo-albida Wain. St. Croix: Northside (Børgesen).

Pertusaria simplicata Wain. St. Croix: Cane Bay (Raunkiær 467).

Pertusaria praetervisa Wain. var. straminea Wain. St. Croix: Hams Bluff et Via Oxholmia (Børgesen); Cane Bay

(Raunkiær 425, 426); Buck Island (Børgesen). St. Jan: Brynes Bay (Raunkiær 429); Cruz Bay (Børgesen).

Var. **expallescens** Wain. St. Croix: Hams Bluff et Crequis (Børgesen). St. Jan: Cruz Bay (Børgesen).

Var. **pileolata** Wain. St. Croix: Hams Bluff et Salt River et ad Prosperity (Børgesen).

Pertusaria flavens Nyl. St. Croix: s. l. (Ove Paulsen).

Pertusaria glaucopunctata Wain. St. Thomas: Crown (Raunkiær 417).

Trib. **Theloschisteae.**

Placodium cupuliferum Wain. St. Jan: Reef Bay (Børgesen).

Placodium cinnabarinum (Ach.) Anzi. Buck Island prope St. Thomas (Rüssl.).

Placordium subfulgescens (Nyl.) Wain. f. dispersa Wain. St. Croix: Caledonia valley (Børgesen); St. Thomas: Magensbay Estate (Børgesen); St. Jan: America Hill (Børgesen).

Placodium aurantiacum (Lightf.) Tuck. *Pl. Bassiae (Willd.) Wain. St. Thomas: Crown (Raunkiær 422).

Placodium ferrugineum (Huds.) Hepp. var. caesiorufa (Nyl.) Wain. St. Jan: Reef Bay et Foygut Bay, America Hill (Børgesen).

Placodium leptozonum (Nyl.) Wain. St. Jan: Reef Bay (Børgesen).

Placodium Boergesenii Wain. var. **squamoso-areolata** Wain. St. Thomas: Magensbay (Børgesen); St. Jan: Reef Bay (Børgesen).

Var. **leptozonoides** Wain. St. Croix: Salt River (Børgesen).

Placodium janinum Wain. St. Jan: Kebay (Børgesen).

Placodium agratum Wain. St. Croix: Hams Bluff et Via Oxholmia (Børgesen).

Placodium diplacioides Wain. St. Croix: Crequis, Mt. Eagle (Børgesen); St. Thomas: Løvenlund (Raunkiær 413), Ma Folie (Biese); St. Jan: Kebay, Esperance et Reef Bay (Børgesen).

Placodium diplacium (Ach.) Wain. var. carneofusca (Nyl.) Wain. St. Croix: Caledonia valley et Crequis (Børgesen); St. Thomas: Løvenlund (Raunkiær 405); St. Jan: Esperance, Kebay et Reef Bay (Børgesen).

Var. phaea (Tuck.) Wain. St. Croix: Crequis, Caledonia valley et Hams Bluff (Børgesen); St. Thomas: Crown (Raunkiær 411), Magensbay Estate (Børgesen), St. Peter (Børgesen); St. Jan: Susannaberg (Børgesen).

Var. verrucosa Wain. St. Thomas: Magensbay Estate (Børgesen); St. Jan: Cruz Bay (Børgesen).

Var. lecideoides Wain. St. Croix: Cane Bay (Raunkiær 427), Via Oxholmi et Prosperity (Børgesen); St. Thomas: Magensbay Estate (Børgesen); Buck Island prope St. Thomas. Transiens in var. verrucosam; St. Thomas: Magensbay Estate (Børgesen); in var. phaeam transiens; St. Croix: Prosperity (Børgesen).

Var. deminuta Wain. St. Thomas: Magensbay Estate (Børgesen).

Trib. **Buellieae.**

Anaptychia granulifera (Ach.) Wain. var. farinulenta Wain. St. Thomas: Signalhill (Eggers).

Physcia callosa Nyl. var. macra Wain. St. Jan: Cruz Bay (Børgesen).

Physcia integrata Nyl. var. obsessa (Mont.) Wain. f. psathyra (Tuck.) Wain. St. Jan: Cruz Bay (Børgesen).

Var. sorediosa Wain. f. tristis Wain. St. Croix: Crequis (Børgesen); St. Thomas: Crown (Raunkiær 402), Magensbay Estate (Børgesen); St. Jan: Reef Bay (Børgesen), Coral Bay (Raunkiær 453); f. pallescens Wain. St. Croix: Fair Plane (Børgesen).

Physcia crispa (Pers.) Nyl. var. mollescens (Nyl.) Wain. St. Croix: Cane Bay (Børgesen); St. Thomas: Løvenlund (Raunkiær 410, 431), Magensbay Estate (Børgesen), Signalhill

(Eggers); St. Jan: Cruz Bay (Raunkiær 554, 556), Reef Bay Makumbo, Susannaberg (Børgesen). f. melanophthalma Wain. St. Thomas: Løvenlund (Raunkiær 541).

Physcia minor (Fée) Wain. St. Croix: Northside (Børgesen).

Physcia adglutinata (Floerk.) Nyl. St. Croix: Cane Bay (Raunkiær 406).

Physcia picta (Sw.) Nyl. St. Croix: Northside (Børgesen) et alibi (Ove Paulsen); St. Thomas: Crown (Raunkiær); St. Jan: Cruz Bay.

Ph. picta (Sw.) Nyl. f. prunifera Wain. St. Croix: Northside (Børgesen); St. Jan: Cruz Bay (Børgesen).

Ph. picta (Sw.) Nyl. f. lavata Wain. St. Croix: s. l. (Ove Paulsen).

Physcia purpurascens Wain. St. Croix: Krausses Lagoon (Raunkiær 542), Fair Plane (Børgesen).

Pyxine Meissneri Tuck. var. genuina Malme. St. Croix: Fair Plane (Raunkiær 548), Jolly Hill (Raunkiær 436), Krausses Lagoon (Raunkiær 546), Hams Bluff et Cane Bay (Børgesen), s. l. (Ove Paulsen).

Var. rinodinoides Wain. St. Jan: Coral Bay (Caroline) (Raunkiær 443).

Pyxine connectens Wain. St. Croix: Cane Bay (Raunkiær 406).

Pyxine dissecta (Fée) Wain. St. Croix: Northside (Børgesen), Cane Bay (Raunkiær 406).

Pyxine heterospora Wain. St. Thomas: Løvenlund (f. rugulosa Wain., Raunkiær 409), Crown (Raunkiær 420); St. Jan: Cruz Bay et Reef Bay (Børgesen).

Pyxine obscurascens Malme. St. Thomas: St. Peter (Børgesen).

Rinodina pyxinoides Wain. St. Jan: Cruz Bay (Børgesen).

Rinodina Boergesenii Wain. St. Croix: Hams Bluff (Børgesen).

Rinodina Antillarum Wain. St. Thomas: Magensbay Estate (Børgesen).

Rinodina intrusa (Krempelh.) Malme. var. leioplaca (Müll. Arg.) Malme. St. Jan: Reef Bay (Børgesen).

Melanospicilia contiguella Wain. St. Thomas: Magensbay Estate (Børgesen).

Var. vegetior Wain. St. Thomas: Magensbay Estate (Børgesen).

Buellia dejungens Nyl. var. chrysophaea Wain. St. Croix: Hams Bluff et Mt. Eagle (Børgesen); St. Thomas: Magensbay Estate (Børgesen).

Var. chrysochlora Wain. St. Croix: Caledonia Valley (Børgesen); St. Jan: Makumbo et Esperance (Børgesen).

Var. chrysochroa Wain. St. Croix: Mt. Eagle (Børgesen); St. Thomas: Løvenlund (Raunkiær 404); St. Jan: Rustenborg (Børgesen).

Buellia endochrysea Wain. St. Thomas: Magensbay Estate (Børgesen).

Buellia trachyspora Wain. St. Jan: Reef Bay (Børgesen).

Buellia gyrosa Wain. St. Jan: Rustenburg (Børgesen).

Buellia poliocheila Wain. St. Thomas: Ma Folie (Biese), Magensbay Estate (Børgesen); St. Jan: Cruz Bay (Børgesen).

Buellia parachroa Wain. var. interrupta Wain. St. Thomas: Magensbay (Børgesen).

Buellia pachydermatica Wain. St. Thomas: Ma Folie (Biese).

Buellia conspirans Nyl. St. Jan: Cruz Bay (Børgesen).

Buellia modesta (Krempelh.) Müll. Arg. St. Croix: Fair Plane (Børgesen), Krausses Lagoon (Raunkiær 542); St. Thomas: Crown (Raunkiær 419).

Buellia Lauricassiae (Fée) Wain. St. Croix: Jolly Hill (Raunkiær 436); St. Thomas: s. l. (Børgesen).

Buellia polyspora (Willey) Wain. var. diminutiva Wain. St. Croix: Cane Bay (Raunkiær 467).

Buellia pachyphragma Wain. St. Jan: Reef Bay (Børgesen).

Buellia orcularia Wain. St. Thomas: Magensbay (Børgesen); St. Jan: Cruz Bay (Børgesen).

Trib. **Pannarieae.**

Coccocarpia pellita (Ach.) Wain. var. parmelioides (Hook.) Müll. Arg. St. Jan: Esperance et Cruz Bay (Børgesen).

Coccocarpia cronia (Tuck.) Wain. var. isidiophylla (Müll. Arg.) Wain. St. Jan: s. l. (Ove Paulsen).

Var. isidiosa (Müll. Arg.) Wain. St. Thomas: St. Peter (Børgesen); St. Jan: Susannaberg (Børgesen).

Trib. **Heppieae.**

Heppia Bolanderi (Tuck.) Wain. St. Jan: Cruz Bay (Børgesen).

Leptogium moluccanum (Pers.) Wain. St. Jan: Makumbo (Raunkiær 428, 441).

Leptogium caesium (Ach.) Wain. St. Jan: Esperance (Børgesen).

Leptogium marginellum (Sw.) Mont. St. Thomas: St. Peter (Børgesen).

Leptogium coralloideum (Mey. et Flot.) Wain. St. Jan: Makumbo (Raunkiær et Børgesen).

Collema (sect. Blennothallia) **acarosporoides** Wain. Buck Island near St. Croix (Børgesen).

Synalissa lichinella Wain. St. Jan: Cruz Bay (Børgesen).

Pyrenopsis Antillarum Wain. St. Thomas: Magensbay Estate (Børgesen); St. Jan: Cruz Bay (Børgesen).

Pyrenopsis negans Wain. St. Jan: Cruz Bay (Børgesen).

Psorotichia aspicilioides Wain. St. Croix: Crequis (Raunkiær 432).

Psorotichia americana Wain. var. pallescens Wain. St. Jan: America Hill (Børgesen).

Psorotichia Boergesenii Wain. St. Thomas: Magensbay (Børgesen).

Trib. **Lecideae.**

Cladonia fimbriata (L.) Fr. f. subulata (L.) Wain. St. Croix: Mt. Eagle (Børgesen). f. radiata (Schreb.) Coem. Wain. parce cum praecedente (Mt. Eagle).

Cladonia pityrea (Floerk.) Fr. f. servediosa Wain. St. Croix: Mt. Stewart (Raunkiær 430).

Lecidea medialis Tuck. Wain. St. Croix: Cane Bay, Mt. Eagle (Børgesen); St. Jan: Makumbo (Børgesen).

Lecidea subvelutina Wain. St. Jan: Debt (Raunkiær, 558, 559, 560).

Lecidea (Biatorina) **trifera** Wain. St. Croix: Jolly Hill (Raunkiær 440).

Lecidea (Biatora) **janina** Wain. St. Jan: Macumbo (Børgesen).

Lecidea piperis (Spreng.) Nyl. f. erythroplaca (Fée) Krempelh. St. Jan: Makumbo (Borgesen); f. circumtincta Nyl. St. Jan: Debt (Raunkiær 454).

Trib. **Gyalecteae.**

Gyalecta lutea (Dicks.) Tuck. St. Jan: Caroline (Raunkiær 464).

Trib. **Diploschisteae.**

Diploschistes actinostoma (Pers.) Zahlbr. St. Croix: Mt. Eagle (Børgesen); St. Thomas: Magensbay Estate (Børgesen); St. Jan: Cruz Bay (Børgesen).

Trib. **Thelotremeae.**

Thelotrema rhodothecium Wain. St. Jan: Debt (Raunkiær 403).

Thelotrema compunctum (Sw.) Nyl. var. Antillarum Wain. St. Croix: s. l. (Ove Paulsen); St. Jan: Cruz Bay (Raunkiær 553).

Thelotrema aquilinum Wain. St. Croix: Mt. Eagle (Børgesen).

Gyrostomum scyphuliferum (Ach.) Fr. St. Thomas: Crown (Raunkiær 412); St. Jan: Reef Bay (Børgesen), Coral Bay (Raunkiær 449, 451), Borcks Creek (Raunkiær 544).

Trib. **Lecanactideae.**

Lecanactis (Basidiactis) **denticulata** Wain. St. Croix: Krausses Lagoon (Raunkiær 546); St. Thomas: s. l. (Børgesen).

Lecanactis dryina (Ach.) Wain. St. Croix: Fair Plane (Børgesen), Krausses Lagoon (Raunkiær 546).

B. Hysterieae.

Trib. 1. Graphideae.

Graphis acuminata Wain. St. Jan: Esperance (Raunkiær 437).

Graphis virginea (Eschw.) Nyl. St. Jan: Bordeaux (Raunkiær 456), Debt (Raunkiær 403).

Graphis collospora Wain. St. Croix: Mt. Eagle (Børgesen).

Graphis punctiformis (Eschw.) Nyl. St. Thomas: Crown (Raunkiær 417).

Graphis arthonioides Wain. St. Croix: Krausses Lagoon (Raunkiær 546), Fair Plane (Raunkiær 548).

Graphis trichosa Ach. St. Jan: Debt (Raunkiær 455).

Graphis tenella Ach. var. epiphaea Wain. St. Croix: Cane Bay (Raunkiær 408), Hams Bluff (Børgesen); St. Jan: Coral Bay (Raunkiær 452), Cruz Bay (Raunkiær 557).

Graphis Afzelii Ach. St. Jan: Debt (Raunkiær 466).

Graphis atroalba Krempelh. St. Jan: Debt (Raunkiær 458).

Graphis (sect. Anomographe) **coriacea** Wain. St. Croix: Caledonia Valley (Børgesen).

Graphis (sect. Glyphis) cicatricosa (Ach.) Wain. var. simplicior Wain. St. Thomas: Crown (Raunkiær 416); St. Jan: Coral Bay (Raunkiær 447).

Var. confluens (Zenk.) Wain. St. Jan: Coral Bay (Raunkiær 447).

Opegrapha (subg. Euopegrapha) cylindrica Raddi. St. Thomas: Mesgin Estate (Børgesen).

Opegrapha obvelata Wain. St. Croix: Little Princess (Ove Paulsen).

Opegrapha interalbata Nyl. St. Jan: Cruz Bay (Raunkiær 555).

Opegrapha brachycarpoides Wain. St. Croix: Kingshill et Little Princess (Børgesen).

Chiodecton (Enterographa) **substellatum** Wain. St. Croix: Mt. Eagle (Børgesen).

Chiodecton endorhodum Wain. St. Jan: Debt (Raunkiær 403).

Chiodecton sanguineum (Sw.) Wain. St. Jan: Cruz Bay (Raunkiær 553).

Chiodecton (Mazosia) granulare (Müll. Arg.) Wain. St. Jan: Debt (Raunkiær 559, 560).

Arthonia nebulosa (Müll. Arg.) Willey. St. Jan: Borcks Creek (Raunkiær 544).

Arthonia lignicola Wain. St. Jan: Bordeaux (Raunkiær 459).

Arthonia americana Wain. St. Jan: Bordeaux (Raunkiær 438).

Arthonia substellata (Ach.) Nyl. St. Croix: Little Princess (Ove Paulsen and Børgesen), Sandy Point (Raunkiær 551).

Arthonia minuta Wain. St. Croix: Little Princess (Ove Paulsen).

Arthonia aquilina Wain. St. Croix: Mt. Eagle (Børgesen).

Arthonia platyspilea Nyl. St. Croix: Cane Bay (Børgesen); St. Thomas: s. l. (Børgesen).

Arthonia perpallens Nyl. St. Croix: Mt. Eagle (Børgesen).

Arthonia subrubella Nyl. In insulis Danicis Indiae Occidentalis 1905—06 (Børgesen).

Arthonia rubella (Fée) Nyl. St. Thomas: Northside Bay (Børgesen), Crown (Raunkiær 418).

Arthonia gregaria (Weig.) Koerb. var. tumidula Almq. St. Jan: Bordeaux (Raunkiær 459).

Naevia subvelutina Wain. St. Jan: Debt (Raunkiær 559).

II. Pyrenolichenes.

Verrucaria aethioboliza Nyl. St. Croix: Crequis (Børgesen).

Parmentaria astroidea Fée. St. Croix: Mt. Eagle (Børgesen).

Thelenella (Microglaena) brasiliensis (Müll. Arg.) Wain. St. Thomas: Magensbay Estate (Børgesen); St. Jan: Reef Bay (Børgesen).

*Bottaria ochraceoflavens (Nyl.) Wain. St. Croix: Fair Plane (Børgesen); St. Jan: Coral Bay (Raunkiær 448, 450).

Bottaria libricola (Fée) Wain. St. Croix: Krausses Lagoon (Raunkiær 543).

Pyrenula glabrescens Wain. St. Croix: Mt. Eagle (Børgesen).

Pyrenula laevigata Pers. var. microspora Wain. St. Croix: Little Princess (Ove Paulsen); St. Jan: Makumbo (Børgesen).

Pyrenula cerina (Eschw.) Müll. Arg. St. Croix: Krausses Lagoon (Raunkiær 543), Sandy Point (Raunkiær 549), Salt River (Børgesen), s. l. (Ove Paulsen).

Pyrenula circumfiniens Wain. St. Thomas: Crown (Raunkiær 401).

Porina (Segestria) rudiuscula (Nyl.) Wain. var. granulatula (Nyl.) Wain. St. Jan: Makumbo (Børgesen). Var. tetraspora Wain. St. Jan: Debt (Raunkiær 403).

Porina (Segestria) nucula Ach. var. nucalis Wain. St. Croix: Mt. Eagle (Børgesen); St. Jan: Makumbo (Børgesen).

Porina (Segestria) **isidiophora** Wain. St. Thomas: Crown (Raunkiær 401); St. Jan: Debt (Raunkiær 454), Bordeaux Hill (Raunkiær 439).

Porina (Segestria) Tetracerae (Ach.) Müll. Arg. St. Jan: Bordeaux Hill (Raunkiær 439).

Porina (Sagedia) **glaucopallida** Wain. St. Jan: Makumbo (Børgesen).

Porina (Sagedia) **buellioides** Wain. St. Jan: Kebay et Susannaberg (Børgesen).

Porina (Sagedia) **Bucidae** Wain. St. Thomas: Mesgin Estate (Børgesen).

Porina (Sagedia) **crequisina** Wain. St. Croix: Crequis (Børgesen).

Strigula (Melanothele) argentea (Fée) Wain. St. Croix: Caledonia valley (Børgesen).

Strigula elegans (Fée) Müll. Arg. St. Croix: Caledonia valley (Børgesen).

Arthopyrenia Antillarum Wain. St. Jan: Makumbo (Børgesen).

Arthopyrenia insularis Wain. Ad corticem arboris in Insulis Danicis Indiae occidentalis (Børgesen annis 1905—1906:).

Arthopyrenia subinsularis Wain. St. Croix: Mt. Eagle (Børgesen).

Didymella Cinchonae (Ach.) Wain. St. Thomas: s. l. (39: H. F. A. Eggers).

Microthelia leucothallina Wain. In Insulis Danicis Indiae occidentalis (Børgesen annis 1905—06).

Didymosphaeria detincta (Nyl.) Wain. St. Jan: Reef Bay (Børgesen).

Lichenes imperfecti.

Lepraria xanthina Wain. St. Croix: Belvédère (Børgesen), Mt. Stewart (Raunkiær 444).

ARBEJDER FRA DEN BOTANISKE
HAVE I KØBENHAVN. Nr. 86.

5.

FRESH-WATER DIATOMS FROM ICELAND

BY

ERNST ØSTRUP

WITH 5 PLATES

1918

The manuscript was completed at the death of the author, April the 16th 1917; it was written in Danish, and the translation into English has been effected later.

THE EDITORS.

PREFACE

The material on which the present paper is based, was like the salt-water material, entrusted to me for examination by the Botanical Museum, Copenhagen University. It comprises in all 572 samples, and has been collected by: cand. mag. J. Boye Petersen (B. P.), cand. O. Davidsson (O. D. †), Professor A. Feddersen (A. F. †), Professor Chr. Grønlund (Grld. †), Professor Th. Holm (Ho.), cand. mag. Hjalmar Jensen (Hj. Js.), Dr. phil. Helgi Jónsson (H. Js.), Professor Dr. phil. L. Kolderup Rosenvinge (K. Rsv.), Dr. phil. C. H. Ostenfeld (C. H. O.), Professor Dr. phil. K. Rørdam (Rd.), Professor Jap. Steenstrup (Stp. †), Skoleforstander St. Stefánsson (St.), Adjunkt B. Sæmundsson (B. S.), Professor Dr. phil. Th. Thoroddsen (Th.), Dr. phil. C. Wesenberg-Lund (W. L.), Professor Dr. phil. E. Warming*).

Special thanks are due to Prof. Dr. phil. Th. Thoroddsen for his valuable assistance in revising and correcting the names of the Icelandic localities. As to the indication of the parts of the country, these have been copied from the labels, where the localities as a rule have been plainly marked. In this way the samples are apportioned as follows:

South,	given in the text as S.	127	samples
South-West	— - - - - S.W.	148	—
North-West	— - - - - N.W.	12	—
North	— - - - - N.	87	—
East	— - - - - E.	191	—
No locality	— - - - - s. l. (sine loco)	7	—
	Total...	572	samples

In case a form is found in no more than 3 samples, these are noted and the name of the collector is added.

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*) The letters in brackets, affixed to the names of the collectors indicate the abbreviations of their names as used in the text; † signifies that the person is by now deceased.

Wherever an apparent discrepancy may be noted, between the number of samples given and those of the list above (f. inst. in the case of Meridion circulare, 15 samples are recorded from N.W., while the list only gives 12 samples from this division) the reason is, that the fresh-water forms occurring at the Icelandic coast are included in the present treatise.

The names Europe, Africa, Asia, America, Australia, Greenland, Jan Mayen, Beeren Island, Spitzbergen, Franz Joseph Land are respectively abbreviated: Eur., Af., As., Am., Aust., Grl., J. M., B. E., Spb., Fz. J.

When the list shows a name marked with an *, it indicates, that the form has been found previously in Iceland. The number of such forms amounts in all to 131.

PENNATÆ

Euraphideæ diraphideæ

Caloneis Cl. 1894. Cl. Syn. I, 46.

Caloneis alpestris (Grun.) Cl. Cl. Syn. I, 53. V. H. Syn., Tab. XII, fig. 30 (Navicula alp.).

5 samples (S. 2, S.W. 1, E. 2).
Area: Eur., Aust.

***Caloneis amphisbæna** (Bory) Cl. Cl. Syn. I, 58. V. H. Trt., Tab. V, fig. 203 (Nav. amph.).

10 samples (S. 3, S.W. 7). Hot spring: 1.
Area: Eur., Af., As., Am., Grl., B. E.

Caloneis bacillaris (Greg.) Cl. Cl. Syn. I, 50. V. H. Syn., Tab. XII, fig. 27 (Nav. bac. thermalis).

Hvitá (S.) A. F., Hornarfjörðrfljót (E.), St.
Area: Eur., As., Am.

Caloneis? bodonensis (Pant.) var. *Heribaudi* M. Per. Cl. Syn. I, 53. Herib. Auv., Tab. IV, fig. 8 (Nav. Herib.).

Seydisfjord (E.), H. Js.
Area: Eur.

Caloneis Clevei (Lgst.) Cl. Cl. Syn. 1, 51. Lgst. Spb., Tab. I, fig. 10 (Nav. Clevei).

Hofsfjall (N.), O. D..
Area: Eur., As., Grl., J. M., Spb., Fz. J.

Caloneis fasciata (Lgst.) Cl. Cl. Syn. I, 50. V. H. Syn., Tab. XII, fig. 34 (Nav. fasc.).

46 samples (S. 13, S.W. 19, N. 7, E. 5, s. l. 2). Hot springs: 2.
Area: Ubiquist., Grl., J. M., Spb., Fz. J.

Caloneis Fedderseni sp. nov., Tab. nost. I, fig. 1.

Long: 42 μ, lat: 8 μ, str. 16 in 10 μ, subtiliter punctatis.

Valva fere lineari, apicibus rotundatis. Raphe area hyalina distincta, media in parte valvæ paululum dilatata, cincta. Striis medianis aliquantulum spatiatis, apices versus densioribus, per totam valvam radiantibus.

Reykholtshver (S.) A. F.

Caloneis islandica sp. nov., Tab. nost. I, fig. 2.

Long: 64 μ, lat: 10 μ, str. 20 in 10 μ.

Valva lineari, apicibus rotundatis. Raphe area hyalina distincta, media in parte valvæ in areolam rotundatam, in qua lunulæ duæ adsunt, dilatata, cincta.

Laugarvatn (E.) B. P.

This form is probably related to, but hardly identical with Cal. alpestris (Grun.) Cl.

Caloneis Jonssoni sp. nov., Tab. nost. I, fig. 3.

Long: 35 μ, lat: 5,5 μ, str. 16 in 10 μ.

Valva lineari, in medio leniter contracta, apicibus rotundatis. Raphe area hyalina lata, media in parte valva in fasciam dilatata, cincta. Striis parallelis.

Norðfjörðr (E.) H. Js.

Caloneis Ladogenis Cl. Cl. Syn. I, 62. Cl. Finl., Tab. II, fig. 3.

4 samples (S. 1, S.W. 1, N. 1, E. 1).

Area: Eur.

Caloneis obtusa (W. Sm.) Cl. Cl. Syn. I, 54. Donk. Br. Diat., Tab. III, fig. 12 (Navicula Hebes).

4 samples (all E.).

Area: Eur.

Caloneis procera sp. nov., Tab. nost. I, fig. 4.

Long: 104 μ, lat: 12 μ, str. c. 25 in 10 μ.

Valva lineari in medio leniter inflata. Raphe area hyalina, media in parte valva paululum patescente, cincta. Striis parallelis.

Vallanes (E.) B. P.

This form has some similarity with Cal. Liber (W. Sm.) Cl., but has not the terminal nodi so characteristic of this latter, and it was found in a sample entirely containing fresh-water forms. The irregularly distributed ridges, illustrated in the figure, are possiby the outcome of a diseased condition.

***Caloneis Silicula** (Ehr.) Cl. Cl. Syn. I, 51. V. H. Trt., Tab. V, fig. 207 (Navicula limosa).

151 samples (S. 35, S.W. 39, N.W. 7, N. 22, E. 46, s. l. 2). Hot springs: 10.

Area: Ubiquist, Grl., B. E.

*Var. *alpina* Cl. Cl. l. c. V. H. Syn., Tab. XII, fig. 21 (Nav. Silicula).

24 samples (S. 6, S.W. 10, N. 3, E. 5). Hot springs: 5.

Area: Eur., Grl., J. M., Spb., Fz. J.

Var. *biconstricta* Øst. Øst. D. D. 15, Tab. I, fig. 6.
Egilstaðir (E.) B. P.
Area: Eur.

*Var. *inflata* Grun. Cl. Syn. I, 51. V. H. Syn., Tab. XII, fig. 20 (Nav. limosa subinflata).
5 samples (S. 3, S.W. 2). Hot springs: 2.
Area: Eur.

Var. *subventricosa* Grun. Cl. l. c. 52. Cl. & Gr. A. D., Tab. 1, fig. 19 (Nav. subv.).
Thingvellir (S.W.) E. W. & Ho.
Area: Kara.

Var. *ventricosa* (Ehr.) Donk. Cl. l. c. V. H. Trt., Tab. V, fig. 209 (Nav. vent.).
Ketilstaðir (S.W.) H. Js.
Area: Eur., As., Grl., Fz. J.

Neidium Pfitzer 1871. Cl. Syn. I, 67.

Neidium affine Ehr. var. *amphirhynchus* Ehr. Cl. Syn. I, 68. V. H. Trt., Tab. V, fig. 214 (Nav. Iridis amph.).
47 samples (S. 8, S.W. 14, N. 4, E. 20, s. l. 1). Hot springs: 5.
Area: Eur., Aust., Grl., B. E., Spb.

Var. *longiceps* Greg. Cl. l. c. Greg. Mic. J. IV, Tab. I, fig. 27.
Eiðar (E.) H. Js.
Area: Eur., Grl.

Var. *undulata* Grun. Cl. l. c. V. H. Trt., Tab. V, fig. 216 (Nav. Irid. und.).
Sandbrekka (E.) H. Js., Vallanes (E.) H. Js.
Area: Eur.

Neidium bisulcatum (Lagst.) Cl. Cl. Syn. I, 68. Lgst. Spb., Tab. I, fig. 8 (Nav. bisulc.).
41 samples (S. 6, S.W. 10, N. 4, E. 20, s. l. 1). Hot spring: 1.
Area: Eur., Af., As., Am., Grl., J. M., B. E., Spb., Fz. J.

Neidium dilatatum (Ehr.) Cl. Cl. Syn. I, 70. A. S. Atl., Tab. XLIX, fig. 6.
7 samples (S. 2, S.W. 3, E. 2).
Area: Eur.

Neidium dubium (Ehr.) Cl. Cl. Syn. I, 70.
10 samples (S. 4, N. 5, E. 1). Hot springs: 2.
Area: Eur., As., Am., Aust.

The above samples, corresponding with the figures in A. S. Atl., Tab. XLIX, figs. 8, 11, 14 and 24, all come within the group of Neidium dubium.

Neidium fasciatum Øst. Øst. D. D. 21, Tab. 1, fig. 14.
Gautavík (E.) H. Js., Vallanes (E.) H. Js.
Area: Eur.

Neidium Hitchcockii (Ehr.) Cl. Cl. Syn. 1, 69. A. S. Atl., Tab. XLIX, fig. 35 & 36 (Nav. Hitch.).
Vallanes (E.) H. Js.
Area: Eur., As., Am., Aust.

Neidium incurvum (Greg.) Øst. Tab. nost. I, fig. 5, cnfr. Greg. Mic. J IV, 8, Tab. I, fig. 26 (Nav. inc.).

Long: 45 μ, lat: 10 & 11 μ.

Valva elongata, in medio leniter incurvata, apicibus capitatis. Nodulis terminalibus summis in apicibus positis. Raphe area hyalina angustissima, media in parte valvæ in areolam parvam dilatata, cincta. Structuram ullam valvæ perspicere non potui.

Grimsá (E.) B. P.
Area: Eur.

I consider this form identical with Gregory's Navicula incurva. The "fragliche" form delineated in A. S. Atl., Tab. XLIX, fig. 13, from Loch Davin, Scotl., must surely be referred to this.

***Neidium Iridis** (Ehr.) Cl. Cl. Syn. I, 69. V. H. Trt., Tab. V, fig. 212 (Nav. Ir.).
5 samples (S.W. 3, E. 2).
Ubiquist, Grl., Fz. J.

Neidium islandicum sp. nov., Tab. nost. I, fig. 6.

Long: 30 μ, lat: 7 μ.

Valva elliptice-lanceolata, apicibus rotundatis. Raphe area hyalina angusta, mediam partem valvæ versus patescente ibique in fasciam latam dilatata, cincta. Lineis inframarginalibus distinctis. Striis ægre perspiciendis.

Brunavíkurstrand (E.) H. Js.

Neidium lineare sp. nov., Tab. nost. I, fig. 7.

Long: 41 μ, lat: 6,4 μ.

Valva lineari, apicibus rotundatis. Raphe area hyalina angusta, media in parte valvæ in fasciam satis latam dilatata. Lineis inframarginalibus distinctis.

Vallanes (E.) B. P.

This small form is possibly related to, but not identical with Neid. bisulcatum.

Neidium panduriforme sp. nov., Tab. nost. I, fig. 8.

Long: 22 μ, lat: 8 & 9,5 μ.

Valva panduriformi, linea inframarginali instructa. Raphe media in parte valvæ modo conspicua. Striæ delicatissimæ, et apicales et transapicales, adsunt.

Reykjarfjord (N). In a hot spring.

I am not sure as to the classification of this small form. Considering the marginal line, I am inclined to place it under Neidium.

Neidium productum (W. Sm.) Cl. Cl. Syn. I, 69. V. H. Trt., Tab. V, fig. 218. (Nav. Irid. prod.).

Staðastaður (S.W.), H. Js., Syðri Garðar (S.W., H. Js., Vatnsdalsá N.) St.
Area: Eur., As., Am.

Diploneis Ehr. 1840. Cl. Syn. I, 76.

Diploneis Boldtiana Cl. Cl. Syn. I, 92. Cl. Finl., Tab. II, fig. 12.

4 samples (S. 1, S.W. 2, N.W. 1).
Area: Eur.

Var. *robusta* A. Cl. A. Cl. Finl. 12, Tab. I, fig. 8.

Spóastadir (S.) A. F.
Area: Eur.

***Diploneis elliptica** (Ktz.) Cl. Cl. Syn. I, 92. V. H. Trt., Tab. IV, fig. 156, 1st fig. (Navicula ell.).

140 samples (S. 29, S. W. 35, N. W. 1, N. 26, E. 42, s. l. 7). Hot springs: 18.
Area: Ubiquist, Grl., Fz. J.

***Diploneis ovalis** (Hilse) Cl. Cl. Syn. I, 92. V. H. Trt., Tab. IV, fig. 156, 2d fig. (Nav. ell. ovalis).

49 samples (S. 7, S.W. 12, N.W. 1, N. 8, E. 20, s. l. 1). Hot spring: 1.
Area: Eur., Am., Aust., Grl., J. M., B. E.

Var. *oblongella* Nægeli. Cl. Syn. I, 93. V. H. Trt., Tab. IV, fig. 157 (Nav. ell. oblong.).

86 samples (S. 15, S.W. 16, N.W. 1, N. 5, E. 45, s. l. 4). Hot springs: 5.
Area: Eur., Af., As., Am.

Forma *subinflata*, Tab. nost. I, fig. 9.

Long: 38 μ, lat: 9 & 10 μ, str. 14 in 10 μ, apices versus densioribus.

Valva lineari, media in parte leniter inflata, ceterum Dipl. ov. obl. simili.

Reykjavík (S.W.) C. H. O.

Doubtless it is this form about which Hustedt (Sudet., 67) under Dipl. ov. obl. adds: "Zuweilen sind die Exemplare in der Mitte leicht transapikal erweitert."

Forma *pumila* Grun. Cl. Syn. I, 92. Grun. Oest. Ung., Tab. XXX, fig. 61 (Nav. ov. pum.).

Hrossholt (S.W.) A. F. In a hot spring.
Area: Eur., As.

Diploneis Puella (Schum.?) Cl. Cl. Syn. I, 92. V. H. Trt., Tab. IV, fig. 158 (Nav. ell. minima).

Mývatn (N.) Rd., Akureyri (N.) B. P.
Area: Eur., Af., Spb.

Diploneis subovalis Cl. Cl. Syn. I, 96, Tab. I, fig. 27, Tab. nost. I, fig. 10.

Stóri Kroppur (S.W.) B. P.
Area: New Zealand.

I have given a delineation of the form found by me, as it differs somewhat from Cleve's figure. About its identity with Dipl. subov. I have no doubt whatever.

Naviculæ orthostichæ Cl. Cl. Syn. I, 107.

Navicula cuspidata Ktz. Cl. Syn. I, 109. V. H. Trt., Tab. IV, fig. 190.

5 samples (S. 1, SW. 1, N. 1, E. 2).
Area: Ubiquist, B. E.

Var. *ambigua* Ehr. Cl. Syn. I, 110. V. H. Trt., Tab. IV, fig. 192 (Nav. amb.).

9 samples (S. 3, S.W. 2, N. 2, E. 2). Hot spring: 1.
Area: Ubiquist, Grl.

Var. *Heribaudi* M. Per. Cl. Syn. I, 110. Herib. Auv., Tab. IV, fig. 16.

Reykjavík (S.W.) B. P.
Area: Eur. (fossil.).

Gyrosigma Hassall 1845. Cl. Syn. I, 112.

Gyrosigma acuminatum (Ktz.) Cl. Cl. Syn. I, 114. V. H. Trt., Tab. VII, fig. 274 (Pleuros. acum.).

4 samples (S.W. 2, N.W. 1, N. 1).
Area: Eur, Af., As.

***Gyrosigma attenuatum** (Ktz.) Cl. Cl. Syn. I, 115. V. H. Trt., Tab. VII, fig. 271 (Pleuros. atten.).

Reykjavík (S.W.) C. H. O., Grímsey (N.) O. D.
Area: Eur., Af., As., Am.

Frustulia Ag. 1824. Cl. Syn. I, 121.

Frustulia islandica sp. nov., Tab. nost. I, fig. 11.

Long: 46 μ, lat: 9 μ.

Valva lanceolata, apicibus leniter attenuatis. Raphe intra costas siliceas duas sita. Nodulis terminalibus ab apicibus remotis. Striis subtilissimis et, quoad perspicere potui, radiantibus, media in parte valvæ deficientibus ibique fasciam latam relinquentibus.

Sælsundslækur (S.) A. F.

Frustulia rhomboides (Ehr.) Cl. var. *saxonica* Rabh. Cl. Syn. I, 123. V. H. Trt., Tab. V, fig. 250 (Van Heurckia rhomb. crassin.).

24 samples (S. 4, S.W. 11, N. 2, E. 7). Hot springs: 2.
Area: Ubiquist, Grl., B. E., Spb.

Var. *leptocephala* Øst. Øst. Østg. Fersk. 257, Tab. I, fig. 1.

7 samples (S. 2, S.W. 3, N. 2). Hot spring: 1.
Area: Grl.

Frustulia vulgaris Thw. Cl. Syn. I, 122. V. H. Trt., Tab. V, fig. 252 (Van Heur. vulg.).

116 samples (S. 28, S.W. 32, N.W. 4, N. 12, E. 39, s. l. 1). Hot springs: 10.
Area: Ubiquist, Grl.

Amphipleura Ktz. 1844. Cl. Syn. I, 125.

Amphipleura pellucida Ktz. Cl. Syn. I, 126. V. H. Trt., Tab. V, fig. 253.

9 samples (S. 3, S.W. 2, E. 4).
Area: Eur., As.

Naviculæ mesolejæ Cl. 1894. Cl. Syn. I, 127.

Navicula bacilliformis Grun. Cl. Syn. I, 131. V. H. Trt., Tab. XXVII, fig. 774.

17 samples (S. 3, S.W. 3, N. 1, E. 10).
Area: Eur., As., Am., Aust.

Navicula Heufleriana Grun. Cl. Syn. I, 130. V. H. Syn., Tab. IV, fig. 1 a (Stauroneis Heufleri).

5 samples (S. 3, N. 1, E. 1).
Area: Eur., Grl., Fz. J.

Navicula mutica Ktz. forma *Cohni* Hilse. Cl. Syn. I, 129. V. H. Trt., Tab. IV, fig. 167 (Nav. mut.).

20 samples (S. 6, S.W. 6, N.W. 2, N. 4, E. 1). Hot springs: 3.
Area: Ubiquist, Grl., J. M., Spb., Fz. J.

Forma *Göppertiana* Bleisch. Cl. Syn. I, 129. V. H. Trt., Tab. IV, fig. 168.

Vallanes (E.) H. Js.
Area: Eur., As., Am., Grl.

Navicula nivalis Ehr. Cl. Syn. I, 130. V. H. Trt., Tab. IV, fig. 178 (Nav. mut. quinquenodis).

5 samples, all N. Hot springs: 4.
Area: Eur., Af., Aust., Grl., Fz. J.

***Navicula Pupula** Ktz. Cl. Syn. I, 131. V. H. Trt., Tab. V, fig. 226, 1st fig.
29 samples (S. 5, S.W. 9, N. 6, E. 9). Hot springs: 3.
Area: Ubiquist, Grl.

Navicula Rotæana Rabh. Cl. Syn. I, 128. V. H. Syn., Tab. XIV, figs. 17—19.
5 samples (S.W. 2, N. 1, E. 2).
Area: Eur., Aust., Grl., J. M., B. E., Spb., Fz. J.

Var. *oblongella* Grun. Cl. l. c. V. H. Syn. l. c., fig. 21.
8 samples (S.W. 3, N. 2, E. 2, S.L. 1). Hot spring: 1.

Navicula Seminulum Grun. Cl. Syn. I, 128. V. H. Trt., Tab. V, fig. 228.
Eystri Rangá (S.) A. F., Vík (S.) H. Js., Thingvellir (S.W.) E. W. & Ho.
Area: Eur., As., Am., Grl., B. E., Spb., Fz. J.

Var. *fragilaroides* Grun. Cl. Syn. l. c. V. H. Syn., Tab. XIV, fig. 10.
Berufjörður (E.) H. Js.
Area: Eur.

Naviculæ entolejæ Cl. 1894. Cl. Syn. I, 131.

***Navicula contenta** Grun. var. *biceps* Arnott. Cl. Syn. I, 132. V. H. Trt., Tab. V, fig. 240.
17 samples (S. 6, S.W. 5, N. 2, E. 4). Hot spring: 1.
Area: Eur., As., Grl.

Naviculæ bacillares Cl. 1894. Cl. Syn. I, 136.

***Navicula Bacillum** Ehr. Cl. Syn. I, 137. V. H. Trt., Tab. V, fig. 222.
5 samples (S. 2, S.W. 1, N. 1, E. 1).
Area: Eur., As., Am., Aust.

Var. *densestriata* var. nov., Tab. nost. I, fig. 12.
Long: 37 μ, lat: 8 μ.
Valva lineari, apicibus rotundatis. Raphe area hyalina angustissima, media in parte valvæ in areolam rotundatam dilatata, cincta. Striis subtilissimis, radiantibus, in medio aliquantulum spatiatis.
Ingjaldshóll (S.W.) H. Js.

Var. *lepida* Greg. Cl. Syn. I, 137, Tab. V, fig. 14.
Skeidarársanður (S.) St.
Area: Eur., Am.

Var. *minor* H. V. H. Cl. Syn. l. c. V. H. Trt., Tab. V, fig. 223.
Aðalvík (N.W.) C. H. O.
Area: Eur., Aust.

Navicula Pseudobacillum Grun. Cl. Syn. I, 137. V. H. Trt., Tab. V, fig. 224.
5 samples (S. 2, S.W. 2, E. 1).
Area: Eur., Af., As., Aust., Grl.

Var. *lanceolata* Øst. Øst. D. D. 40, Tab. 1, fig. 29.
Mývatn (N.) B. P.
Area: Eur.

Naviculæ decipientes Grun. 1880. Cl. Syn. I, 138.

Navicula crucicula W. Sm. Cl. Syn. I, 139. V. H. Trt., Tab. IV, fig. 138.
7 samples (S.W. 5, N.W. 1, E. 1).
Area: Eur., Af., As., Aust., Grl.

Var. *capitata* Øst. Øst. D. D. 42, Tab. I, fig. 30.
Skeiðarársandur (S.) St.
Area: Eur.

Navicula integra W. Sm. Cl. Syn. I, 141. V. H.Trt., Tab. IV, fig. 174.
Skeiðarársandur (S.) St., Reykjavík (S.W.) B. P.
Area: Eur.

Navicula protracta Grun. Cl. Syn. I, 140. V. H. Trt., Tab. IV, fig. 173 (Nav. crucic. protr.).
9 samples (S. 5, S.W. 3, E. 1).
Area: Eur., Af.

***Navicula Semen** Ehr. Cl. Syn. I, 138. Grun. Fz. J., Tab. 1, fig. 34.
49 samples (S. 4, S,W. 6, N.W. 2, N. 8, E. 29). Hot springs: 2.
Area: Eur., Am., Fz. J.

Navicula subtilissima Cl. Cl. Syn. I, 141. Cl. Finl., Tab. II, fig. 15.
Reykjavík (S,W.) C. H. O.
Area: Eur., Spb.

Naviculæ microstigmaticæ Cl. 1894. Cl. Syn. I, 141.

Stauroneis Ehr. 1843. Cl. Syn. I, 144—151.

***Stauroneis acuta** W. Sm. Cl. Syn. I, 150. V. H.Trt., Tab. I, fig. 51.
Máfahlið (S.W.) H. Js., Hofsá (N.) O. D.
Area: Eur., As., Am., Aust., Grl., Fz. J.

***Stauroneis anceps** Ehr. Cl. Syn. I, 147. V. H. Trt., Tab. I, fig. 55.
66 samples (S. 13, S.W. 8, N. 9, E. 36). Hot spring: 1.
Area: Ubiquist, Grl., J. M., B. E., Spb., Fz. J.
Under Staur. anc. I also include var. amphicephala Ktz. V. H. Trt., Tab. I, fig. 57, as this can scarcely be distinguished from the type.

Var. *birostris* Ehr. Cl. Syn. l. c. Cl. Grl. & Argent., Tab. XVI, fig. 5.
Egilstaðir (E.) B. P.
Area: Eur., Am.

Var. *elliptica* var. nov., Tab. nost. I, fig. 13.

Long: 26 μ, lat: 7,2 μ.

Valva elliptica, apices subcapitatos versus attenuata. Raphe area hyalina, mediam partem valvæ versus patescente, cincta. Stauro satis lato. Striis subtilissimis, radiantibus.

Hreiðarsstaðir (E.) B. P.

*Var. *gracilis* Ehr. Cl. Syn. I, 147. A. S. Atl., Tab. CCXLII, fig. 7 & 12.

Gljúfurholtsá (S.) B. P., Stóri Kroppur (S.W.) B. P., Mývatn (N.) Rd.
Area: Eur., Am.

Var. *hyalina* Br. & Per. Cl. Syn. l. c. Hérib. Auv., Tab. III, fig. 19.

4 samples, all E.
Area: Eur., Aust.

*Var. *linearis* Ehr. Cl. Syn. l. c. V. H. Trt., Tab. 1, fig. 56.

Isafjord (N.W.) B. P., Njardvík (E.) H. Js., Sævarendi (E.) H. Js.
Area: Eur., Aust.

Var. *siberica* Grun. Cl. Syn. l. c. Cl. & Grun. A. D., Tab. III, fig. 65.

9 samples (S. 2, S.W. 4, E. 3).

Stauroneis bifissa sp. nov., Tab. nost., fig. 14.

Long: 34 μ, lat: 8 μ.

Valva lanceolata, apicibus productis. Raphe area hyalina, mediam partem valvæ versus patescente, cincta. Stauro satis lato, utrisque in lateribus linea singula instructa. Striis inconspicuis.

Glammarstaðavatn (S.W.) B. P., Vallanes (E.) B. P.

Stauroneis elegantula sp. nov., Tab. nost. I, fig. 15.

Long: 28 μ, lat: 5,5 μ.

Valva elliptica, apices capitatos versus attenuata. Raphe area hyalina angusta, mediam partem valvæ versus patescente, cincta. Stauro latissimo. Striis inconspicuis.

Reykholt (S.W.) H. Js.

Stauroneis Javanica Grun. Cl. Syn. I, 150. Grun. Nov., Tab. I, fig. 14. Øst. Østg. Ferskv., Tab. I, fig. 4.

4 samples (S.W. 2, E. 2).
Area: Eur., As., Am., Aust., Grl.

In a sample from a valley near Isafjord (N.W.) B. P., I have found a Staroneis javanica of the following dimensions: length 78 μ, width 21 μ, consequently shorter and comparatively broader than the type.

Stauroneis Legumen Ehr. Cl. Syn. I, 149. V. H. Trt., Tab. I, fig. 59.

8 samples (S. 1, SW. 1, N.W. 2, N. 3, E. 1).
Area: Eur., Af., As., Am., Grl.

Stauroneis obtusa Lgst. Cl. Syn. I, 149. Lgst. Spb., Tab. I, fig. 11.
Ketilsstaðir (S.W.), H. Js.
Area: J. M., Spb., Fr. J.

Stauroneis parvula Grun. Var. *producta* Grun. Cl. Syn. I, 149. V. H. Syn., Tab. IV, fig. 12.
31 samples (S. 2, S.W. 14, N.W. 3, N. 3, E. 9).
Area: Eur., Grl.

Var. *capitata* var. nov., Tab. nost. I, fig. 16.

Long: 46 μ, lat; 10 μ.

Valva elliptica, apicibus capitatis, diaphragmate distincto instructis. Raphe area hyalina distincta cincta. Stauro satis angusto. Striis subtilissimis, radiantibus.

Reykjavík (S.W.), Stp.

This form is nearest to Staur. parv. prod. forma subcapitata in my D. D. P. 47, Tab. II, fig. 34, but to me it seems nevertheless differing sufficiently for placing it as a special variety.

Stauroneis perexilis sp. nov., Tab. nost. I, fig. 17.

Long: 20 μ, lat: 4,5 μ.

Valva lanceolata, apicibus diaphragmate instructis. Raphe area hyalina angusta, mediam partem valvæ versus patescenti, cincta. Structuram ullam valvæ perspicere non potui.

Reykjavík (S.W.), H. Js.

***Stauroneis Phonicenteron** Ehr. Cl. Syn. 1, 148. V. H. Trt., Tab. I, fig. 50.
65 samples (S. 6, S.W. 20, N.W. 3, N. 10, E. 25, s. l. 1). Hot spring: 1.
Area: Ubiquist, Grl.

Var. *amphilepta* Ehr. Cl. Syn. I, 149. Hérib. Auv., Tab. III, fig. 18.
30 samples (S. 6, S.W. 7, N.W. 1, N. 2, E. 14).
Area: Eur., Afr., Aust., Grl., B. E.

Stauroneis Smithi Grun. Cl. Syn. I, 150. V. H. Trt., Tab. I, fig. 58.
Skeiðarársandur (S.) St., Vallanes (E., two samples), H. Js.
Area: Eur., As., Am.

S. Stefanssoni sp. nov., Tab. nost. II, fig. 18.

Long: 46 μ, lat: 8 μ, str. 20 in 10 μ.

Valva lanceolata, margine undulato, in medio leniter inciso. Apicibus apiculatis, diaphragmate distincto instructis. Raphe area hyalina angusta cincta. Stauro bifisso. Striis radiantibus.

Skeiðarársandur (S.) St.

This pretty and characteristic form probably belongs to the group of St. Smithi. It has the median constriction in common with St. Smithi var. incisa: Pant. in Pant. Bel. S.. 27. Tab. II, fig. 45, but differs otherwise to such extent, that I do not think it can be classed with this form; nor can it be identical with Schizostauron Karsteni O. M. in Ch. Nyassa, 88. Tab. II, figs. 17—18. It undoubtedly deserves a place as a distinct species.

Cymbella Ag. 1830. Cl. Syn. I, 156.

***Cymbella æqualis** W. Sm. Cl. Syn. I, 170. V. H. Trt., Tab. I, fig. 26 (C. subæqu.) & fig. 27 (C. obtusa).
12 samples (S. 8, S.W. 18, N.W. 1, N. 2, E. 13). Hot spring: 1.
Area: Eur., Afr., As., Am., Grl.

Cymbella affinis Ktz. Cl. Syn. I, 171. V. H. Trt., Tab. I, fig. 31.
7 samples (S. 1, S.W. 2, E. 4).
Area: Ubiquist, Grl., Spb.

***Cymbella amphicephala** Nægeli. Cl. Syn. I, 164. V. H. Trt., Tab. I, fig. 25.
15 samples (S. 3, S.W. 1, E. 11).
Area: Ubiquist, Grl., Spb., Fr. J.

Cymbella angustata W. Sm. Cl. Syn. I, 161. Lgst. Spb. Tab. II, fig. 10.
7 samples (S.W. 3, E. 4).
Area: Eur., Grl., Spb.

***Cymbella aspera** Ehr. Cl. Syn. I, 175. V. H. Trt. I, fig. 35 (C. gastroides).
44 samples (S. 2, S.W. 18, NW. 4, N. 3, E. 22). Hot spring: 1.
Area: Ubiquist, Fr. J.

Var. *dubravicensis* Grun. Cl. Syn. l. c. Grun. Foss. Oestr. Tab. XXIX, fig. 30.
Mývatn (N.), Rd.
Area: Eur.

***Cymbella Cesatii** Rabh. Cl. Syn. I, 160. V. H. Trt., Tab. III, fig. 143 (Navicula Ces.).
Reykjavík (S.W), H. Js.
Area: Eur., Am., Grl., Spb.

***Cymbella Cistula** Hempr. Cl. Syn. I, 173. V. H. Trt., Tab. I, fig. 40.
100 samples (S. 38, S.W. 27, N. 5, E. 22, s. l. 2). Hot spring: 1.
Area: Ubiquist, Grl., Spb.

Var. *arctica* Lgst. Cl. Syn. l. c. Lgst. Spb., Tab. II, fig. 21 (Cymb. variab. arct.).
Möðruvellir (S.W.), B. P.
Area: Eur., As., B. E., Spb.

Var. *Caldogastensis* Prud. Prud. Lacs du Jura IV. P. 22, Tab. I, fig. 1. Tab. nost. II, fig. 19.

Long: 126 μ, lat: 23 μ. Str. 8 in 10 μ, distincte punctatis.

Valva cymbiformi, margine ventrali in medio leniter inflata. Raphe area hyalina satis lata, media in parte valvæ in aream rotundatam dilatata, cincta. Utraque in parte areæ centralis puncta solitaria adsunt, et quidem 5 in parte dorsali, 7 in parte ventrali. Nodulis terminalibus ab apicibus remotis.

Laugarvatn (S.), A. F.
Area: Eur.

This Cymbella is decidedly Prudent's above mentioned variant of C. Cist. but hardly identical with Cymb. Nordenskjöldi O. M. (O. M. Patag. P. 25, Tab. I, fig. 18) which has a similar double set of puncta.

Var. *maculata* Ktz. Cl. Syn. I, 173. V. H. Trt., Tab. I, fig. 41.

Gljúfurholtsá (S.) B. P., Sælulækr (S.W.) A. F., Staðarhraun (S.W.) A. F.
Area: Eur., Am., Grl., Spb., Fz. J.

Cymbella cuspidata Ktz. Cl. Syn. I, 160. V. H. Trt., Tab. I, fig. 23.

23 samples (S. 5, S.W. 8, N. 3, E. 7).
Area: Ubiquist, Grl.

***Cymbella cymbiformis** (Ag.) Ktz. Cl. Syn. I, 172. V. H. Trt., Tab. I, fig. 38.

20 samples (S. 2, S.W. 9, N. 1, E. 8). Hot springs: 2.
Area: Ubiquist.

Cymbella dubia sp. nov., Tab. nost. II, fig. 20.

Long: 43 μ, lat: 6,4 μ, Str. 12,5 in 10 μ.

Valva lineari, apicibus rotundatis. Raphe obliqua, area hyalina, media in parte valvæ unilateraliter in areolam rotundatam dilatata, cincta. Striis per totam valvam radiantibus.

Mjóanes (E.) B. P.

By reason of the oblique raphe, the striæ radiating throughout and the unilateral central area, I have considered it proper placing this form as a Cymbella.

Cymbella Ehrenbergi Ktz. Cl. Syn. I, 165. V. H. Trt., Tab. I, fig. 22 (greatest fig.).

23 samples (S. 8, S.W. 6, N. 3, E. 6).

Var. *delecta* A. S. Cl. Syn. l. c. A. S. Atl., Tab. IX, fig. 17 (Cymb. del.).

Mývatn (N.), B. P.
Area: Eur., Am., Aust., Grl.

Cymbella gracilis Rabh. Cl. Syn. I, 169. V. H. Trt., Tab. XXVIII, fig. 791 bis b (Encyon. grac.) and 791 bis c (Enc. lunatum).

79 samples (S. 4, S.W. 26, NW. 3, N. 14, E. 31, s. l. 1). Hot springs: 2.
Area: Ubiquist, Grl.

Cymbella helvetica Ktz. Cl. Syn. I, 174. V. H. Trt., Tab. I, fig. 43.

57 samples (S. 11, SW. 22, N. 6, E. 17, s. l. 1). Hot springs: 2.
Area: Eur., Grl.

***Cymbella heteropleura** Ehr. var. *minor* Cl. Cl. Syn. I, 167. A. S. Atl., Tab. IX, fig. 52.

41 samples (S. 4, S.W. 9, N.W. 2, N. 8, E. 17, s. l. 1). Hot springs: 2.
Area: Eur., As., Grl., Spb.

Cymbella incerta Grun. var. *naviculacea* Grun. Cl. Syn. I, 170. Cl. Grl. & Arg., Tab. XVI, fig. 11.

7 samples (S.W. 5, E. 2). Hot spring: 1
Area: Eur., Grl.

Cymbella islandica sp. nov., Tab. nost. II, fig. 21.

Long: 100 μ, lat: 11 μ, str. 12 in 10 μ, subtiliter punctatis.

Valva cymbiformi, margine ventrali fere recta. Apicibus acutis. Raphe area hyalina angusta, media in parte valvæ in aream longinam, marginem ventralem versus aliquantum dilatata, cincta.

Egilstaðir (E.) B. P.

Cymbella Jonssoni sp. nov., Tab. nost. II, fig. 22.

Long: 56 μ, lat: 9 μ, str. 10 in 10 μ, apices versus densioribus, indistincte punctatis.

Valva anguste lanceolata. Raphe area hyalina, media in parte valvæ in aream asymmetricam dilatata, cincta. Striis per totam valvam radiantibus.

Owing to the radiating striation and the non-symmetrical central area I assume this form to be a Cymbella. It has probably nothing to do with Cymb. inc. naviculacea.

Cymbella lanceolata Ehr. Cl. Syn. I, 174. V. H. Trt., Tab. I, fig. 37.

99 samples (S. 25, S.W. 20, N. 12, E. 40, s. l. 2). Hot springs: 2.
Area: Eur., Af., As., Am.

Var. *cornuta* Ehr. Cl. Syn. l. c. Øst. D. D., Tab. II, fig. 43.

8 samples (S.W. 5, E. 3).
Area: Eur.

Var. *ventricosa* A. Cl. A. Cl. Finl. P. 19, Tab. I, fig. 17 (C. lanc. inflata).

Reykjavík (S.W.) C. H. O.
Area: Eur.

***Cymbella lapponica** Grun. Cl. Syn. I, 165, Tab. IV, fig. 28.

26 samples (S. 5, S.W. 10, N.W. 1, N. 1, E. 9). Hot spring: 1.
Area: Eur.

Cymbella linearis sp. nov., Tab. nost. II, fig. 23.

Long: 67 μ, lat: 6,4 μ, str. 12 in 10 μ.

Valva lineari, apicibus rostratis. Raphe directa, fissuris terminalibus recurvatis. Striis per totam valvam radiantibus, in apicibus deficientibus, media in parte valvæ areolam rotundatam relinquentibus, ceterum raphen attingentibus.

Staðastaður (S.W.) H. Js.

This form is without doubt a Cymbella; the peculiar course of the raphe at the apices and the striation radiating throughout, seem to point in this direction. It is hardly identical with Cymb. amphioxys (Ktz.? Grun.) Cl. (see Le Diatomiste II, 145, Tab. IX, fig. 6) which however it somewhat resembles.

Cymbella marginata sp. nov., Tab. nost. II, fig. 24.

Long: 46 μ, lat: 7 μ, str. 20 in 10 μ.

Valva elliptice-lanceolata. Raphe obliqua. Fissuris terminalibus in eandem partem valvæ declinantibus. Striis marginalibus, parallelis, aream apicalem latam circa raphen relinquentibus.

Egilstaðir (S.), B. P.

Cymbella microcephala Grun. Cl. Syn. I, 160. V. H. Trt., Tab. I, fig. 34.

8 samples (S. 2, S.W. 3, E. 3). Hot spring: 1.
Area: Eur., Am., Grl.

Cymbella naviculiformis Auersw. Cl. Syn. I, 166. V. H. Trt., Tab. I, fig. 24 (C. cusp. navicl.).

52 samples (S. 6, S.W. 19, N. 10, E. 16, s. l. 1). Hot springs: 3.
Area: Eur., As., Am., Aust., Grl., B. E., Spb.

***Cymbella parva** W. Sm. Cl. Syn. I, 172. V. H. Trt., Tab. I, fig. 39 (C. cymbif. parva).

200 samples (S. 40, S.W. 56, NW. 1, N. 22, E. 76, s. l. 5). Hot springs: 9.
Area: Eur., Af., As., Am., Grl., B. E., Fz. J.

Cymbella prostrata Berk. Cl. Syn. I, 167. V. H. Trt., Tab. I, fig. 44 (Encyon. prost.).

Krókur (S.) H. Js.
Area: Eur., Af., As., Am.

Cymbella recta sp. nov., Tab. nost. II, fig. 25.

Long: 105 μ, lat: 18 μ, str. 11 in 10 μ, distincte punctatis.

Valva lanceolata, apicibus rotundalis, raphe directa, media in parte valvæ in aream satis latam dilatata, cincta. Striis parallelis.

Thingvellir (S.W.). B. P.

Cymbella sinuata Greg. Cl. Syn. I, 170. V. H. Trt., Tab. XXV, fig. 699 (C. abnormis).

10 samples (S.W 6, N. 2, E. 2).
Area: Eur., Af., As., Austr., Grl., B. E.

Cymbella stauroneiformis Lgst. Cl. Syn. I, 165. Lgst. Spb., Tab. I, fig. 15.

Ormastaðir (E.) B. P.
Area: B. E., Spb.

Cymbella subconstricta sp. nov., Tab. nost. II, fig. 26.

Long: 42 μ, lat: 6 μ, str. 16 in 10 μ, subtiliter punctatis.

Valva fere lineari, margine ventrali in medio leniter incurvata. Striis radiantibus, in apicibus deficientibus, media in parte ventrali valvæ abbreviatis, ibique areolam elongatam relinquentibus, ceterum raphen attingentibus.

Reykjavík (S.W.) H. Js.

Cymbella turgida Greg. Cl. Syn. I, 168. V. H. Trt., Tab. I, fig. 45 (Encyon. turg.).

Borgarnes (E.) H. Js.
Area: Eur., As., Am., Aust., Grl.

***Cymbella ventricosa** Ktz. Cl. Syn. I, 168. V. H. Trt., Tab. I, figs. 46, 47 & 49 (Encyon. cæsp. & ventric.).

247 samples (S. 43, S.W. 71, N.W. 3, N. 35, E. 92, s. l. 3). Hot springs: 5
Area: Ubiquist, Grl., B. E., Spb., Fz. J.

Gomphonema Ag. 1824. Cl. Syn. I, 178.

***Gomphonema acuminatum** Ehr. Cl. Syn. I, 184. V. H. Trt., Tab. VIII, fig. 299.

63 samples (S. 10, S.W. 23, N. 9, E. 21). Hot springs: 2.

Forma *coronata* Ehr. Cl. Syn. l. c. V. H. Trt. l. c. fig. 300.

47 samples (S. 10, S.W. 14, NW. 1, E. 21, s. l. 1). Hot spring: 1.

Var. *elongatum* W. Sm. Cl. Syn. l. c. V. H. Syn., Tab. XXIII, fig. 22.

Skaftafellssysla (S.) St., Vallanes (E.), H. Js.

Forma *pusilla* Grun. Cl. Syn. l. c. V. H. Syn. l. c. fig. 19.

11 samples (S. 1, S.W. 1, E. 9).

Forma *trigonocephala* Ehr. Cl. Syn. l. c. V. H. Syn. l. c. fig. 18.

9 samples (S.W. 3, N. 6). Hot springs: 2.
Area for Gomph. acum. with var.: Eur., Af., As., Am., Grl.

Gomphonema angustatum Ktz. var. *productum* Grun. Cl. Syn. I, 181. V. H. Trt., Tab. VIII, fig. 314 (G. ang.).

87 samples (S. 9, SW. 28, NW. 5, N. 9, E. 36). Hot springs: 3.
Area: Eur., Af., As., Am., Grl., B. E., Spb., Fz. J.

***Gomphonema constrictum** Ehr. Cl. Syn. I, 186. V. H. Trt., Tab. VII, fig. 296.

70 samples (S. 9, S.W. 11, N.W. 1, N. 11, E. 38). Hot spring: 1.
Area: Ubiquist.
In a sample from Desjamyri (E.) H. Js. I have found a form which corresponds well with *G. const.* forma *curta* in V. H. Trt., Tab. VIII, fig. 298.

***Gomphonema gracile** Ehr. var. *auritum* Al. Br. Cl. Syn. I, 182. V. H. Trt., Tab. VII, fig. 311.

18 samples (S. 4, S.W. 2, N.W. 1, N. 9, E. 1, s. l. 1). Hot springs: 4.
Area: Eur., Af., Am., B. E.

Var. *dichotomum* W. Sm. Cl. Syn. l. c. V. H. Trt. l. c. fig. 310.

4 samples (S. 1, S.W. 1, N. 1, E. 1). Hot springs: 2.
Area: Ubiquist.

Var. *naviculaceum* W. Sm. Cl. Syn. I, 183. V. H. Trt. l. c. fig. 309.
13 samples (S.W. 6, N. 3, E. 3, s. l. 1). Hot spring: 1.
Area: Eur., Af., As., Aust.

Gomphonema intricatum Ktz. Cl. Syn. I, 181. V. H. Trt., Tab. VII, fig. 313.
Höfdabrekka (S.) H. Js.
Area: Eur., Af., As., Am., B. E.

Var. *dichotomum* Ktz. Cl. Syn. I, 182. V. H. Syn., Tab. XXIV, figs. 30—31.
Reykjavík (S.W) H. Js., Stykkishólmur (S.W.) H. Js.
Area: Eur., Am., Aust.

Var. *Vibrio* Ehr. Cl. Syn. l. c. V. H. Syn. l. c. figs. 26—27 (G. Vibrio).
Isafjord (N.W.) B. P.
Area: Eur., As.

Gomphonema irregulare sp. nov., Tab. nost. II, fig. 27.

Long: 60 μ, lat: 10 μ.

Valva clavata, apice superiori subcapitata. Raphe area hyalina satis lata, media in parte valvæ in fasciam unilateralem dilatata, cincta. Striis punctatis, lenites radiantibus et irregulariter distributis, uno in latere superiori 6 in 10 μ, altero in latere 9 in 10 μ, apices versus densioribus.

Vallanes (E.) B. P.).

Gomphonema islandicum sp. nov., Tab. nost. II, fig. 28.

Long: 46 μ, lat: 9 μ, str. 11 in 10 μ, punctatis.

Valva subclavata, margine undulata, apices versus attenuata. Striis subradiantibus, apices versus in raphen perpendicularibus, in apicibus deficientibus. Raphe area hyalina, media in parte valvæ in fasciam latam dilatata, cincta, qua in fascia punctum unilaterale solitarium et striæ paucæ abbreviatæque adsunt.

Ingjaldshóll (S.W.) H. Js.

This form is possibly related to, but not identical with, the »Sporangialform« of Gomph. tergestinum Grun. given in A. S. Atl., Tab. CCXXXIV, fig. 39, which H. Reichelt considers should be referred to G. semiapertum Grun.

Gomphonema Lagerheimi A. Cl. A. Cl. Lul. Lappm. 22, Tab. I, fig. 15.
Ketilstaðir (S.W) H. Js.
Area: Eur.

***Gomphonema lanceolalum** Ehr. var. *insigne* Grun. Cl. Syn. I, 183. V. H. Syn., Tab. XXIX, figs. 39—41.
Krossá (S.) A. F., Reykjavík (S.W.) H. Js.
Area: Ubiquist.

Gomphonema medio-constrictum sp. nov., Tab. nost. II, fig. 29. Long: 108 μ, lat: 10 & 12 μ, str. 12 in 10 μ, punctatis. Valva clavata, media in parte constricta. Raphe area hyalina, media in parte valvæ in areolam rotundatam dilatata, cincta. Striis radiantibus, uno in latere in medio deficientibus ibique fasciam unilateralem, in qua striæ singulæ et punctum solitarium adsunt, relinquentibus.

Fljótsdalur (E.) B. P.

***Gomphonema olivaceum** Lyngb. Cl. Syn. I, 187. V. H. Trt., Tab. VII, figs. 315—316.

15 samples (S. 7, S.W. 3, N. 2, E. 3).
Area: Eur., Af., As., Am., Grl.

Var. *calcareum* Cl. Cl. Syn. I, 188. Cl. Sv. & N. Diat., Tab. IV, fig. 7.

Skeiðarársandur (S.) St.
Area: Eur., Am.

Var. *stauroneiforme* Grun. Cl. Syn. l. c. A. S. Atl., Tab. CCXXXIII, figs. 22—24.

Ulfjólsvatn (S.) A. F.
Area: Eur., As.

Gomphonema parvulum Ktz. Cl. Syn. I, 180. A. S. Atl., Tab. CCXXXIV, figs. 1—15 & 18—19.

160 samples (S. 23, S.W. 44, N.W. 4, N. 35, E. 52, S.E. 2). Hot springs: 5.
Area: Ubiquist, Grl., Fz. J.

***Gomphonema subclavatum** Grun. Cl. Syn. I, 183. V. H. Trt., Tab. VII, fig. 304 (G. mont. subcl.).

222 samples (S. 37, S.W. 58, N.W. 6, N. 32, E. 85, s. l. 4). Hot springs: 4.
Area: Ubiquist.

Var. *montanum* Schum. Cl. Syn. I, 184. V. H. Trt. l. c., fig. 303 (G. mont.).

8 samples (N. 1, E. 7).
Area: Eur., Af., Am.

Var. *Mustela* Ehr. Cl. Syn. l. c. V. H. Syn., Tab. XXIV, figs. 4—6 (G. Must.).

14 samples (S. 1, S.W. 3, N. 2, E. 8).
Area: Eur., Af., As., B. E., Spb.

Gomphonema subtile Ehr. Cl. Syn. I, 182. V. H. Trt., Tab. XXIX, fig. 811.

Hórnafjörðr (E.) St., Vallanes (E.) H. Js.
Area: Eur., Am.

Naviculæ minusculæ Cl. 1895. Cl. Syn. II, 3.

Navicula Atomus Nægeli var. *circularis* Øst. Øst. Koss., 84, Tab. I, fig. 10.
Apavatn (S.) A. F., Reykjavík (S.W) H. Js.
Area: As.

***Navicula lucidula** Grun. Cl. Syn. II, 4. V. H. Syn., Tab. XIV, fig. 40.
Apavatn (S.) A. F., Husavík (N.) B. P.
Area: Eur., As., Grl.

Navicula minuscula Grun. Cl. Syn. II, 4. V. H. Syn., Tab. XIV, fig. 3.
Hvitá (S.) A. F.
Area: Eur., As.

Navicula pelliculosa (Bréb.) Hilse. Cl. Syn. II, 3. V. H. Syn, Tab. XIV. fig. 32.
Skeiðarársandur (S.W.) St.
Area: Eur.

Anomoeoneis Pfitzer 1871. Cl. Syn. II, 5.

Anomoeoneis brachyura (Bréb.) Grun. Cl. Syn. II, 7. V. H. Syn., Tab. XII, figs. 8—9 (Nav. serians minor & minima).
8 samples (S. 4, E. 4).
Area: Ubiquist.

Anomoeoneis exilis (Ktz.) Grun. Cl. Syn. II, 8. V. H. Trt., Tab. IV, fig. 198.
11 samples (S.W. 9, E. 2). Hot spring: 1.
Area: Eur., Grl.

Anomoeoneis sculpta (Ehr.) Cl. Cl. Syn. II, 6. V. H. Trt., Tab. IV, fig. 194 (Nav. sculpt.).
Reykjavík (3 samples) H. Js.
Area: Ubiquist.

Anomoeoneis sphærophora (Ktz.) Cl. Cl. Syn. II, 6. V. H. Trt., Tab. IV, fig. 195 (Nav. sphær.).
Reykjavík (S.W.) H. Js.
Area: Ubiquist.

Anomoeoneis zellensis (Grun.) Cl. Cl. Syn. II, 7. V. H. Syn., Tab. XII, fig. 14 (Nav. zell.).
Reykjavík (S.W.) C. H. O. In a hot spring.
Area: Eur., Grl.

Naviculæ heterostichæ Cl. 1895. Cl. Syn. II, 8.

Navicula cocconeiformis Greg. Cl. Syn. II, 9. V. H. Trt., Tab. XXVII, fig. 729.
13 samples (S. 3, S.W. 7, N. 1, E. 2).
Area: Eur., As., Am., Grl., J. M., B. E., Spb.

Naviculæ lineolatæ Cl. 1895. Cl. Syn. II, 10.

Navicula anglica Ralfs. Cl. Syn. II, 22. V. H. Trt., Tab. III, fig. 136.
25 samples (S. 7, SW. 6, N. 6, E. 6). Hot springs: 2.
Area: Eur., Af., As., Am., Grl.

Var. *minuta* Cl. Cl. Syn. l. c. Øst. Koss., Tab. I, fig. 5.
Skeiðarársandur (S.) St., Ulfjólsvatn (S.) A. F.
Area: Eur., As., Am., B. E.

Var. *subsalsa* Grun. Cl. Syn. l. c. V. H. Trt., Tab. III, fig. 137.
10 samples (S. 1, S.W. 2, N.W. 2, E. 5).
Area: Eur., Grl.

Navicula anguste-fasciata sp. nov., Tab. nost. III, fig. 30.
Long: 43 μ, lat: 9 μ, str. 12 in 10 μ, indistincte punctatis.

Valva lineari, apicibus late rostratis. Extremitatibus medianis raphes in eandem partem vergentibus. Raphe mediam partem valvæ versus area hyalina, sensim patescente et fasciam angustam efficiente, cincta. Striis radiantibus, apices versus convergentibus.

Staðastaður (S.W.) H. J.

Navicula Boyei sp. nov., Tab. nost. III, fig. 31.
Long: 14 μ, lat: 7 μ, str. 12 in 10 μ.

Valva late-lanceolata, apicibus truncatis. Striis debilissimis et vix perspiciendis, media in parte valvæ paululum spatiatis, apices versus densioribus, radiantibus et per totam valvam raphen attingentibus.

Hallormstaðr (E.) B. P.

Navicula cincta Ehr. Cl. Syn. II, 16. V. H. Trt., Tab. III, fig. 105.
49 samples (S. 11, S.W. 18, N.W. 1, N. 8, E. 10, s. l. 1). Hot springs: 2.
Area: Eur., Af., As., Am., Grl., J. M., B. E., Fz. J.

Var. *angusta* Grun. Cl. Syn. II, 17. V. H. Syn., Tab. VII, fig. 17.
Reykjarfjord (N.W.)? In a hot spring.
Area: Eur., As., Am., Aust.

Var. *Heufleri* Grun. Cl. Syn. II, 16. V. H. Trt., Tab. III, fig. 106.
Arnafellskvisl (S.) St.
Area: Eur., Af., Am.

Navicula cryptocephala Ktz. Cl. Syn. II, 14. V. H. Trt., Tab. III, fig. 122.
53 samples (S. 25, S.W. 15, N. 3, E. 9, s. l. 1). Hot springs: 2.
Area: Eur., Af., As., Am., Grl.

Var. *exilis* Ktz. Cl. Syn. l. c. V. H. Trt. l. c., fig. 124.
25 samples (S. 10, S.W. 11, N. 2, E. 1, s. l. 1). Hot spring: 1:
Area: Eur., As., Am.

Navicula curte-striata sp. nov., Tab. nost. III, fig. 32.

Long: 22 μ, lat: 7 μ, str. 10 in 10 μ, subtiliter punctatis.

Valva elliptice-lanceolata. Extremitatibus medianis raphes in eandem partem vergentibus. Striis marginalibus, aream apicalem latam lanceolatam relinquentibus, leniter radiantibus, apices versus convergentibus.

Ingjalðshóll (S.W.) H. Js.

Navicula dicephala (Ehr.) W. Sm. Cl. Syn. II, 21. V. H. Trt., Tab. III, fig. 138.

56 samples (S. 8, S.W. 16, N. 12, E. 19, s. l. 1). Hot springs: 7.
Area: Eur., Af., As., Am., Grl.

Var. *undulata* var. nov., Tab. nost. III, fig. 33.

Long: 25 μ, lat: 8 μ, str. 10 in 10 μ.

Valva triundulata, ceterum ut in typo.

Torfastaðir (S.) A. F. In a hot spring.

This form has nothing to do with Nav. Motshii Meist. (Schw. 147, Tab. XXII, fig. 16), neither with Nav. integra W. Sm. var. gibba Pant. in Pant. Bal. 47, Tab. V, fig. 113.

Navicula exilior sp. nov., Tab. nost. III, fig. 34.

Long: 13 μ, lat: 4 μ, str. 10 in 10 μ.

Valva anguste-elliptica. Raphe area hyalina angusta cincta. Striis per totam valvam radiantibus.

Reykir (S.) A. F.

Navicula Gastrum Ehr. Cl. Syn. II, 22. V. H. Trt., Tab. III, fig. 134 (the two first figs.).

Hvitá (S.) A. F.
Ubiquist, Grl.

Var. *exigua* Grun. Cl. Syn. II, 23. V. H. Trt. l. c. 3rd fig.

10 samples (S. 7, S.W. 1, N. 1, E. 1).
Area: Eur., Aust.

Navicula gracilis Ehr. Cl. Syn. II, 17. V. H. Trt., Tab. III, fig. 109.

Laugafells Laug (N.) St., Hornafjörðr (E.) St. Hot spring: 1.
Area: Eur., Af., As., Am., Grl.

Var. *schizonemoides* M. V. H. Cl. Syn. l. c. V. H. Trt. l. c., fig. 110.

8 samples (S. 5, E. 3). Hot spring: 1.
Area: Eur.

Navicula hungarica Grun. Cl. Syn. II, 16. Grun. Oest. Ung., Tab. XXX, fig. 42.

7 samples (S. 2, S.W. 3, N. 1, E. 1).
Area: Eur., As., Am., B. E.

Var. *capitata* Ehr. Cl. Syn. l. c. V. H. Trt., Tab. III, fig. 127 (Nav. humilis).

7 samples (S.W. 5, N. 2). Hot spring: 1.
Area: Eur., As., B. E.

Navicula Fustis sp. nov., Tab. nost. III, fig. 35.

Long: 46 μ, lat: 6,4 μ, str. 12 in 10 μ.

Valva lineari, apicibus leniter attenuatis. Raphe obliqua, area hyalina angusta cincta. Striis per totam valvam radiantibus.

Egilstaðir (E.) B. P.

Navicula islandica sp. nov., Tab. nost. III, fig. 36.

Long: 22 μ, lat: 8 μ, str. 20 in 10 μ, subtiliter punctatis.

Valva elliptica. Raphe area hyalina, mediam partem valvæ versus aliquantulum dilatata, cincta. Striis per totam valvam radiantibus, medianis duabus valde spatiatis.

Sævarendi (E.) B. P.

Navicula Jonssoni sp. nov., Tab. nost. III, fig. 37.

Long: 23 μ, lat: 8 μ.

Valva elliptica, apices rostratos versus attenuata. Raphe area hyalina angustissima cincta. Striis subtilissimis et, quoad perspicere potui, per totam valvam radiantibus.

Hafnarhólmi (E.) H. Js.

Possibly this form is related to, but not identical with Nav. cryptocephala var. latior Jul. Dannf. in Diat. o. t. Balt. p. 26, Tab. II, fig. 12.

Navicula lanceolata (Ag.) Ktz. Cl. Syn. II, 21. V. H. Trt., Tab. III, fig. 139.

Thjórsá (S.) A. F., Staðastaður (S.W.) H. Js.
Area: Eur., Af., Am., Aust., Grl.

Var. *Cymbula* Donk. Cl. Syn. II, 22. V. H. Syn., Tab. VII, fig. 32.

4 samples (S.W. 3, E. 1).
Area: Eur., As.

Var. *latior* Dannf. Cl. Syn. l. c. Dannf. Balt., Tab. II, fig. 12 (N. cryptoc. lat.).

Laxá (S.) A. F.
Area: Eur.

Var. *phyllepta* Ktz. Cl. Syn. l. c. V. H. Trt., Tab. III, fig. 141.

Thórsá (S.) A. F.
Area: Eur.

Navicula ludloviana A. S. Cl. Syn. II, 24. A. S. Atl., Tab. XLVI, fig. 15.

7 samples (S. 2, S.W. 1, E. 4).
Area: Am.

Navicula lyrigera sp. nov., Tab. nost. III, fig. 38.

Long: 20 μ, lat: 11 μ, str. 20 in 10 μ.

Valva late lanceolata, apicibus attenuatis. Raphe area hyalina angusta cincta. Striis debilissimis, difficiliter perspiciendis, utroque in latere ita abruptis, ut figura lyræformis, male autem definita, existat.

Fresh-water sampl.: Grímsey (N.) O. D., Marine sampl.: Skerjafjörður (S.W.) H. Js., Thõrishólmi (S.W.) H. Js.

This form has some resemblance to Navicula bifissa A. S. in A. S. Atl., Tab. CCXII, fig. 33, but it is much more closely striated, and the lateral areas are not so distinctly defined. Nav. bifissa is from Yokohama (therefore probably a marine form). As regards Nav. lyrigera, I have found it in 3 samples, of which one is a fresh-water sample solely containing fresh-water forms; the two others are salt-water samples, both however mixed with fresh-water forms; for this reason I have considered it best placing it as a fresh-water form.

***Navicula oblonga** Ktz. Cl. Syn. II, 21. V. H. Trt., Tab. III, fig. 100.

Sydri Gardar (S.W.) H. Js., Staðastaður (S.W.) H. Js.

Area: Ubiq.

Navicula Ostenfeldi sp. nov., Tab. nost. III, fig. 39.

Long: 24 μ, lat: 4 μ.

Valva anguste-lanceolata, apicibus capitatis. Raphe media in parte valvæ area hyalina longina cincta. Striis inconspicuis.

Krisuvík (S.) C. H. O.

Navicula peregrina Ehr. Cl. Syn. II, 18. V. H. Trt., Tab. III, fig. 101.

8 samples (S.W. 6, N. 1, E. 1).

Area: Eur., Af., As., Am.

Var. *Menisculus* Schum. Cl. Syn. l. c. V. H. Trt. l. c., fig. 103.

4 samples (S. 1, S.W. 2, E. 1).

Area: Eur., Af., As., Am.

Var. *Meniscus* Schum. Cl. Syn. l. c. V. H. Trt. l. c., fig. 102.

6 samples (S. 1, S.W. 2, N. 2, E. 1). Hot spring: 1.

Area: Eur., Af., As., Am., Grl.

Var. *polaris* Cl. Syn. l. c. Lgst. Spb., Tab. II, fig. 3.

Reykholt (S.W.) H. Js., Grímsey (N.) O. D.

Area: Eur., Grl., B. E., Spb.

In a sample from Hánefsstaðaeyrar (E.) H. Js., I have found a Nav. pereg. with 12 striæ on 10 μ being thus more closely striated than the typical form.

Navicula pinnularioides sp. nov., Tab. nost. III, fig. 40.

Long: 36 μ, lat: 6,4 μ, str. 8 in 10 μ.

Valva lineari apices rostratos versus attenuata. Raphe area hyalina satis lata cincta. Striis per totam valvam radiantibus, in medio uno in latere valvæ deficientibus ibique fasciam unilateralem satis latam relinquentibus.

Fljótsdalur (E.) B. P.

When I place this form under Nav. lineolatæ, it is owing to the striæ which, by great enlargement, assume the peculiar "woollen" appearance, indicating a finer structure.

***Navicula radiosa** Ktz. Cl. Syn. II, 17. V. H. Trt., Tab. III, fig. 112.

286 samples (S. 66, S.W. 77, N.W. 4, N. 38, E. 97, s. l. 4). Hot springs: 8.

Area: Eur., Af., As., Am., Grl., B. E., Spb.

***Navicula Reinhardti** Grun. Cl. Syn. II, 20. V. H. Trt., Tab. III, fig. 132.

5 samples (S. 3, N. 1, E. 1).

Area: Eur., As., Am., Grl., B. E.

Var. *Yenisseyensis* Grun. Cl. Syn. l. c. Cl. & Gr. A. D., Tab. II, fig. 30 (N. digitr. striolata).

Alftatjörn (E.) B. P.

Area: As.

Navicula rhyncocephala Ktz. Cl. Syn. II, 15. V. H. Trt., Tab. III, fig. 119.

21 samples (S. 7, S.W. 10, N. 1, E. 2, s. l. 1). Hot spring: 1.

Area: Ubiquist, Grl., B. E.

Var. *amphiceros* Ktz. Cl. Syn. l. c. V. H. Trt. l. c., fig. 120.

7 samples (S.W. 6, N. 1).

Area: Eur., Aust.

Navicula Salinarum Grun. Cl. Syn. II, 19. V. H. Trt., Tab. III, fig. 108.

Apavatn (S.) A. F. Skeiðarársandur (S.) St.

Area: Eur., Af., Am., Spb.

Navicula semifasciata sp. nov., Tab. nost. III, fig. 41.

Long: 27 μ, lat: 9 μ, str. 12 in 10 μ, subtiliter punctatis.

Valva rhomboidea, apicibus subcapitatis. Raphe area hyalina angustissima, mediam partem valvæ versus patescente, ibique in fasciam latam unilateralem dilatata, cincta. Striis radiantibus, apices versus convergentibus densioribusque.

Krókur (S.) H. Js.

Navicula spatiata sp. nov., Tab. nost. III, fig. 42.

Long: 16 μ, lat: 8 μ, str. 14 in 10 μ, obscure punctatis.

Valva elliptica. Raphe area angusta cincta. Striis medianis valde spatiatis, cetera in parte valvæ radiantibus, apices versus leniter curvatis.

Apavatn (S.) A. F.

Navicula Thingvallæ sp. nov., Tab. nost. III, fig. 43.

Long: 25 μ, lat: 7,2 μ, str. 16 in 10 μ, subtiliter punctatis.

Valva elliptica, apicibus capitatis. Raphe area hyalina angusta, media in parte valvæ in fasciam latam dilatata, cincta. Striis radiantibus, apices versus convergentibus. In fascia striæ singulæ, longæ abbreviatæque, adsunt.

Thingvallavatn (S.W.) A. F.

***Navicula Tuscula** Ehr. Cl. Syn. II, 19. V. H. Trt., Tab. IV, fig. 166.

6 samples (S.W. 1, N. 2, E. 3).
Area: Eur., Af., As., Am., Grl., B. E., Spb.

Var. *Strösei* Øst. Øst. D. D., 84. Ströse Kliek., Tab. 1, fig. 28 (Staur. dilat.).

11 samples (S. 4, S.W. 5, N. 1, E. 1).
Area: Eur.

Navicula viridula Ktz. Cl. Syn. II, 15. V. H. Trt., Tab. III, fig. 115.

12 samples (S.W. 2, N. 9, E. 1).
Area: Ubiquist.

Var. *slesvicensis* Grun. Cl. Syn. l. c. V. H. Trt. l. c., fig. 116.

74 samples (S. 23, S.W. 20, N.W. 1, N. 14, E. 16). Hot springs: 2.
Area: Eur., Grl.

Navicula vulpina Ktz. Cl. Syn. II, 15. V. H. Trt., Tab. III, fig. 111.

9 samples (S. 2, S.W. 3, E. 4).
Area: Eur., As., Am., Aust., Grl.

Naviculæ punctatæ Cl. 1895. Cl. Syn. II, 37.

***Navicula amphibola** Cl. Cl. Syn. II, 45. Lgst. Spb., Tab. II, fig. 7 (Nav. punct. asym.).

24 samples (S. 1, S.W. 2, N. 6, E. 15).
Area: Eur., As., Am., Grl., B. E., Spb., Fz. J.

Navicula lacustris Greg. Cl. Syn. II, 44. Cl. Finl., Tab. II, fig. 14.

4 samples (S. 3, E. 1).
Area: Eur., Am.

Navicula pusilla W. Sm. Cl. Syn. II, 41. V. H. Trt., Tab. IV, fig. 186.

40 samples (S. 5, S.W. 17, N.W. 3, N. 9, E. 6). Hot springs: 5.
Area: Ubiquist, Grl., J. M.

Pinnularia Ehr. 1843. Cl. Syn. II, 71.

Gracillimæ Cl. 1895. Cl. Syn. II, 74.

Pinnularia gracillima Greg. Cl. Syn. II, 74. V. H. Syn., Tab. VI, fig. 24 (Nav. grac.).

6 samples (S. 3, S.W. 2, E. 1).
Area: Eur., As., Grl., J. M., Fz. J.

Pinnularia leptosoma Grun. Cl. Syn. II, 74. V. H. Syn., Tab. XII, fig. 29 (Nav. lept.).

6 samples (S.W. 4, N. 2). Hot springs: 3.
Area: Eur., Grl.

Var. *undulata* var. nov., Tab. nost. III, fig. 44.

Long: 42 μ, lat: 5,4 μ, str. 16 in 10 μ.

Valva lineari, leniter undulata. Raphe area hyalina angusta, media in parte valvæ in fasciam satis latam dilatata, cincta. Striis subradiantibus, apices versus convergentibus.

Mývatn (N.) Rd.

Pinnularia molaris Grun. Cl. Syn. II, 74. V. H. Syn., Tab. VI, fig. 19 (Nav. mol.).

Hrafnagil (N.) H. Js., Gautavík (E.) H. Js. Hot spring: 1.
Area: Eur., As., Am., Aust.

Pinnularia sublinearis Grun. Cl. Syn. II, 74. V. H. Trt., Tab. II, fig. 78 (Nav. subl.).

15 samples (S. 2, S.W. 3, N. 4, E. 6).
Area: Eur., Grl., J. M.

Capitatæ Cl. 1895. Cl. Syn. II, 75.

***Pinnularia appendiculata** Ag. Cl. Syn. II, 75. V. H. Trt., Tab. II, fig. 93 (Nav. app.).

19 samples (S. 3, S.W. 10, N. 1, E. 5). Hot springs: 2.
Area: Ubiquist, Grl.

Var. *budensis* Grun. Cl. Syn. l. c. V. H. Syn., Tab. VI, figs. 27—28 (Nav. app. bud.).

Grafarbakki (S.) A. F., Hrafnagil (N.) H. Js., Snæfell (E.) B. S. Hot springs: 2.
Area: Hot springs, Eur., New Zealand.

***Pinnularia Brauni** Grun. Cl. Syn. II, 75. V. H. Trt., Tab. II, fig. 95 (Nav. Br.).

Brunavíkurstrand (E.) H. Js.
Area: Ubiquist.

Pinnularia interrupta W. Sm. f. *stauroneiformis* Cl. Cl. Syn. II, 76. V. H. Trt., Tab. II, fig. 97 (Nav. mesolepta Termes).

30 samples (S. 4, S.W. 13, N.W. 1, N. 9, E. 3). Hot springs: 5.
Area: Eur., As., Am., Aust., Grl.

F. *biceps* Cl. Cl. Syn. l. c. Lgst. Spb., Tab. 1, fig. 5 (Nav. bicapitata).

10 samples (S. 1, S.W. 4, N. 1, E. 4).
Area: Eur., As., Am., Aust., Grl., Spb., Fz. J.

Pinnularia mesolepta Ehr. var. *angusta* Cl. Cl. Syn. II, 76. A. S. Atl., Tab. XLV, fig. 62 (Nav. gracillima).

17 samples (S. 3, S.W. 5, N.W. 1, N. 3, E. 5). Hot spring: 1.
Area: Eur., Am.

Var. *polyonca* Bréb. Cl. Syn. l. c. V. H. Trt., Tab. II, fig. 99.

10 samples (S. 1, S.W. 5, E. 4).
Area: Eur.

Var. *stauroneiformis* Grun. Cl. Syn. l. c. A. S. Atl., Tab. XLV, figs. 52—53.

55 samples (S. 11, S.W. 20, N.W. 1, N. 5, E. 18). Hot springs: 5.
Area: Eur., Af., Am., Grl., J. M., F. J.

Pinnularia microstauron Ehr. Cl. Syn. II, 77. V. H. Syn, Tab. VI, fig. 9 (Nav. biceps hybrida).

11 samples (S. 3, S.W. 2, N.W. 1, E. 1). Hot spring: 1.
Area: Ubiquist, Grl., J. M., Spb., Fz. J.

Pinnularia Oculus Øst. Øst. Østg. Ferskv., 269, Tab. I, fig. 6.

7 samples (S. 1, S.W. 1, N. 1, E. 4).
Area: Eur., Grl.

Pinnularia perexilis sp. nov., Tab. nost. III, fig. 45.

Long: 17 μ, lat: 2,7 μ.

Valva linearis, in medio inflata, apicibus capitatis. Striis subtilissimis et, quoad perspicere potui, per totam valvam radiantibus, media in parte valvæ aliquantulum spatiatis.

Laugaá (S.W.) A. F.

In spite of the striation radiating all throughout, at least as far as I can see, I consider that this small form requires its place among Pinn. capitatæ.

Pinnularia subcapitata Greg. Cl. Syn. II, 75. V. H. Trt., Tab. II, fig. 91 (Nav. subc.).

51 samples (S. 11, S.W. 16, N.W. 1, N. 8, E. 15). Hot springs: 2.
Area: Ubiquist, Grl., J. M., Spb., Fz. J.

Var. *paucistriata* Grun. Cl. Syn. l. c. V. H. Trt. l. c., fig. 92 (Nav. sub. pauc.).

Hvitá (S.) A. F.
Area: Eur.

Divergentes Cl. 1895. Cl. Syn. II, 77.

***Pinnularia Brebissoni** Ktz. Cl. Syn. II, 78. V. H. Trt., Tab. II, fig. 82 (Nav. Bréb.).

34 samples (S. 1, S.W. 9, N. 6, E. 17, s. l. 1). Hot spring: 1.
Area: Eur., Af., As., Am., Grl., J. M., Spb.

*Var. *diminuta* H.V.H. Cl.Syn. l. c. V. H.Trt. l. c., fig. 84 (N.Breb. dim.).
8 samples (S. 1, S.W. 1, N. 1, E. 4, S. L. 1). Hot spring: 1.
Area: Eur., Am., Grl.

Var. *linearis* O. M. O. M. Rieseng., 25, Tab. III, fig. 12.
Yttri Skógar (S.), H. Js.
Area: Eur.

Pinnularia bryophila sp. nov., Tab. nost. III, fig. 46.
Long: 43 μ, lat: 9,6 μ, str. 12 in 10 μ.

Valva lineari, apicibus rotundatis. Raphe area hyalina lata, media in parte valvæ, in fasciam, in qua uno in latere stria singula adest, dilatata cincta. Fissuris terminalibus et extremitatibus medianis raphes in partes diversas inclinantibus. Striis radiantibus, apices versus convergentibus.

Seyðisfjord (E.) B. P. On moss.

***Pinnularia divergens** W. Sm. var. *elliptica* Grun. Cl. Syn. II, 79. Grun. Fz. J., Tab. 1, fig. 19 (Nav. div. ell.).
64 samples (S. 6., S.W. 16, N.W. 2, N. 7, E. 33). Hot spring: 1.
Area: Eur., Af., Am., Aust., Grl., Fr. J.

Var. *elongata* Øst. Øst. D. D., 98, Tab. III, fig. 68.
Staðastaður (S.W.) H. Js.
Area: Eur.

***Pinnularia divergentissima** Grun. Cl. Syn. II, 77. V. H. Syn., Tab. VI, fig. 32, (Nav. div.).
9 samples (S. 2, SW. 3, E. 4).
Area: Eur., As., Am., Aust., Grl., J. M., Spb.

Pinnularia islandica sp. nov., Tab. nost. III, fig. 47.
Long: 82 μ, lat: 14 μ, str. 9 in 10 μ.

Valva fere lineari, apicibus rotundatis. Raphe area hyalina satis lata, mediam partem versus patescente ibique aream longinam magnam efficiente, cincta. Striis radiantibus, apices versus convergentibus.

Skutustaðir (N.) B. P., Lagarfljót (E.) B. P.

Pinnularia karelica Cl. Cl. Syn. II, 78. Cl. Finl., Tab. I, fig. 6. A. S. Atl., Tab. CCCXI, figs. 14—15.
Seyðisfjord (E.) B. P.

Var. *rostrata* var. nov., Tab. nost. III, fig. 48.
Long: 41 μ, lat: 11 μ, str. 12 in 10 μ.

Valva lineari, apicibus late rostratis. Raphe area hyalina, media in parte valvæ in aream magnam rotundatam dilatata, cincta.

Grímsá (E.) B. P.

The somewhat wider striation notwithstanding, this form must surely be considered as a var. of Pinn. karelica.

***Pinnularia Legumen** Ehr. Cl. Syn. II, 78. V. H. Trt., Tab. II, fig. 98 (Nav. Leg.).

Reykjanes (N.) Thor., in a hot spring, Ulfsbær (N.) B. P.
Area: Ubiquist, Grl.

Var. *longa* A. Cl. f. *interrupta* A. Cl. Finl., 28, Tab. 1, fig. 26.

Torfastaðir (S.) A. F., in a hot spring.
Area: Eur.

Pinnularia parallela Brun var. *crassa* Øst. Øst. D. D., 99, Tab. III, fig. 64.

Staðastaður (S.W.) H. Js.
Area: Eur.

Pinnularia platycephala Ehr. Cl. Syn. II, 79. Cl. Finl., Tab. II, fig. 1. A. S. Atl., Tab. CCCX, figs. 6—8.

Fróðarheiði (S.W.) H. Js.
Area: Eur., Grl., J. M.

Distantes Cl. 1895. Cl. Syn. II, 80.

Pinnularia alpina W. Sm. Cl. Syn. II, 81. V. H. Trt., Tab. XXV, fig. 705 (Nav. alp.).

Sandbrekka (E.) H. Js., Seyðisfjord (E.) B. P.
Area: Eur.

Var. *linearis* var. nov., Tab. nost. III, fig. 49.

Long: 64 μ, lat: 14,4 μ, str. 5 in 10 μ.

Valva lineari, apicibus rotundatis. Raphe area hyalina, media in parte valvæ in aream rotundatam dilatata, cincta. Fissuris terminalibus semicircularibus. Striis radiantibus, apices versus convergentibus.

Sævarendi (E.) B. P.

Owing to the radiate-convergent striæ, I consider this form should rather be classed with Pinnularia alpina than with Pinn. lata. It has hardly anything to do with Pinn. borealis.

***Pinnularia Balfouriana** Grun. Cl. Syn. II, 80, Tab. I, fig. 18. A. S. Atl., Tab. CCCXIII, figs. 29—31.

6 samples (S. 2, S.W. 1, N. 2, E. 1). Hot springs; 2.
Area: Eur., Fz. J.

***Pinnularia borealis** Ehr. Cl. Syn. II, 80. V. H. Trt., Tab. II, fig. 77.

195 samples (S. 32, S.W. 49, N.W. 9, N. 39, E. 64, s. l. 2). Hot springs: 17. Never in great numbers in the samples.
Area: Ubiquist, Grl., J. M., B. E., Sp., Fz. J.

Var. *brevicostata* Hust. Hust. Sud., 82, Tab. nost. III, fig. 50.

Long: 25 μ, lat: 7 μ, str. 5 in 10 μ.

Valva sublineari, apicibus capitatis. Striis marginalibus, aream apicalem latam relinquentibus.

Hrafnagil (N.) H. Js., in a hot spring, Ulfsbær (N.) B. P.

Area: Eur.

This form I consider identical with Hustedt's var. brevicostata, of which no figure is given.

Var. *linearis* Hérib. Hérib. Auv. III, 45, Tab. XIII, fig. 20.

15 samples (S. 6, S.W. 5, N. 1, E. 3).

Area: Eur.

Pinnularia intermedia (Lgst.) Cl. Cl. Syn. II, 80. Lgst. Spb., Tab. I, fig. 3 (Nav. int.).

12 samples (S.W. 4, N. 4, E. 4). Hot spring: 1.

Area: Eur., Aust., Grl., B. E., Spb., Fz. J.

Pinnularia lata (Bréb.) Cl. Cl. Syn. II, 81. Grun. Fz. J., Tab. I, fig. 14 (Nav. lata).

32 samples (S. 10, S.W. 3, N.W. 4, N. 6, E. 8, s. l. 1). Hot springs: 4.

Area: Eur., As., Am., Aust., Grl., J. M., Fz. J.

Var. *minor* Grun. Cl. Syn. l. c. Grun. l. c., figs. 16—17 (Nav. lat. min.).

Hofsfjall (N.) O. D., Seyðisfjarðarheiði (E.) H. Js.

Area: Casp. Sea, J. M., Spb., Fz. J.

In a sample from Reykjavík (S.W.) H. Js. I have found a Pinn. lata forma minima, of which I give a figure on tab. nostr. III fig. 51. Its dimensions are: length 27 μ, width 8 μ, str. 4,5 in 10 μ.

Tabellarieæ Cl. 1895. Cl. Syn. II, 81.

Pinnularia Brandeli Cl. var. *linearis* var. nova, Tab. nost. III, fig. 52.

Long: 47 μ, lat: 8 μ, str. 12 in 10 μ.

Valva lineari, apicibus rotundatis. Raphe area hyalina satis angusta, media in parte valvæ in fasciam satis latam dilatata, cincta. Utroque in latere fasciæ striola fere linearis adest. Fissuris terminalibus semicircularibus.

Torfastaðir (S.) A. F., in a hot spring.

Undoubtedly a somewhat wider striated variant of Pinn. Brand.

Pinnularia densestriata sp. nov., Tab. nost. III, fig. 53.

Long: 50 μ, lat: 6,4 μ, str. 20 in 10 μ.

Valva lineari, leniter undulata, apicibus rostratis. Raphe area hyalina lata, media in parte valvæ in fasciam latam dilatata, cincta. Striis radiantibus, apices versus convergentibus.

Hallormstaðr (E.) B. P.

I am not sure as to the place of this form within the several groups of Pinnularia. Possibly, owing to the close striation, it ought to be classed with Pinn. gracillimæ, against which however speaks the broad area and the transapical fasciæ.

***Pinnularia mesogongyla** Ehr. Cl. Syn. II, 84. Cl. Finl., Tab. 1, fig. 11.
28 samples (S. 1, S.W. 14, N.W. 1, N. 2, E. 2). Hot springs: 3.
Area: Eur., Am., Grl.

Var. *interrupta* Cl. Syn. l. c. Cl. Finl. l. c., fig. 10.
Skaftafellssysla (S.) St., Hornafjörðr (E., two samples) St.
Area: Eur., Grl., Fz. J.

***Pinnularia stauroptera** (Grun.) Cl. Syn. II, 82. A. S. Atl., Tab. XLV, figs. 48—50 (Nav. staur.).
33 samples (S. 4, S.W. 13, N. 3, E, 12, s. l. 1). Hot springs: 2.
Area: Eur., As., Am., Aust., Fz. J.

Var. *interrupta* Cl. Syn. II, 83. V. H. Trt., Tab. II, figs. 85—86 (Nav. staur. et Nav. staur. parva).
35 samples (S. 6, S.W. 12, N.W. 1, N. 3, E. 13). Hot springs: 2.
Area: Eur., Af., Am., Aust., Grl.

Pinnularia subsolaris (Grun.) Cl. Syn. II, 84. V. H. Syn., Tab. VI, fig. 17 (Nav. Legumen vix undulata).
Ketilsstaðir (S.W) H. Js.
Area: Eur., Af., Am., Aust., Grl.

Brevistriatæ Cl. 1895. Cl. Syn. II, 85.

***Pinnularia acrosphæria** (Bréb.) Cl. Syn. II, 86. A. S. Atl., Tab. XLIII, fig. 16 (Nav. acrosph.).
Reykjavík (S.W.) C. H. O., Mývatn (N.) Rd.
Area: Eur., Af., As., Am.

Pinnularia brevicostata Cl. Cl. Syn. II, 86. Cl. Finl. I, fig. 5.
47 samples (S. 4, S.W. 17, N.W. 1, N. 8, E. 22, s. l. 1). Hot springs: 3.
Area: Eur., As.

Var. *islandica* var. nov., Tab. nost. III, fig. 54.

Long: 36 μ, lat: 8 μ, str. 9 in 10 μ.

Valva lineari, apicibus rotundatis. Raphe area hyalina lata, media in parte valvæ in fasciam dilatata, cincta. Striis parallelis, apices versus leniter convergentibus.

Vallanes (E.) B. P.

Var. *leptostauron* Cl. Cl. Syn. II, 86. A. S. Atl., Tab. XLIII, fig. 25 (sine nomine).
5 samples (S.W. 3, E. 2).

***Pinnularia hemiptera** (Ktz.) Cl. Cl. Syn. II, 85. Hérib. Auv. (Nav. hemipt. Bielawzki).
Lagarfljót (E.) B. P.
Area: Eur., Af., As., Am.

Var. *interrupta* Cl. Syn. l. c. Øst. D. D., Tab. III, fig. 67.
Ulfjólsvatn (S.) A. F., Reykjavík (S.W.) H. Js.
Area: Eur., As.

Pinnularia nodosa (Ehr.) Cl. Cl. Syn. II, 87. A. S. Atl., Tab. XLV, fig. 58 (Nav. nod.).
Egilstaðir (E.) B. P.
Area: Eur., Am.

Pinnularia parva (Greg.) Cl. Cl. Syn. II, 87. Grun. Oest. Ung, Tab. XXX, fig. 37 (Nav. parvula).
10 samples (S. 1, S.W. 4, N. 2, E. 3).
Area: Eur., As., Am., Aust., Grl.

Var. *Lagerstedti* Cl. Cl. Syn. l. c. Lgst. Spb., Tab. II, fig. 4 (Nav. parvula).
13 samples (S. 4, S.W. 5, N. 1, E. 4).
Area: B. E., Spb.

Var. *minuta* var. nov., Tab. nost. IV, fig. 55.

Long: 16 μ, lat: 4 μ, str. 10 in 10 μ.

Valva anguste lanceolata, fere lineari. Striis marginalibus, aream apicalem latam relinquentibus.
Hvitá (S.) A. F.

P. paulensis Grun. Cl. Syn. II, 86, Tab. I, fig. 20.
Hofsfjall (N.) O. D.
Area: Am., Grl.

P. subundulata sp. nov., Tab. nost. IV, fig. 56.

Long: 75 μ, lat: 9 μ, str. 10 in 10 μ.

Valva lineari, leniter undulata, apicibus rotundatis. Raphe area hyalina lata, media in parte valvæ in fasciam latam dilatata, cincta. Fissuris terminalibus semicircularibus. Striis radiantibus, apices versus convergentibus.
Mývatn (E.) Rd.

P. Thoroddseni sp. nov., Tab. nost. IV, fig. 57.

Long: 27 μ, lat: 7 μ, str. 10 in 10 μ.

Valva lineari-lanceolata, apicibus obtusis. Raphe leniter arcuata, area hyalina satis lata, media in parte valvæ in fasciam latam dilatata, cincta. Striis subradiantibus, apices versus leniter convergentibus.
Reykjanes (N.W.) Thor. in a hot spring.

Majores Cl. 1895. Cl. Syn. II, 88.

***Pinnularia Dactylus** (Ehr.) Cl. Cl. Syn. II, 90. V. H. Trt., Tab. II, fig. 68 (Nav. nobilis Dact.).
Aðalvík (N.W.) C. H. O.
Area: Eur., Af., Am.

Pinnularia gigantea sp. nov., Tab. nost. IV, fig. 58.

Long: 260 μ, lat: 36 μ, str. 5,5 in 10 μ.

Valva lineari, apicibus rotundatis. Raphe obliqua, area angustissima cincta. Extremitatibus medianis raphes approximatis, fissuris terminalibus semicircularibus. Striis in medio subradiantibus, deinde parallelis, apices versus leniter convergentibus.

Staðastaður (S.W.) H. Js.

Pinnularia major (Ktz.) Cl. Cl. Syn. II, 89. V. H. Trt., Tab. II, fig. 69 (Nav. maj.).

111 samples (S. 18, S.W. 34, N.W. 4, N. 10, E. 43, s. l. 2). Hot springs: 4.

Area: Ubiquist.

Var. *linearis* Cl. Cl. Syn. l. c. W. Sm. Syn., Tab. XVIII, fig. 162 (Pinn. major).

Staðastaður (S.W.) H. Js.

Area: Eur., Af., Am.

Pinnularia secernenda A. S. Cl. Syn. II, 88. A. S. Atl., Tab. XLIII, fig. 13 (Nav. secern.).

Egilstaðir (E.) B. P.

Area: Am.

Complexæ Cl. 1895. Cl. Syn. II, 90.

Pinnularia æstuarii Cl. Cl. Syn. II, 93. Tab. I, fig. 16.

Grímsey (N.) O. D.

Area: Eur., Am.

Pinnularia distinguenda Cl. Cl. Syn. II, 92. Cl. Finl., Tab. I, fig. 1 (Pinn. vir. disting.).

4 samples (S. 1, S.W. 3).

Area: Ubiquist.

Pinnularia flexuosa Cl. Cl. Syn. II, 93. Tab. I, fig. 23.

4 samples, all E.

Area: Am.

***Pinnularia icostauron** (Grun.) Cl. Cl. Syn. II, 93. Cl. & Grun. A. D., Tab. 1, fig. 14 (Nav. vir. icost.).

4 samples (S. 1, N.W. 2, E. 1).

Area: Eur., Am., Grl.

***Pinnularia nobilis** (Ehr.) Cl. Cl. Syn. II, 92. V. H. Trt., Tab. II, fig. 67 (Nav. nob.).

6 samples (S. 1, S.W. 3, E. 1, s. l. 1).

Area: Eur., As., Am.

Pinnularia streptoraphe Cl. Cl. Syn. II, 93. A. S. Atl., Tab. XLII, fig. 7 (Nav. sp.).

49 samples (S. 3, S.W. 19, N.W. 3, N. 4, E. 20). Hot springs: 3.
Area: Eur., Am., Grl., Fz. J.

Var. *minor* Cl. Cl. Syn. l. c. Cl. Finl., Tab. I, fig. 2 (Pinn. vir. minor).

Reykjavík (S.W.) Grld., Vallanes (E.) H. Js.
Area: Eur., Grl.

***Pinnularia viridis** (Nitsch) Cl. Cl. Syn. II, 91. V. H. Trt., Tab. II, fig. 70 (Nav. vir.).

214 samples (S. 39, S.W. 44, N.W. 12, N. 25, E. 82, s. l. 2). Hot springs: 10.
Area: Ubiquist.

Var. *commutata* Grun. Cl. Syn. l. c. A. S. Atl., Tab. XLV, figs. 35—37 (Nav. comm.).

148 samples (S. 21, S.W. 31, N.W. 5, N. 24, E. 66, s. l. 1). Hot springs: 6.
Area: Eur., Am., Aust., Grl.

Var. *fallax* Cl. Cl. Syn. l. c. V. H. Trt., Tab. II, fig. 71 (Nav. vir. comm.).

6 samples (S. 2, S.W. 2, E. 2).
Area: Eur., Am., Aust., Grl., Fz. J.

Var. *intermedia* Cl. Cl. Syn. l. c. A. S. Atl., Tab. XLII, figs. 9—10 (Nav. major).

Thingvellir (S.W.) E. W. & Ho., Reykjavík (S.W.) C. H. O., Mývatn (N.) Rd.
Area: Eur., Af., As., Aust., Grl., J. M.

Var. *leptogongyla* Grun. Cl. Syn. l. c. A. S. Atl., Tab. XLV, figs. 26—28 (Nav. leptog.).

Ketilstaðir (S.W.), H. Js., Vallanes (E.) H. Js.
Area: Eur.

Var. *rupestris* Hantsch. Cl. Syn. II, 92. A. S. Atl. l. c., fig. 42 (Nav. rupest.).

12 samples (S. 2, S.W. 5, N.W. 1, N. 1, E. 3). Hot springs: 3.
Area: Eur., Am., Grl., Fz. J.

Amphora Ehr. 1840. Cl. Syn. II, 99.

Subgenus *Amphora* Cl. 1895. Cl. Syn. II, 100.

Amphora cimbrica Øst. Øst. D. D., 110, Tab. III, fig. 72.
Hornarfjörðr (E.) St.
Area: Eur.

***Amphora ovalis** Ktz. Cl. Syn. II, 104. V. H. Trt., Tab. 1, fig, 15.

159 samples (S. 38, S.W. 37, N.W. 14, N. 22, E. 44, s. l. 4). Hot springs: 6.

Area: Ubiquist, Grl., B. E., Spb.

Var. *Pediculus* Ktz. Cl. Syn. II, 105. V. H. Trt. l. c., fig. 19.

41 samples (S. 14, S.W. 14 N. 5, E. 8). Hot springs: 3.

Area: Ubiquist, B. E., Fz. J.

Amphora perpusilla Grun. Cl. Syn. II, 105. V. H. Trt., Tab. I, fig. 12.

Vík (S.) H. Js., Grímsey (N.) O. D.

Area: Eur., Af., As.

Subgenus *Halamphora* Cl. 1895. Cl. Syn. II, 117.

***Amphora coffæiformis** Ag. Cl. Syn. II, 120. V. H. Trt., Tab. I, fig. 6.

6 samples, all S. Hot spring: 1.

Area: Ubiquist, Grl.

Amphora dubiosa sp. nov., Tab. nost. IV, fig. 59.

Long: 20 μ, lat: 8 μ.

Valva semilanceolata, apicibus valde capitatis. In parte apicali valvæ striæ duæ raphoideæ adsunt. Structuram ullam valvæ perspicere non potui.

Spinstaðir (S.) A. F.

Owing to the amphora-like shape and the two striæ, resembling raphes, of this small form, I have classed it with Amphora. Possibly it is closest related to A. Normani Rabh.

Amphora Normani Rabh. Cl. Syn. II, 119. V. H. Trt., Tab. I, fig. 4.

Syðri Garðar (S.W.) H. Js.

Area: Eur., Af., As., Am., Fz. J.

Amphora protracta Pant. var. *gallica* Hérib. Hérib. Auv. III, 61, Tab. XIII, fig. 1.

8 samples (S. 3, S.W. 1, N. 1, E. 3). Hot springs: 2.

Area: Eur., Am.

Amphora veneta Ktz. Cl. Syn. II, 118. A. S. Atl., Tab. XXVI, figs. 74—80.

4 samples (S. 1, S.W. 1, N. 1, E. 1). Hot spring: 1.

Mastogloia Thwaites 1848. Cl. Syn. II, 142.

Mastogloia elliptica Ag. var. *Dansei* Thw. Cl. Syn. II, 152. V. H. Trt., Tab. II, fig. 64 (M. Dansei).

13 samples (S. W. 2, N.W. 1, N. 4, E. 6). Hot springs: 5.

Area: Eur., Af., Am., Aust.

Mastogloia Grevillei W. Sm. Cl. Syn. II, 146. V. H. Trt., Tab. II, fig. 65.

Hornarfjörðr (E.) St.
Area: Eur., Af., Am.

***Mastogloia Smithi** Thw. var. *lacustris* Grun. Cl. Syn. II, 152. V. H. Trt., Tab. II, fig. 61.

Hrossholt (S.W.) A. F., in a hot spring.
Area: Eur., Spb.

Monoraphideæ

Achnantheæ Cl. 1895. Cl. Syn. II, 163.

Rhoicosphenia Grun. 1860. Cl. Syn. II, 165.

Rhoicosphenia curvata (Ktz.) Grun. Cl. Syn. II, 165. V. H. Trt., Tab. VII, fig. 319.

86 samples (S. 39, S.W. 17, N.W. 2, N. 16, E. 11, s. l. 1). Hot springs: 9.
Area: Ubiquist, Grl., Spb., Fz. J.

Cocconeis (Ehr. 1835) Grun. 1868. Cl. Syn. II, 168.

Subgenus *Cocconeis* Cl. 1895. Cl. Syn. II, 168.

Cocconeis Placentula Ehr. Cl. Syn. II, 169. V. H. Trt., Tab. VIII, fig. 341.

126 samples (S. 44, S.W. 37, N.W. 1, N. 18, E. 25, s. l. 1). Hot springs: 7.
Area: Ubiquist.

Subgenus *Eucocconeis* Cl. 1895. Cl. Syn. II, 173.

Cocconeis flexella Ktz. Cl. Syn. II, 179. V. H. Trt., Tab. VIII, fig. 322 (Achnanthidium flex.).

54 samples (S. 1, S.W. 26, N. 5, E. 21, s. l. 1). Hot springs: 2.
Area: Eur., Af., As., Am.

Var. *intermedia* Øst. Øst. D. Exp. 244, Tab. XIV, fig. 12.

Unaós (E.) H. Js.
Area: Grl.

Cocconeis minuta Cl. Cl. Syn. II, 179. Lgst. Spb., Tab. II, fig. 16 (C. Thwaitesi v. arctica).

4 samples (S. 1, S.W. 3).
Area: Eur., Grl., Spb., Fz. J.).

Var. *alpestris* Br. Cl. Syn. II, 180. Le Diat. II, Tab. V, fig. 15.
Hof (N.), Gautavík (E.) H. Js.
Area: Eur., Grl.

Subgenus *Microneis* Cl. 1895. Cl. Syn. II, 187.

Achnanthes affinis Grun. Cl. Syn. II, 190. V. H. Trt., Tab. VIII, fig 329.
Thingvellir (S.W.) E. W. & Ho.
Area: Eur., Am., Aust.

Achnanthes Biassolettiana Ktz. Cl. Syn. II, 189. V. H. Trt., Tab. VIII, fig. 331.
24 samples (S. 4, S.W. 4, N. 3, E. 12, s. l. 1).
Area: Eur., Am., J. M.

Achnanthes Boyei sp. nov., Tab. nost. IV, fig. 60.

Long: 30 μ, lat: 6 μ, str. 12,5 in 10 μ, subtiliter punctatis.

Valva anguste lanceolata, paululum asymmetrica.

Hypotheca: Raphe area hyalina angusta, media in parte valvæ in fasciam latam dilatata, cincta. Striis per totam valvam radiantibus.

Epitheca: Striis media in parte valvæ uno in latere deficientibus, altero in latere paululum abbreviatis. Ceterum forma hypothecæ simili.

4 samples (N. 3, E. 1), all B. P.

***Achnanthes delicatula** Ktz. Cl. Syn. II, 190. V. H. Trt., Tab. VIII, fig. 330.
Spóastaðir (S.) A. F., Eidistjörn (S.W.) C. H. O.
Area: Eur., Af., As., Grl.

Achnanthes exigua Grun. Cl. Syn. II, 190. V. H. Syn., Tab. XXVII, figs. 29—30.
7 samples (S. 3, S.W. 4). Hot spring: 1.
Area: Ubiquist.

***Achnanthes exilis** Ktz. Cl. Syn. II, 189. V. H. Trt., Tab. VIII, fig. 333.
Reykjavík (S.W.) C. H. O., in a hot spring.
Area: Eur., Af., As.

Achnanthes linearis W. Sm. Cl. Syn. II, 188. V. H. Trt., Tab. VIII, fig. 335.
4 samples (S. 1, N. 2, E. 1).
Area: Eur., As., Am., Grl., Fz. J.

Achnanthes minutissima Ktz. Cl. Syn. II, 188. V. H. Trt., Tab. VIII, fig. 334.
27 samples (S. 4, S.W. 11, N. 3, E. 8, s. l. 1). Hot springs: 3.
Area: Eur., Af., As., Am., Grl., J. M., B. E., Spb.

Under A. minut. I include var. cryptocephala (cnfr. Cl. l. c.), which can hardly be kept apart from the typical species.

Achnanthes tylophora (Reichelt) Cl. Reich. Schöhsee, 199 (Stauron. tyl.), A. S. Atl., Tab. CCXLII, figs. 17—18 (Achn. exigua).
Apavatn (S., two samples) A. F.
Area: Eur.

Subgenus *Achnanthidium* (Ktz. 1844) Heib. 1863. Cl. Syn. II, 191.

Achnanthes Calcar Cl. Cl. Syn. II, 174. Cl. Finl., Tab. III, fig. 8.
6 samples (S. 2, S.W. 1, N. 2, E. 1).
Area: Eur.
Cleve places this species under "Eucocconeis". When I have moved it from there, it is owing to the horseshoe marking, which, it seems to me, approaches it to the group of Achn. lanceolata.

Achnanthes coarctata (Brés.) Cl. Syn. II, 192. V. H. Trt., Tab. VIII, fig. 327.
39 samples (S. 9, S.W. 8, N.W. 1, N. 6, E. 13, s. l. 2). Hot spring: 1.
Area: Eur., Af., As., Am., Grl., J. M., B. E., Spb.
I have given a figure of a square form of A. coarctata on Tab. nost. IV, fig. 61. It resembles somewhat the A. coarct. elineata Lgst., figured in O. M. Pat., Tab. 1, fig. 8, which variant, however, is referred by Cleve, l. c. to the typical species. I found it in a sample from Vík (S.) H. Js.

***Achnanthes lanceolata** Bréb. Cl. Syn. II, 191. V. H. Trt., Tab. VIII, fig. 336.
140 samples (S. 53, S.W. 29, N.W. 10, N. 10, E. 38). Hot springs: 9.
Area: Ubiquist.

Var. *capitata* O. M. O. M. Pat., 8, Tab. I, figs. 6—7.
Krókur (S.) H. Js., Skutustaðir (E. two samples) B. B.
Area: Am.

Var. *dubia* Grun. Cl. Syn. II, 192. V. H. Trt., Tab. VIII, fig. 337.
Apavatn (S.) A. F.
Area: Eur., Am.

Var. *elliptica* Cl. Cl. Syn. l. c. Cl. Finl., Tab. III, figs. 10—11.
Apavatn (S.) A. F., Hornafjörðr (E.) St.
Area: Eur.

Var. *færöensis* Øst. Øst. Fær. Freshw. 277, fig. 44.
58 samples (S. 22, S.W. 7, N.W. 1, N. 1, E. 17, s. l. 3). Hot springs: 2.
Area: Eur., B. E.

Var. *subinflata* var. nov., Tab. nost. IV, fig. 62.
Long: 15 μ, lat: 4 μ, str. 14 in 10 μ.
Valva lineari, in medio paululum inflata, apicibus rotundatis. Striis per totam valvam radiantibus.

Hypotheca: Striis media in parte valvæ deficientibus, ibique fasciam latam relinquentibus.

Epitheca: Uno in latere mediæ partis valvæ spatium hyalinum, soleæ equinæ instar, adest.

Egilstaðir (E.) B. P., Hornafjörðr (E.) St.

This small form is hardly identical with Hustedt's Ach. lanc. ventricosa (cnfr. Hust. Sud. 64, Tab. II, fig. 321; it seems to me, it should rather be placed close to Ach. lanc. færöensis.

Achnanthes Peragalli Brun & Hérib. Cl. Syn. II, 192. Øst. D. D., Tab. IV, fig. 85.

Apavatn (S.) A. F., Úlfjólsvatn (S.) A. F.

Area: Eur.

Achnanthes rhyncocephala A. Cl. A. Cl. Finl., 43, Tab. IV, fig. 85.

Husavík (N.) B. P., Grimsá (E.) B. P.

Area: Eur.

Kalyptoraphideæ

Eschatoraphideæ

Surirella Turpin 1827. V. H. Trt., 368.

Surirella asymmetrica sp. nov., Tab. nost. IV, fig. 63.

Long: 40 μ, lat: 10 μ.

Valva elliptice-lanceolata, margine una recta, altera autem convexa. Area apicali angusta. Canaliculis in margine recta omnino 14, in margine convexa omnino 7.

In a flowing off from Geysir (S.W.) A. F.

***Surirella biseriata** Bréb. V. H. Trt., 369, Tab. XII, fig. 575.

34 samples (S. 6, S.W. 8, N.W. 1, N. 7, E. 12). Hot springs.

Area: Eur., Af., As., Am.

Surirella Engleri O. M. f. angustior. O. M. Nyassa, 28, Tab. 1, fig. 5. A. S. Atl. CCXLV, fig. 14.

Laugavatn (S.) B. P. Möðruvellir (S.W.) B. P.

Area: Af.

Surirella granulata Øst. var. *elliptica* var. nov., Tab. nost. IV, fig. 64.

Long: 72 μ, lat: 20 μ, canalic. 2,7 in 10 μ.

Valva elliptica, irregulariter punctata, area apicali angustissima.

Reykjavík (S.W.) C. H. O.

This form answers in every respect, except by the exterior contour, to Sur. granulata Øst. in Øst. Koss. 91, Tab. II, fig. 17.

Surirella islandica sp. nov., Tab. nost. IV, fig. 65.

Long: 28 μ, lat: 7 μ, canalic. 5 in 10 μ.

Valva lineari-elliptica, canaliculis marginalibus.

Vallanes (E.) B. P.

This small form reminds somewhat of the S. minuta Bréb., figured in Pant. Bal., Tab. XI, fig. 286. As to the claim of this appellation see besides O. M. Pat., pag. 37—38.

Surirella Jónssoni sp. nov., Tab. nost. IV, fig. 66.

Long: 81 μ, lat: 9 μ, canaliculis 5,5 in 10 μ.

Valva lineari, delicatissime transverse lineata, apicibus cuneatis. Linea apicalis vix conspicua adest.

Desjamýri (E.) H. Js.

This form is possibly related to, though hardly identical with Sur. gracilis Grun., V. H. Syn., Tab. LXXIII, fig. 16, which shows a similar transversal striation of very fine rows of puncta.

Surirella linearis W. Sm. V. H. Trt., 369. A. S. Atl., Tab. XXIII, fig. 27.

21 samples (S. 3, S.W. 5, N. 7, E. 6).
Area: Eur., Af., As., Am., Spb.

Var. *constricta* Grun. De Toni Syll., 568. A. S. Atl., Tab. XXIII, fig. 28.

8 samples (S. 1, S.W. 2, N. 2, E. 3).
Area: Eur., Am.

Surirella Mölleriana Grun. Øst. Fær. Freshw. 285, fig. 49. A. S. Atl., Tab. LVI, figs. 21—22.

11 samples (S. 1, S.W. 5, N. 2, E. 3).
Area: Eur., As., Am.

Surirella ovalis Bréb. var. *angusta* Ktz. V. H. Trt. 373, Tab. XIII, fig. 590.

21 samples (S. 3, S.W. 5, N. 3, E. 10).
Area: Eur., Af., As., Am., Grl., Spb., Fz. J.

Var. *minuta* Bréb. V. H. Trt. l. c., Tab. c., fig. 588.

23 samples (S. 1, S.W. 5, N. 3, E. 14). Hot springs: 2.
Area: Eur., Af., As., Am., Grl., B. E.

*Var. *ovata* Ktz. V. H. Trt. l. c., Tab. c., fig. 587.

97 samples (S. 34, S.W. 28, N.W. 2, N. 16, E. 17). Hot springs: 5.
Area: Eur., Af., As., Am., Grl., B. E., Spb., Fz. J.

I have found nearly circular forms of this variant in two samples from Borg (S.W.) B. P., Slutnes (N.) B. P.

Var. *pinnata* W. Sm. V. H. Trt. l. c., Tab. c., fig. 591.

36 samples (S. 9, S.W. 9, N.W. 1, N. 3, E. 14).
Area: Eur., Spb.

Var. *panduriformis* W. Sm. W. Sm. Syn. I, 33. V. H. Syn., Tab. LXXIII, fig. 11.

11 samples (S. 4, S.W. 2, E. 5).
Area: Eur.

Surirella robusta Ehr. V. H. Trt. 371, Tab. XII, fig. 577. A. S. Atl., Tab. XXIII, fig. 3 (Sur. rob. valida).

Laugarvatn (S., two samples) B. P.
Area: Eur.

Var. *splendida* Ktz. V. H. Trt. l. c., Tab. c., fig. 578.

Apavatn (S.) B. P.
Area: Eur., Af., Am.

Surirella turgida W. Sm. V. H. Trt. 372, Tab. XXXI, fig. 867.

Thingvallavatn (S.W.) C. H. O.
Area: Eur.

Stenopterobia Bréb. in litteris. Hust. Sur., 114.

Stenopterobia intermedia Lewis. Hust. Sud., 115. Lew. interm. F., Tab. 1, fig. 2 (Surirella interm.).

Reykjavík (S.W.) H. Js.
Area: Eur., Af., Am., Grl.

Campylodiscus Ehr. 1841. V. H. Trt., 375.

***Campylodiscus hibernicus** Ehr. var. *noricus* Ehr. V. H. Trt. 379, Tab. XIV, fig. 594.

6 samples (S. 1, S.W. 2, N. 2, E. 1).
Area: Eur., B. E.

On tab. nost. IV, fig. 67, I have given a delineation of a fragment of a Campylodiscus, which I have not been able to refer to any species known by me. It was found in a "small waterhole near Geitaberg".

Cymatopleura W. Sm. 1851. V. H. Trt., 366.

***Cymatopleura elliptica** (Bréb.) W. Sm. V. H. Trt. 367, Tab. XII, fig. 480 b.

10 samples (S. 1, S.W. 4, N. 2, E. 3).
Area: Eur., Af., As., Am.

***Cymatopleura Solea** (Bréb.) W. Sm. V. H. Trt. 367, Tab. XII, fig. 482 b.

52 samples (S. 20, S.W. 11, N. 4, E. 17). Hot springs: 2.
Area: Eur., Af., As., Am., B. E.

Tropidoraphideæ

Hantzschia Grun. 1877. V. H. Trt., 380.

***Hantzschia amphioxys** (Ehr.) Grun. V. H. Trt. 381, Tab. XV, fig. 483 b.

176 samples (S. 31, S.W. 37, N.W. 2, N. 31, E. 73, s. l. 2). Hot springs: 9.

Area: Eur., Af., As., Am., Grl., J. M., B. E., Spb., Fz. J.

Var. *constricta* Pant. Pant. Bal. S. 83, Tab. IX, fig. 141.

Vallanes (E.) H. Js.

Area: Eur.

*Var. *elongata* Grun. V. H. Trt. 381, Tab. XV, fig. 487 b.

22 samples (S. 2, S.W. 4, N. 2, E. 14). Hot spring: 1.

Area: Eur., Af., Am., Aust.

Hantzschia dubravicensis Grun. Grun. Øst. Ung. 140, Tab. XXIX, fig. 23. Tab. nost. V, fig. 68.

Long: 94 μ, lat: 7 μ, punct. carinal. 5 in 10 μ, str. 16 in 10 μ, subtiliter punctatis.

Margine carinali in medio leniter incurvata, margine altera fere recta.

Lagarfljót (E.) B. P.

Area: Eur.

Grunow l. c. places this species as a Hantzschia, but with a query. This is however undoubtedly correct. When I give a figure of it, it is because the form found by me is substantially larger and on the whole somewhat more elegantly built than Grunow's H. dubrav., but I have no doubt whatever that they are identical.

Hantzschia truncata sp. nov., Tab. nost. V, fig. 69.

Long: 43 μ, lat: 10 μ, punct. carinal. 5,5 in 10 μ, str. 14 in 10 μ, punctatis.

Valva hantzschioidea, apicibus curte truncatis. Punctis carinalibus partim confluentibus.

Hrafnagil (N.) H. Js., in a hot spring.

Hantzschia virgata (Roper) Grun. var. *leptocephala* Øst. Øst. D. D. 144, Tab. IV, fig. 96.

Skeiðarársandur (S.) St.

Area: Eur.

Hantzschia forma abnormis, Tab. nost. V, fig. 70.

Long: 104 μ, lat: 12,8 μ, str. 20 in 10 μ, subtilissime punctatis.

Valva hantzschioidea, apicibus capitatis. Adest area hyalina apicalis angusta, utrisque in lateribus serie punctorum, irregulariter distributorum, inclusa.

Lagarfljót (E.) B. P.

I consider this form abnormal, and have therefore not classified it as an independent species.

Nitzschia (Hassall 1845, W. Smith) Grun. ch. em. 1880. V. H. Trt. 382.

Tryblionella (W. Sm. ex p.) Grun. V. H. Trt. 384.

Nitzschia angustata (W. Sm.) Grun. V. H. Trt. 385, Tab. XV, fig. 498.

11 samples (S. 2, S.W. 4, N. 3, E. 2). Hot spring: 1.

Area: Eur., As., Am.

In a sample from Geysir, Blesö (S.W.) Stp., I have found a Nitzschia angustata, a delineation of which I have given on Tab. nost. V, fig. 71. Its dimensions are: long: 72 μ, lat: 54 μ, str. 14 in 10 μ punctatis. It has more attenuated apices than the typical N. ang.

Nitzschia debilis (Arnott) Grun. V. H. Trt. 385, Tab. XV, fig. 498.

Reykir (S.) Stp.

Area: Eur., Grl., J. M., Spb., Fz. J.

Apiculatæ Grun. 1880. V. H. Trt. 387.

Nitzschia apiculata (Greg.) Grun. V. H. Trt. 387, Tab. XV, fig. 505.

18 samples (S. 2, S.W. 3, E. 12, s. l. 1).

Area: Eur., As., Am., Grl., B. E.

Dubiæ Grun. 1880. V. H. Trt. 388.

Nitzschia commutata Grun. V. H. Trt. 389, Tab. XV, fig. 512.

4 samples (S. 1, S.W. 1, N. 2). Hot spring: 1.

Area: Eur., Af., As.

Nitzschia Jonssoni sp. nov., Tab. nost. V, fig. 72.

Long: 48 μ, lat: 7 μ, punct. carin. 6,5 in 10 μ, str. subtilissimis.

Valva hantzschioidea, apicibus moderate productis. Punctis carinalibus prolongatis, medianis duobus spatiatis.

Seyðisfjord (E.) H. Js.

Nitzschia Nathorsti Brun. Brun J. M. et E. Gr. 9, Tab. II, fig. 5.

7 samples (S. 5, N. 2). Hot spring: 1.

Area: Grl., J. M., Fz. J.

Nitzschia serians Rabh. Cl. & Gr. A. D. 78. V. H. Syn., Tab. LIX, fig. 23.

Thingvellir (S.W.) E. W. & Ho.

Area: Eur., As.

Nitzschia stagnorum Rabh. Cl. & Gr. A. D. 78. V. H. Syn., Tab. LIX, fig. 24.

Berufjörðr (E.) H. Js.

Area: Eur., Af., As.

***Nitzschia thermalis** (Ktz.) Grun. V. H. Trt. 389, Tab. XV, fig. 509.
16 samples (S. 8, S.W. 4, E. 4). Hot springs: 3.
Area: Eur., Af., As.

Var. *minor* Hilse. Cl. & Gr. A. D. 78. V. H. Syn., Tab. LIX, fig. 22.
7 samples (S. 1, S.W. 3, N. 1, E. 1, s. l. 1). Hot spring: 1.
Area: Eur., Grl., Fz. J.

Grunowia Rabh. 1864. V. H. Trt. 390.

***Nitzschia Denticula** Grun. V. H. Trt. 390, Tab. XV, fig. 514.
28 samples (S. 1, S.W. 3, N.W. 1, N. 8, E. 14, s. l. 1). Hot springs: 4.
Area: Eur., Af, As., Am., Grl., Spb.

***Nitzschia sinuata** (W. Sm.) Grun. V. H. Trt. 390, Tab. XV, fig. 516.
26 samples (S. 2, S.W. 5, N.W. 1, N. 4, E. 13, s. l. 1). Hot springs: 4.
Area: Eur., As., Am., Spb.

Dissipatæ Grun. 1880. V. H. Trt. 394.

Nitzschia dissipata (Ktz.) Grun. V. H. Trt. 394, Tab. XVI, fig. 525.
Keldur (S.) A. F., Höfðabrekka (S.) H. Js., Thingvallavatn (S.W.) C. H. O.
Area: Eur., Af., As., Am., B. E., Spb.

Sigmoideæ Grun. 1880. V. H. Trt. 395.

***Nitzschia sigmoidea** (Ehr.) W. Sm. V. H. Trt. 395, Tab. XVI, fig. 528.
13 samples (S. 2, S.W. 3, N. 5, E. 3). Hot spring: 1.
Area: Eur., Af., As., Am.

Sigmata Grun. 1880. V. H. Trt. 396.

***Nitzschia Sigma** W. Sm. V. H. Trt. 396, Tab. XVI, fig. 531.
Reykjavík (S.W. in two samples) H. Js.
Area: Ubiquist, Grl.

Var. *Clausi* Hantzsch. Grun. Casp. S. 119. V. H. Syn., Tab. LXVI, fig. 10.
14 samples (S. 10, S.W. 3, N. 1). Hot springs.
Eur., Grl., Fz. J.

Lineares Grun. 1880. V. H. Trt. 398.

Nitzschia Kittli Grun. Grun. Oest. Ung. 155, Tab. XXIX, figs. 24—25.
6 samples (S. 3, S.W. 1, N. 1, E. 1).
Area: Eur.

***Nitzschia linearis** (Ag.) W. Sm. V. H. Trt. 399, Tab. XVI, fig. 542.
15 samples (S. 9, S.W. 1, N.W. 1, N. 1, E. 3). Hot springs: 2.
Area: Eur., Af., As., Am., Grl.

Nitzschia vitrea Norman var. *recta* Hentzsch. V. H. Trt. 400, Tab. XVI, fig. 547.

Ulfjólsvatn (S.) A. F.
Area: Eur., As., Am., Grl.

Var. *Salinarum* Grun. V. H. Trt. 399, Tab. XVI, fig. 546.

Arnafellskvisl (S.) St., Vestmannaeyjar (S.) St.
Area: Eur.

In Denmark I have found the identical form in fresh-water (cnfr. Øst. D. D. 161).

Nitzschia Oestrupi Pant. Pant. Lac. Peis. 36, Tab. III, fig. 145.

Arnafellskvisl (S.) St., Skaptafellssysla (S.) St.

Pantocsek (l. c.) refers this species to a new section "Constrictæ". I think it might very well be placed under "Lineares", closest to N. Kittli.

Lanceolatæ Grun. 1880. V. H. Trt. 400.

Nitzschia amphibia Grun. V. H. Trt. 403, Tab. XVII, fig. 563.

55 samples (S. 14, S.W. 17, N. 11, E. 12, s. l. 1). Hot springs: 17.
Area: Eur., Af., Am.

Var. *acutiuscula* Grun. Cl. & Gr. A. D. 98. V. H. Syn., Tab. LXVIII, figs. 19—22.

Laugarvatn (S.) A. F.
Area: Eur., Am., Aust.

Var. *Frauenfeldi* Grun. Cl. & Gr. A. D. 98. V. H. Syn., Tab. c., fig. 18.

12 samples (S. 4, S.W. 4, N. 2, E. 2). Hot spring: 1.
Area: Eur., Am., Aust.

Nitzschia Frustulum (Ktz.) Grun. V. H. Trt., 403, Tab. XVII, fig. 564.

6 samples (S. 3, N. 1, E. 2). Hot spring: 1.
Area: Eur., Af., Am., Grl., J. M., Spb., Fz. J.

Nitzschia glaberrima sp. nov., Tab. nost. V, fig. 73.

Long: 64 μ, lat: 3 μ.

Valva lineari, apicibus subcapitatis. Structuram ullam valvæ perspicere non potui. Una in margine valvæ autem puncta minutissima et innumerabilia adsunt.

Reykjavík (S.W.) H. Js.

I consider this form must be placed under "Lanceolatæ" possibly nearest to Nitz. gracilis.

Nitzschia Hantzschiana Rbh. var. *glacialis* Grun. Cl. & Grun. A. D. 99. V. H. Syn., Tab. LXIX, fig. (N. Frust. glac.).

7 samples (S.W. 5, E. 2).
Area: Eur., Grl., Spb., Fz. J.

Nitzschia Heufleriana Grun. Cl. & Grun. A. D. 96. V. H. Syn., Tab. LXVIII, figs. 13—14.

Eyjólfsstaðir, Breiðalsá, Hólmanes (all E.) H. Js.
Area: Eur., B. E., Fz. J.

Nitzschia intermedia Hantzsch. Cl. & Gr. A. D. 95. V. H. Syn., Tab. LXIX, fig. 10.

9 samples (S. 4, S.W. 3, E. 2).
Area: Eur., Am.

***Nitzschia Kützingiana** Hilse. Cl. & Gr. A. D. 96. V. H. Syn., Tab. LXIX, figs. 24—26.

Hornarfjörðr (E.) St.
Area: Eur., Am., B. E.

Nitzschia mucronata sp. nov., Tab. nost. V, fig. 74.

Long: 18 μ, lat: 2 μ.

Valva anguste-lanceolata, apicibus acutis. Punctis carinalibus minutissimis innumerabilibusque. Structuram ullam valvæ perspicere non potui.

Minni Laxá (S.) A. F.

Nitzschia Palea (Ktz.) W. Sm. V. H. Trt. 401, Tab. XVII, fig. 514.

83 samples (S. 26, S.W. 23, N.W. 2, N. 14, E. 16, s.l. 2). Hot springs: 2.
Area: Eur., Af., As., Am., Fz. J.

Var. *fonticola* Grun. V. H. Trt. 402, Tab. c., fig. 557.

6 samples (S. 3, S.W. 2, N. 1). Hot spring: 1.
Area: Eur., As.

Var. *minuta* Bleisch. Cl. & Gr. A. D. 96. V. H. Syn., Tab. LXIX, fig. 23.

Laugarvatn (S.) A. F., Grimstaðir (E.) B. P.
Area: Eur., Grl., J. M., Fz. J.

Var. *tenuirostris* Grun. V. H. Trt. 402, Tab. XVII, fig. 556.

20 samples (S. 8, S.W. 2, N. 2, E. 7, s. l. 1). Hot spring: 1.

Nitzschia subtilis Grun. V. H. Trt. 401, Tab. XVII, fig. 552.

Reykjavík (S.W.) H. Js., Thingvellir (S.W.) E. W. & Ho.
Area: Eur., Af., Am., Grl.

Rhopalodia O. Müller. O. M. Afr. XI, 57.

***Rhopalodia gibba** (Ktz.) O. M. O. M. Rhop. 65. V. H. Trt., Tab. IX, figs. 352 a. b. (Epithemia g.).

216 samples (S. 48, S.W. 48, N.W. 3, N. 40, E. 73, s. l. 4). Hot springs: 11.
Area: Eur., Af., As., Am., Grl.

Rhopalodia gibberula (Ehr.) O. M. var. *Van Heurcki* forma *a* O. M. El. Kab. 292. V. H. Trt., Tab. IX, fig. 361 (Epith. gib. producta).
69 samples (S. 13, S.W. 22, N.W. 3, N. 15, E. 16). Hot springs: 13.
Area: Eur., Af., As., Am.

*Var. *rupestris* (W. Sm.) O. M. O. M. El. Kab. 292. W. Sm. Syn., Tab. I, fig. 12 (Epith. rup.).
50 samples (S. 7, S.W. 17, N.W. 2, N. 9, E. 15). Hot springs.
Area: Eur., Af., Am.

Rhopalodia gracilis O. M. O. M. Rhop. 63, Tab. II, fig. 6.
6 samples (S,W. 1, N. 3, E. 2).
Area: Af.

Rhopalodia parallela O. M. O. M. Rhop. 64. V. H. Trt., Tab. IX, fig. 353 (Epith. gib. parall.).
43 samples (S. 4, S.W. 12, N.W. 1, N. 7, E. 19). Hot springs: 5.
Area: Eur., Af., As., Am.

Rhopalodia uncinata O. M. O. M. Rhop. 63, Tab. II, figs. 3 4.
Thingvallavatn (S.W.) C. H. O.
Area: Af.

Rhopalodia ventricosa O. M. O. M. Rhop. 64. V. H. Trt., Tab. IX, fig. 354 (Epith. vent.).
196 samples (S. 61, S.W. 38, N.W. 1, N. 32, E. 63, s. l. 1). Hot springs.
Area: Eur., Af., As., Am., Grl.

Gonyraphideæ

Epithemia Bréb. 1838. V. H. Trt. 394.

***Epithemia Argus** Ktz. V. H. Trt. 296, Tab. IX, fig. 355.
32 samples (S. 7, S.W. 12, N. 3, E. 8, s. l. 2). Hot springs: 4.
Area: Eur., Af., As., Am.

Epithemia Hyndmanni W. Sm. V. H. Trt. 295, Tab. IX, fig. 350.
8 samples (S. 2, N. 3, E. 3).
Area: Eur.

Epithemia Sorex Ktz. V. H. Trt. 295, Tab. IX, fig. 355.
40 samples (S. 15, S.W. 6, N. 10, E. 9).
Area: Eur., Af., As., Grl.

Var. *amphicephala* Øst. Øst. Østg. Ferskv. 271, Tab. 1, fig. 9.
13 samples (S. 2, N. 2, E. 8, s. l. 1). Hot spring: 1.
Area: Grl.

***Epithemia turgida** (Ehr.) Ktz. V. H. Trt. 294, Tab. IX, fig. 346 & 348 (E. t. granulata).

139 samples (S. 35, S.W. 33, N.W. 2, N. 32, E. 33, s. l. 4). Hot springs: 3.

Area: Eur., Af., As., Am., Grl.

Under Ep. turgida I include var. granulata, which can scarcely be kept apart from the typical species.

Var. *capitata* Fricke. A. S. Atl., Tab. CCL, fig. 7.

Hallormstaðir (E.) B. P.

Area: Eur.

Differs only from the type by having capitate apices.

Forma anomala cnfr. Øst. D. D. 169, Tab V, fig. 110.

Varmá (S.) B. P., Skutustaðir (N.) B. P., Lagarfljót (E.) B. P.

This peculiar form which I, l. c., referring to Heiberg's Ep. globifera (cnfr. Heib. consp. 103, Tab. VI, fig. 22) placed as an abnormity of E. turgida, might be the sporangial form of this species. It has been found in 3 samples all containing plenty of E. turgida.

***Epithemia Zebra** (Ehr.) Ktz. V. H. Trt. 296, Tab. IX, fig. 357.

264 samples (S. 62, S.W. 63, N.W. 6, N. 41, E. 88, s. l. 4), Hot springs: 15.

Area: Eur., Af., As., Am.

Var. *longicornis* M. Per. & Hérib. Hérib. Auv. 128, Tab. III, fig. 14.

Laxá (S.) A. F., Vallanes (E.) H. Js., Hallormstaðir (E.) B. P.

Area: Eur.

Var. *longissima* M. Per. & Hérib. Hérib. l. c. 128, Tab. c., fig. 13.

8 samples (S.W. 5, E. 3). Hot spring: 1.

Area: Eur.

Var. *proboscidea* Grun. V. H. Trt. 297, Tab. IX, fig. 358.

23 samples (S. 7, S.W. 2, N. 3, E. 11). Hot springs: 4.

Area: Eur.

Brachyraphideæ

Eunotia (Ehr.) 1837. Char. emend. H. Van Heurch. V. H. Trt. 298.

***Eunotia Arcus** Ehr. V. H. Trt. 299, Tab. IX, fig. 362.

13 samples (S. 1, S.W. 4, N. 4, E. 4).

Area: Eur., Af., As., Am., Grl., Spb.

Var. *bidens* Grun. V. H. Trt. l. c., Tab. c., fig. 365.

4 samples (S. 1, S.W. 2, E. 1).

Area: Eur., Grl.

Var. *minor* Grun. V. H. Trt. l. c., Tab. c., fig. 363.

5 samples (S.W. 2, E. 3).

Area: Eur., Grl.

Var. *tenella* Grun. Schönf. Germ. 116. V. H. Syn., Tab. XXXIV, figs. 5—6.

Thingvellir (S.W.) E. W. & Ho., Reykjavík (S.W.) H. Js.

Var. *uncinata* Grun. V. H. Trt. 299, Tab. IX, fig. 364.
Alftatjörn (E.) B. P.
Area: Eur.

Eunotia bidentula W. Sm. V. H. Trt. 302, Tab. XXX, fig. 828.
Mosfellsheiði (S.W.) C. H. O., Seyðisfjord (E.) B. P.
Area: Eur.

Eunotia diodon Ehr. V. H. Trt. 303, Tab. XXX, figs. 829—830.
8 samples (S.W. 3, N.W. 1, N. 1, E. 3).
Area: Eur., Af., As., Am., Grl., Spb.

Var. *diminuta* Grun. A. Cl. Lul. Lappm. 28. V. H. Syn., Tab. XXXIII, fig. 7.
West Iceland St., Seyðisfjord (E.) B. P.

Eunotia elegans Øst. Øst. D. D. 172, Tab. V, fig. 105.
Staðastaður (S.W.) H. Js.
Area: Eur.

Eunotia exigua Bréb. V. H. Trt. 300, Tab. IX, fig. 369.
West Iceland St.
Area: Eur., Am.

Eunotia Faba (Ehr.) Grun. var. *densestriata* Øst. Øst. D. D. 173, Tab. V, fig. 107.
Reykjavík (S. W.) C. H. O., Grimstaðir (N.) B. P., Vallanes (E.) H. Js. Hot spring: 1.
Area: Eur., Grl.

Eunotia flexuosa Ktz. V. H. Trt. 304, Tab. IX, fig. 387.
Ulfsbær (N.) B. P.
Area: Eur.

***Eunotia gracilis** (Ehr.) Rbh. V. H. Trt. 300, Tab. IX, fig. 368.
48 samples (S.W. 25, N. 7, E. 16). Hot spring: 1.
Area: Eur., Afr., Am., Grl., J. M., B. E., Spb., Fz. J.

Eunotia impressa Ehr. var. *angusta* Grun. A. Cl. Lul. Lappm. 31. V. H. Syn., Tab. XXXV, fig. 1.
30 samples (S.W. 14, N.W. 3, N. 3, E. 10). Hot springs: 2.
Area: Eur.

Eunotia islandica sp. nov. Tab. nost. V, fig. 75.
Long: 68 μ, lat: 10 μ, str. 16 in 10 μ, subtiliter punctatis.
Valva arcuata, margine dorsali bigibba. Apicibus recurvatis.
Seyðisfjord (E.) B. P.

Not having been able to refer this form to any known species of Eunotia, I have thought it proper describing it as a new species.

Eunotia lunaris (Ehr.)Grun. V. H. Trt. 303, Tab. IX, fig. 384.
94 samples (S. 4, S.W. 36, N.W. 3, N. 9, E. 41, s. l. 1). Hot springs: 2.
Area: Eur, As., Am.

Var.? *alpina* Grun. De Ton. Syll. 808 (Pseudeun. alp.). V. H. Syn., Tab. XXXV, fig. 5.
4 samples, all S.W.

Var. *bilunaris* (Ehr.) Grun. V. H. Trt. 304, Tab. IX, fig. 386.
Hallormstaðr (E.) B. P.
Area: Eur.

Var. *subarcuata* (Naeg.) Grun. V. H. Trt. l. c., Tab. c., fig. 385.
Minni Laxá (S.) A. F., West Iceland St.

Eunotia major (W. Sm.) Rabh. V. H. Trt. 300, Tab. IX, fig. 366.
4 samples (S.W. 3, E. 1). Hot spring: 1.
Area: Eur., Grl.

Var. *bidens* (Greg.) W. Sm. V. H. Trt. l. c., Tab. c., fig. 367.
Vallanes (E.) H. Js.
Area: Eur.

Eunotia Monodon Ehr. A. Cl. Lul. Lappm. 28. V. H. Syn., Tab. XXXIII, fig. 3.
Eiðar (E.) H. J.
Area: Eur., Grl.

Eunotia Nymanniana Grun. A. Cl. Lul. Lappm. 33. V. H. Syn., Tab. XXXIV, fig. 8.
4 samples (S.W. 2, E. 2).
Area: Eur., Am., Grl.

Eunotia paludosa Grun. De Ton. Syll. 798. V. H. Syn., Tab. XXXIV, fig. 9.
Husavík (N.) B. P., Skutustaðir (E.) B. P.
Area: Eur.

***Eunotia parallela** Ehr. A. Cl. Lul. Lappm. 28. V. H. Syn., Tab. XXXIV, fig. 16.
Ketilstaðir (SW.) H. Js., Omundarfjord (N.W.) B. P., Hof (N.) O. D.
Area: Eur., As., Am., Grl., Spb., Fz. J.

***Eunotia pectinalis** (Ktz.) Rbh. V. H. Trt. 300, Tab. IX, figs. 370—371.
9 samples (S.W. 5, N.W. 1, E. 3).
Area: Eur., Af., As., Am., Grl.

*Var. *minor* (Ktz.) Rbh. A. Cl. Lul. Lappm. 31. V. H. Syn., Tab. XXXIII, figs. 20—21.
42 samples (S. 20, N.W. 2, N. 8, E. 12). Hot spring: 1.
Area: Eur., Af., As., Am., Grl., Fz. J.

Var. *stricta* Rbh. A. C. l. c. 31. V. H. Syn., Tab. c., fig. 18.
6 samples (S. 1, S.W. 1, E. 4).
Area: Eur.

Eunotia polyglyphis Grun. A. C. Lul. Lappm. 30. V. H. Syn., Tab. XXXIV, fig. 33.
4 samples (S. 1, S.W. 1, N.W. 1, E. 1). Hot spring.
Area: Eur.

Eunotia prærupta Ehr. V. H. Trt. 302., Tab. IX, fig. 376.
41 samples (S. 3, S.W. 10, N.W. 2, N. 17, E. 9). Hot springs: 3.
Area: Eur., Grl.

Var. *bidens* V. H. Trt. 302, Tab. IX, fig. 379.
16 samples (S. 6, S.W. 2, N. 1, E. 7).
Area: Eur., Grl., J. M., Fz. J.

Var. *bigibba* Ktz. V. H. Trt. l. c., Tab. c., fig. 380. V. H. Syn., Tab. XXXIV, fig. 27 (E. big. pumila).
6 samples (S. 1, S.W. 1, N. 2, E. 2).
Area: Eur., Grl., Fz. J.

Var. *curta* Grun. V. H. Trt. l. c., Tab. c., fig. 377.
82 samples (S. 7, S.W. 41, N.W. 1, N. 7, E. 26). Hot springs: 5.
Area: Eur., Am., Grl., Fz. J.

Var. *laticeps* Grun. A. Cl. Lul. Lappm. 34. V. H. Syn., Tab. XXXIV, fig. 25 (E. pr. lat. curta).
Reykjanes (N.) K. Rsv., Eiðar (E.) H. Js.
Area: Eur., Grl., J. M., Fz. J.

Eunotia robusta Ralfs var. *Diadema* Ralfs V. H. Trt. 303, Tab. IX, fig. 381, 1st fig.
17 samples (S.W. 5, N. 2, E. 10). Hot spring: 1.
Area: Eur., Am., Grl., Spb.

Eunotia tridentula Ehr. var. *perminuta* Grun. A. Cl. Lul. Lappm. 28. V. H. Syn., Tab. XXXIV, fig. 30.
Rauðimalur (S.W.) A. F., West Iceland St., Eyjólfsstaðir (E.) H. Js.
Area: Eur., Grl.

Eunotia Triodon Ehr. V. H. Trt. 303, Tab. IX, fig. 383.
9 samples (S. 1, SW. 5, N. 1, E. 2). Hot spring: 1.
Area: Eur., Am., Grl., Spb.

***Eunotia Veneris** Ktz. V. H. Trt. 301, Tab. XXX, fig. 826.
Vík (S.) H. Js.
Area: Eur.

Var. *obtusiuscula* Grun. V. H. Trt. l. c., Tab. c,, fig. 387.
Ketilsstaðir (S.W.), H. Js.
Area: Eur.

Arraphideæ

Ceratoneis Ehr. 1840. V. H. Trt. 305.

***Ceratoneis Arcus** Ktz. V. H. Trt. 306, Tab. X, fig. 401.
126 samples (S. 37, S.W. 28, N.W. 5, N. 15, E. 40, s. l. 1). Hot springs: 8.
Area: Eur., Am., Grl., J. M., B. E., Spb., Fz. J.

Synedra Ehr. 1831. V. H. Trt. 307.

***Synedra Acus** (Ktz.) Grun. V. H. Trt. 311, Tab. X, fig. 420.
Apavatn (S.) A. F., Staðastaður (S.) A. F., Laugaá (S.W.) A. F.
In a sample from Arnarstapi (S.W.) H. Js. I have found a form analogous to Syn. Acus var. amphicephala H. L. Sm. V. H. Syn., Tab. XXXIX, fig. 8 (S. delicatiss. amphic.).

*Var. *delicatissima* W. Sm. V. H. Trt. 312, Tab. X, fig. 421.
33 samples (S. 3, S.W. 5, N. 12, E. 13).
Area: Eur., As., Am.

Var. *mesoleja* Grun. V. H. Syn., Tab. XXXIX, fig. 6 (Syn. delic. mesol.).
8 samples (S. 5, S.W. 2, N. 1). Hot spring: 1.
Area: Eur.

Synedra amphicephala Ktz. V. H. Trt. 313, Tab. X, fig. 429.
Fróðarheiði (S.W.) H. Js.
Area: Eur., Am.

Var. *austriaca* Grun. De Ton. Syll. 660. V. H. Syn. XXXIX, figs. 16 a & b.
Eystri Rangá (S.), Fróðarheiði (S.W.) H. Js., Kolbeinsá (N.W.) H. Js.
Area: Eur.

Synedra capitata Ehr. V. H. Trt. 313, Tab. X, fig. 427.
17 samples (S. 2, S.W. 3, N. 4, E. 8). Hot spring: 1.
Area: Eur., As.

Synedra famelica Ktz. var. *minuscula* Grun. De Ton. Syll. 660. V. H. Syn., Tab. XXXIX, fig. 13.
5 samples (S. 2, S.W. 2, E. 1).
Area: Eur.

Synedra familiaris Ktz. forma major. De Ton. Syll. 667. V. H. Syn., Tab. XL, fig. 16.
Ketilstaðir (S.W.) H. Js., Skutustaðir (N.) B. P.
Area: Eur.

Synedra pulchella Ktz. V. H. Trt. 309, Tab. X, fig. 402.
22 samples (S. 1, S.W. 15, N. 4, E. 2). Hot spring: 1.
Area: Eur., Af., As., Am., Grl.

Var. *naviculacea* Grun. De Ton. Syll. 652. V. H. Syn., Tab. XLI, fig. 8.

Grimsey (N.) O. D.
Area: Eur.

Synedra radians (Ktz.) Grun. V. H. Trt. 312, Tab. X, fig. 423.

7 samples (S. 3, S.W. 4, E. 1).
Area: Eur., As., Grl.

Synedra rostrata Pant. Pant. Bal. S. 76, Tab. VIII, fig. 4.

12 samples (S. 2, S.W. 4, N. 7). Hot spring: 1.
Area: Eur.

Hustedt claims in Sud. p. 46, that Syn. rostrata is to be considered a sporangial form "aus dem Gebiet der Synedra Ulna".

Synedra rumpens Ktz. var.? *fragilaroides* Grun. cnfr. De Ton. 680. V. Syn., Tab. XL, fig. 12.

38 samples (S. 14, S.W. 14, N.W. 1, N. 4, E. 4, s. l. 1). Hot springs: 3.
Area: Eur., Am.

Var. *islandica* var. nov., Tab. nost. V, fig. 76.

Long: 36 μ, lat: 3,2 μ, str. 20 in 10 μ.

Valva lineari, apices versus leniter attenuata. Striis media in parte valvæ aream nudam relinquentibus.

Hallormstaðr (E.) B. P.

I have placed this small Synedra as a variant of S. rumpens, possibly to be placed nearest to S. rump. genuina (V. H. Syn., Tab. XL, fig. 14), owing to its close striation; for the same reason perhaps related to S. (Vaucheriæ var.?) capitellata Grun. (V. H. Syn., Tab. XL, fig. 26).

***Synedra Ulna** (Nitzsch) Ehr. V. H. Trt. 310, Tab. X, fig. 409.

207 samples (S. 50, S.W. 50, N.W. 6, N. 32, E. 69). Hot springs: 11
Area: Eur., Af., As., Am., Grl.

Var. *amphirhynchus* Ehr. V. H. Trt. 311, Tab. X, fig. 414.

Minni Laxá (S.) A. F.
Area: Eur.

Var. *Danica* Ktz. V. H. Trt. l. c., Tab. c., fig. 415.

148 samples (S. 33, S.W. 30, N. 18, E. 67). Hot springs: 7.
Area: Eur., Af., Grl., B. E.

In 60 samples (S. 12, S.W. 16, N.W. 1, N. 2, E. 25, s. l. 4) and in 2 hot springs I have noted S. Ulna, which however could not be determined accurately, they being only present as fragments or lying on the connecting zone.

Var. *longissima* W. Sm. V. H. Trt. 310, Tab. c., fig. 412.

Laugaá (S.) A. F., Krókur (S.) H. Js., Hornarfjörðr (E.) St.
Area: Eur., Af.

Forma *arcuata* Tab. nost. V, fig. 77 (× 333).

Long. chordæ arcus 302,4 μ, lat: sagittæ arcus 64,5 μ, str. 11 in 10 μ.

Valva arcuata, in medio leniter inflata.

I think this form can only be considered as a curved form of S. Ulna longissima.

Asterionella Hassall 1850. V. H. Trt. 320.

***Asterionella formosa** Hass. var. *gracillima* (Hantzsch) Grun. V. H. Trt. 321, Tab. XI, fig. 440.

8 samples, all S.W.
Area: Ubiquist, Grl.

Fragilaria Lyngbye 1819. V. H. Trt. 323.

Fragilaria Baculus sp. nov., Tab. nost. V, fig. 78.

Long: 24 μ, lat: 3,2 μ, str. 12,5 in 10 μ.

Valva lineari, apicibus rotundatis. Area apicali angustissima. Striis parallelis.

Egilstaðir (E.) B. P.

***Fragilaria capucina** Desmz. V. H. Trt. 325, Tab. XI, fig. 446.
Skeiðarársandur (S.) St., Krókur (S.) H. Js.
Area: Eur., Af., As., Am., Grl., Spb., Fz. J.

Var. *acuminata* Grun. V. H. Trt. l. c., Tab. c., fig. 449.
Steinsmyri (S.) H. Js.
Area: Eur., As., Am.

Var. *acuta* Grun. V. H. Trt. l. c., Tab. c., fig. 448.
9 samples (S. 7, S.W. 2).

Var. *lanceolata* Grun. Hust. Sud. 38. V. H. Syn, Tab. XLV, fig. 5.
Thjórsá (S.) A. F.
Area: Eur., Am.

*Var. *mesolepta* Rbh. V. H. Trt. 325, Tab. XI, fig. 447.
Skeiðarársandur (S.) St.
Area: Eur.

***Fragilaria construens** (Ehr.) Grun. V. H. Trt. 325, Tab. XI, fig. 450.
52 samples (S. 16, S.W. 19, N. 7, E. 10). Hot spring: 1.
Area: Eur., Af., As., Am., Grl., B. E.

Var. *binodis*. V. H. Trt. 326, Tab. c., fig. 452.
14 samples (S. 6, S.W. 5, N.W. 1, E. 2).
Area: Eur., Af., Am.

Var. *pumila* Grun. V. H. Syn., Tab. XLV, fig. 21 a.
Kirkjubær (S.) H. Js.
Area: Eur., As.

Var. *semibinodis* Øst. Øst. D. D. 190, Tab. V, fig. 115.
Laxá (S.) A. F.
Area: Eur.

Var. *Venter* Grun. V. H. Trt. 325, Tab. XI, fig. 451.
53 samples (S. 11, S.W. 14, N. 11, E. 17).
Area: Eur., Af., Am., Grl.

***Fragilaria crotonensis** (A. M. Edwards) Kitton. V. H. Trt. 324, Tab. XI, fig. 444.
10 samples (S.W. 1, N. 1, E. 8).
Area: Eur.

Fragilaria intermedia Grun. V. H. Trt. 326 (F. tenuicollis Heib. interm.). V. H. Syn., Tab. XLV, figs. 9—11.
85 samples (S. 42, S.W. 25, N. 5, E. 10, s. l. 3). Hot springs: 2.
Area: Eur., As., Grl.

Fragilaria lapponica Grun. A. C. Lul. Lappm. V. H. Syn., Tab. XLV, fig. 35.
Ulfjólsvatn (S.) A. F., Apavatn (S.) A. F.
Area: Eur., Grl.

Fragilaria mutabilis (W. Sm.) Grun. V. H. Trt. 326, Tab. XI, fig. 454.
39 samples (S. 11, S.W. 4, N. 6, E. 17, s. l. 1). Hot spring: 1.
Area: Eur., Af., As., Am., Grl.

Var. *elliptica* Schum. f. minor. Meist. S. 66 (Fr. ellipt). V. H. Syn., Tab. XLV, figs. 16—17.
16 samples (S. 6, S.W. 6, E. 4).
Area: Eur., As., Am.

Var. *inflata* var. nov., Tab. nost. V, fig. 79.
Long: 36 μ, lat: 6,4 μ, str. 8,5 in 10 μ.
Valva lineari, in medio inflata, apicibus rotundatis. Striis parallelis, aream apicalem satis latam relinquentibus.
Hallormstaðr (E.) B. P.

*Var. *intercedens* Grun. V. H. Syn., Tab. XLV, fig. 13.
9 samples (S. 5, S,W. 1, N.W. 1, E. 2). Hot spring: 1.
Area: Eur., As.

Var. *minutissima* Grun. V. H. Syn., Tab. c., fig. 14.
Skeiðarársandur (S.) St., Mývatn (N.) Rd.
Area: Eur., Am.

Fragilaria parasitica W. Sm. W. Sm. Syn. II, 19, Tab. LX, fig. 375.
8 samples (S. 3, S.W. 3, N. 1, E. 1).
Area: Eur., Af., As.

Fragilaria producta Lgst. Lgst. Spb. 15, Tab. I, fig. 1 (F. æqualis prod.).

41 samples (S. 6, S.W. 12, N.W. 2, N. 8, E. 13).
Area: B. E., Spb.

Fragilaria rhombica sp. nov., Tab. nost. V, fig. 80.

Long: 16 μ, lat: 7 μ, str. 10 in 10 μ.

Valva rhomboidea, apices subcapitatos versus valde attenuata. Striis mediam partem valvæ versus obliterantibus ibique areolam centralem relinqventibus.

Grímsey (N.) O. D.

I think this small Fragilaria is probably to be considered as an intermediate form between F. constr. venter and F. Harrisoni.

Fragilaria Smithiana Grun. V. H. Syn., Tab. XLV, fig. 1.

Ulfjólsvatn (S.) A. F.
Area: Eur.

Fragilaria triundulata sp. nov., Tab. nost. V, fig. 81.

Long: 26 μ, lat: 6,7 μ, str. 16,6 in 10 μ.

Valva leniter triundulata, apicibus capitalis. Striis marginalibus, aream apicalem latam relinquentibus.

Apavatn (S.) B. P.

This form has nothing to do with Fr. construens var. triundulata Reichelt (cnfr. Øst. Diat. Afl. 57, Tab. II, fig. 15). Possibly it is more closely related to Frag. trigibba Pant. (Pant. Bal. S. 79, Tab. IX, fig. 224), but it is scarcely identical with it.

Fragilaria undata W. Sm. V. H. Trt. 324. A. S. Atl., Tab. CCXC, figs. 48—61.

5 samples (S.W. 2, N. 1, E. 2).
Area: Eur., Grl.

In tab. nostr., fig. 82, I have given a figure of a particularly elegantly built form of Frag. undata. It was found in a sample from West Iceland, St.

***Fragilaria virescens** Ralfs. V. H. Trt. 323, Tab. XI, fig. 442.

30 samples (S. 5, S.W. 15, N.W. 1, N. 5, E. 3, s. l. 1).
Area: Eur., Af., As., Am., Grl.

Var.? *exigua* Grun. V. H. Syn., Tab. XLIV, figs. 2—3.

6 samples (S. 2, N. 2, E. 1, s. l. 1). Hot spring: 1.
Area: Eur.

Meridion Agardh 1847. V. H. Trt. 347.

***Meridion circulare** Ag. V. H. Trt. 347, Tab. XI, fig. 474.

347 samples (S. 60, S.W. 71, N.W. 15, N. 40, E. 157, s. l. 4). Hot springs: 12.
Area: Eur., Af., As., Am., Grl.

Forma anormalis, cnfr. A. S. Atl., Tab. CCLXVII, figs. 37—40, which figures F. Fricke thinks can be understood thus: fig. 37, "vielleicht Auxospore"; figs. 38—39, "vielleicht teratologische Auxosporen"; fig. 40, "vielleicht die Zelle zweiter oder folgender Generation".

10 samples (S. 1, S. W. 3, E. 6). In these samples varying in different ways.

Diatoma de Candolle 1805. V. H. Trt. 348.

***Diatoma hiemale** (Lyngbye) Heib. V. H. Trt. 350. A. S. Atl., Tab. CCLXVII, figs. 16—33 (Diat. hiem. mesodon).

258 samples (S. 57, S. W. 64, N. W. 11, N. 33, E. 91, s. l. 2). Hot springs: 10.

Area: Eur., As., Am., Grl.

The reason, why I place this form as a Diat. hiemale, and in addition cite figures of D. hiemale, is, that I consider Heiberg (Consp. D. 58) is right when he says "it is perfectly clear that it (ɔ: var. mesodon) is only a short form of Diatoma hiemale", and that "specimens of both forms are by Lyngbye determined as Fragilaria (now Diatoma) hiemale". It is especially the short form met with in Icelandic material.

Diatoma elongatum Ag. V. H. Trt. 349, Tab. XI, fig. 467.

Ulfjólsvatn (S.) A. F., Reykjavík (S.W.) H. Js., Hallormstaðr (E.) B. P.

Area: Eur., Af., As., Am., Grl.

Var. *minus* Grun. A. S. Atl., Tab. CCLXVIII, figs. 60—61.

Krossá (S.) H. Js., Stykkishólmur (S.W) H. Js.

Area: Eur., Am.

Var. *tenue* Ag. V. H. Trait. 349, Tab. XI, fig. 468.

35 samples (S. 10, S.W. 15, N.W. 1, N. 2, E. 6, s. l. 1). Hot spring: 1.

Area: Eur., Am., Spb., Fz. J.

***Diatoma vulgare** Bory. V. H. Trt. 348, Tab. XI, fig. 465.

43 samples (S. 12, S.W. 12, N.W. 2, N. 7, E. 10).

Area: Eur., Af., As., Am., Grl., Fz. J.

Denticula Ktz. 1844. V. H. Trt. 351.

***Denticula elegans** Ktz. V. H. Trt. 351, Tab. XXXI, fig. 860.

10 samples (S. 1, S.W. 3, N. 5, E. 1). Hot spring: 1

Area: Eur., Am.

Denticula islandica sp. nov., Tab. nost. V, fig. 83.

Long: 40 μ, lat: 4 μ, costis 6,25 in 10 μ.

Valva lineari, apicibus subacutis. Costis seriebus punctorum subtilissimorum interpositis.

Vallanes (E.) B. P.

Possibly this form is nearest related to Dent. subtilis Grun. (V. H. Syn., Tab. XLIX, figs. 10—13), although it differs from this, especially in size, or it is perhaps related to Dent. lauta Bail. (V. H. Syn., Tab. XLIX, figs. 1—2), but it is hardly identical with either of these.

Denticula subtilis Grun. V. H. Trt. 352, Tab. XI, fig. 464.
5 samples (S.W. 2, E. 3).
Area: Eur., Af., As., Am.

Denticula tenuis Ktz. V. H. Trt. 352, Tab. XI, fig. 461.
5 samples (S.W. 3, E. 2).
Area: Eur., Af., As., Am.

Diatomella Greville 1855. V. H. Trt. 353.

***Diatomella Balfouriana** Grev. V. H. Trt. 353, fig. 104.
168 samples (S. 20, S.W. 55, N.W. 5, N. 34, E. 54). Hot springs: 7.
Area: Eur., Am., Grl., B. E., Spb., Fz. J.

Tabellaria Ehr. 1839. V. H. Trt. 356.

***Tabellaria fenestrata** (Lyngb.) Ktz. V. H. Trt. 356, Tab. XI, fig. 477.
108 samples (S. 17, S.W. 39, N.W. 2, N. 7, E. 43). Hot springs: 2.
Area: Eur., Af., As., Am., Grl.

***Tabellaria flocculosa** (Roth) Ktz. V. H. Trt. 357, Tab. XI, fig. 478.
192 samples (S. 36, S.W. 60, N.W. 6, N. 28, E. 60, s. l. 2). Hot springs: 10.
Area: Eur., Af., As., Am., Grl., J. M., B. E., Spb., Fz. J.

Tetracyclus (Ralfs) Grun. 1862. V. H. Trt. 357.

Tetracyclus emarginatus W. Sm. W. Sm. Syn. II, 38. Hérib. Auv., Tab. III, fig. 27.
30 samples (S. 4, S.W. 14, N. 5, E. 7).
Area: Eur.

CENTRICÆ

Rhizosolenia (Ehr., Brightw.) H. Perag. emend. 1892.

***Rhizosolenia eriense** H. L. Smith. Ostenf. Thingv. 1123, Tab. II, figs. 1—3.

Thingvallavatn (S.W.) C. H. O.
Area: Eur., Am.
Found by C. H. Ostenfeld, not by myself.

***Rhizosolenia paludosa** O. Zacharias. Ostenf. Thingv. 1124, Tab. II, figs. 4—5.

Thingvallavatn (S.W.) C. H. O.
Area: Eur.
Found by C. H. Ostenfeld, not by myself.

Melosira Ag. 1824. V. H. Trt. 438.

Melosira ambigua O. M. O. M. Nyas. 283, Tab. IV, figs. 9—10.

Minni Laxá (S.) A. F., Seyðisfjarðarheiði (E.) H. Js., Eyjólfstaðir (E.) H. Js.
Area: Eur., Af., As.

***Melosira arenaria** Moore. V. H. Trt. 443, Tab. XIX, fig. 621.

Thingvallavatn (S W.) C. H. O.
Area: Eur., As.
Found by O. H. Ostenfeld (cnfr. Ostf. Thingv. 1115), not by myself.

***Melosira crenulata** Ehr. O. M. Nyas. 263. V. H. Trt., Tab. XIX, fig. 618.

27 samples (S. 9, S.W. 2, N. 5, E. 11).
Area: Eur., Af., As., Am.

***Melosira distans** (Ehr.) Ralfs var. *alpigena* Grun. O. M. Nyas. 271. V. H. Syn. LXXXVI, figs. 28—29.

55 samples (S. 4, SW. 13, N.W. 5, N. 4, E. 29).
Area: Eur.

Var. *nivalis* (W. Sm.) Grun. O. M. Nyas. 272. V. H. Syn., Tab. c., figs. 25—27.

21 samples (S.W. 6, N.W. 2, N. 7, E. 6). Hot spring: 1.
Area: Eur., Grl.

***Melosira granulata** (Ehr.) Ralfs. O. M. Nyas. 267. O. M. Mut., Tab. XVII, figs. 9—10.

7 samples (S. 1, S.W. 4, N. 1, E. 1).
Area: Eur., Af., As., Am., Grl., Fz. J.

***Melosira islandica** O. M. O. M. Pleom. 56, Tab. I, figs. 1—3.

11 samples (S.W. 9, E. 2).

Area: Iceland.

***Melosira italica** Ktz. var. *tenuis* (Ktz.) O. M. O. M. Nyas. 265. V. H. Syn., Tab. LXXXVIII, figs. 9 a, 10, 13, 14 (13—14 M. crenulata ambigua).

123 samples (S. 22, S.W. 22, N.W. 1, N. 22, E. 56). Hot springs: 2.

Area: Eur., Af., Am., Grl.

*Var. *tenuissima* (Grun.) O. M. O. M. Nyas. 265. V. H. Syn., Tab. c., fig. 11 & 16 (16 M. Binderiana).

20 samples (S. 3, S.W. 11, N. 3, E. 3).

Area: Eur., Af.

Melosira lævis (Ehr.) Grun. O. M. Nyas. 265. A. S. Atl., Tab. CLXXXI, fig. 84.

6 samples (S. 1, S.W. 2, E. 3).

Area: Eur., B. E.

***Melosira Roeseana** Rabh. V. H. Trt. 442, Tab. XIX, fig. 614.

11 samples (S. 3, S.W. 1, N. 2, E. 5).

Area: Eur., Fær., Grl., J. M., Spb.

Melosira Stefanssoni sp. nov., Tab. nost. V, fig. 84.

Diam. 9—14 μ.

Disco plano, margine serie manifesta granularum prædita. Interiori parte disci granulis satis magnis, centro-punctatis et irregulariter distributis, repleta.

S. l. (West-Iceland) St.

This Melosira is perhaps related to fig. 41 in A. S. Atl., Tab. CLXXXI, but it lacks the inner ring on the discus. That form of A. S. is from the Pitt River (Oregon) and is according to Grove M. distans var. scalaris Grun., while Cleve takes it to be a variety of Mel. crenulata.

***Melosira Varennarum** M. Pér. & Hérib. Hérib. Diat. d'Auv. 189, Tab. V, figs. 12—14.

6 samples (S.W. 5, E. 1).

Area: Eur.

Melosira varians Ag. V. H. Trt. 441, Tab. XVIII, fig. 611.

113 samples (S. 48, S.W. 22, N.W. 2, N. 23, E. 17, s. l. 1). Hot springs: 4.

Area: Eur., Af., As., Am., Grl.

Cyclotella Ktz. 1833. V. H. Trt. 445.

Cyclotella antiqua W. Sm. V. H. Trt. 446, Tab. XXII, fig. 652.

18 samples (S. 3, S.W. 4, N. 1, E. 10).

Area: Eur., As., Grl., Spb.

Cyclotella comta (Ehr.) Ktz. V. H. Trt. 446, Tab. XXII, fig. 653. Ostenf. Thingv. 1115, Tab. I, figs. 9—10.
Thingvallavatn (S.W.) C. H. O.
Area: Eur., Af., As.
Found by C. H. Ostenfeld, not by myself.

Cyclotella Kützingiana Chauvin. V. H. Trt. 447, Tab. XXII, fig. 657.
18 samples (S. 1, SW. 3, N. 1, E. 13).
Area: Eur., Af, As.

Cyclotella Meneghiniana Ktz. V. H. Trt. 447, Tab. XXII, fig. 656.
6 samples (S.W. 5, E. 1).
Area: Eur., Af., As., Am.

Stephanodiscus (Ehr. 1845) Grun. emend. 1880.

Stephanodiscus Astræa (Ehr.) Grun. Cl. & Gr. A. D. 114. V. H. Syn., Tab. XCV, fig. 5.
Krisuvík (S.) C. H. O.
Area: Eur., Af., As., Grl., Fz. J.

The following are forms of fresh-water Diatoms (including a few forms from brackish water) not found again by me, but by other Diatomologists, without their having definitely localised them.

Ceratoneis Arcus (Ehr.) Kütz. var. *amphioxys* Rabh. Rabh. Süssw. 37, Tab. IX, fig. 4. Found by Belloc.

Cyclotella minutissima. Unknown to me. Perhaps identic with Cyclotella minutula Ktz. = Stephanodiscus Astræa (Ehr.) Grun. var. minutulus (Ktz.) Grun. V. H. Syn. CXCV, figs. 7—8 or with Cyclotella operculata (Ag.) Kütz. var. minutula (Ktz.) Br. Brun Diat. Alp. & Jura 133, Tab. I, fig. 7. F. b. E. Belloc.

Cymbella norvegica Grun. Cl. Syn. I, 169. A. S. Atl., Tab. X, fig. 41. F. b. P. T. Cleve.

This Cymbella is very closely related to C. gracilis Rabh. (cnfr. Cl: l. c.) and is hardly a different species.

Denticula obtusa W. Sm. W. Sm. Syn. II, 19, Tab. XXXIV, fig. 292. F. b. E. Belloc.

This species is without doubt identical with Nitzschia Denticula Grun.

Gomphonema geminatum Lyngb. Cl. Syn. I, 186. V. H. Trt., Tab. XXIX, fig. 10. F. b. E. Belloc.

Mastogloia Brauni Grun. Cl. Syn. II, 158. V. H. Trt., Tab. II, fig. 66. F. b. E. Belloc.

Mastogloia Smithi Thwaites v. *lanceolata* Grun. Cl. Syn. II, 152. Pant. foss. Ung. III, Tab. XXXV, fig. 520. F. b. E. Belloc.

Navicula binodis Ehr. Cl. Syn. I, 129. V. H. Trt., Tab. V, fig. 235. F. b. E. Belloc.

Navicula scutelloides W. Sm. Cl. Syn. II, 40. V. H. Trt., Tab. XXVII, fig. 763. F. b. C. Hansen.

Neidium amphigomphus Ehr. Cl. Syn. I, 69. V. H. Trt., Tab. V, fig. 213 (Nav. Iridis amphig.). F. b. E. Belloc.

Nitzschia acicularis W. Sm. V. H. Trt. 405, Tab. XVII, fig. 571. F. b. E. Belloc.

Nitzschia communis Rabh. V. H. Trt. 402, Tab. XVII, fig. 560. F. b. E. Belloc.

Nitzschia obtusa W. Sm. V. H. Trt. 397, Tab. XVI, fig. 537. F. b. E. Belloc.

Nitzschia parvula W. Sm. W. Sm. Syn. I, 41, Tab. XIII, fig. 106. F. b. E. Belloc.

Nitzschia Sigma W. Sm. v. *Sigmatella* Grun. V. H. Trt. 397, Tab. XVI, fig. 535. F. b. E. Belloc.

TABULAR SURVEY

		Universal distribution										Distribution in the different parts of Iceland					
		Eur.	Af.	As.	Am.	Aust.	Grl.	J.M.	B.E.	Spb.	Fz.J.	S.	S.W.	N.W.	N.	E.	s.l.
	Achnanthes																
1	affinis	×				×							×				
2	Biasolettiana	×			×			×				×	×		×	×	×
3	Calcar	×										×	×		×	×	
4	coarctata	×	×	×	×		×	×	×	×		×	×	×	×	×	×
5	delicatula	×	×	×			×					×	×				
6	exigua	×	×	×	×	×						×	×				
7	exilis	×	×	×									×				
8	lanceolata	×	×	×	×	×						×	×	×	×	×	
9	— capitata				×							×				×	
10	— dubia	×			×							×					
11	— elliptica	×										×				×	
12	— færoensis	×										×	×	×	×	×	×
13	linearis	×		×	×		×				×	×			×	×	
14	minutissima	×	×	×	×		×	×	×	×		×	×		×	×	×
15	Peragalli	×										×					
16	rhyncocephala	×													×	×	
17	tylophora	×										×					
	Amphipleura																
18	pellucida	×		×								×	×			×	
	Amphora																
19	cimbrica	×														×	
20	coffæiformis	×	×	×	×	×	×					×					
21	Normani	×	×	×	×						×		×				
22	ovalis	×	×	×	×	×	×		×	×		×	×	×	×	×	×
23	— Pediculus	×	×	×	×	×			×		×	×	×		×	×	
24	perpusilla	×	×	×								×			×		
25	protracta gallica	×			×							×	×		×	×	
26	veneta	×	×	×	×	×						×	×		×	×	
	Anomoeoneis																
27	brachysira	×	×	×	×	×	×					×				×	
28	exilis	×					×						×			×	
29	sculpta	×	×	×	×	×							×				
30	sphærophora	×	×	×	×	×							×				
31	zellensis	×					×						×				
	Asterionella																
32	formosa gracill.	×	×	×	×	×	×						×				
	Caloneis																
33	alpestris	×				×						×	×			×	
34	amphisbæna	×	×	×	×		×		×			×	×				

		Universal distribution										Distribution in the different parts of Iceland					
		Eur.	Af.	As.	Am.	Aust.	Grl.	J.M.	B.E.	Spb.	Fz.J.	S.	S.W.	N.W.	N.	E.	s.l.
35	bacillaris	×		×	×							×				×	
36	bodonensis	×														×	
37	Clevei	×		×			×	×		×	×				×		
38	fasciata	×	×	×	×	×	×	×		×	×	×	×		×	×	×
39	ladogensis	×										×	×		×	×	
40	obtusa	×														×	
41	Silicula genuina	×	×	×	×	×	×		×			×	×	×	×	×	×
42	— alpina	×					×	×		×	×	×	×		×	×	
43	— biconstricta	×														×	
44	— inflata	×										×	×				
45	— subventricosa			×									×				
46	— ventricosa	×		×			×				×		×				
	Campylodiscus																
47	hibernicus noricus	×							×			×	×		×	×	
	Ceratoneis																
48	Arcus	×			×		×	×	×	×	×	×	×	×	×	×	×
	Cocconeis																
49	flexella	×	×	×	×							×	×		×	×	×
50	— intermedia						×									×	
51	minuta	×					×			×	×	×	×				
52	— alpestris	×						×							×	×	
53	Placentula	×	×	×	×	×						×	×	×	×	×	×
	Cyclotella																
54	antiqua	×		×			×			×		×	×		×	×	
55	comta	×	×	×									×				
56	Kützingiana	×	×	×								×	×		×	×	
57	Meneghiniana	×	×	×	×								×			×	
	Cymatopleura																
58	elliptica	×	×	×	×							×	×		×	×	
59	Solea	×	×	×	×				×			×	×		×	×	
	Cymbella																
60	æqualis	×	×	×	×		×					×	×	×	×	×	
61	affinis	×	×	×	×	×	×			×		×	×		×		
62	amphicephala	×	×	×	×	×	×			×	×	×	×			×	
63	angustata	×					×			×			×			×	
64	aspera	×	×	×	×	×					×	×	×	×	×	×	
65	— dubravic.	×														×	
66	Ceratii	×			×		×			×			×				
67	Cistula	×	×	×	×	×	×			×		×	×		×	×	×

		Universal distribution										Distribution in the different parts of Iceland					
		Eur.	Af.	As.	Am.	Aust.	Grl.	J.M.	B.E.	Spb.	Fz.J.	S.	S.W.	N.W.	N.	E.	s.l.
68	Cistula arctica	×		×					×	×			×				
69	— Caldogast.	×										×					
70	— maculata	×			×		×			×	×	×	×				
71	cuspidata	×	×	×	×	×	×					×	×		×	×	
72	cymbiformis	×	×	×	×	×						×	×		×	×	
73	Ehrenbergi	×	×	×	×		×					×	×		×	×	
74	— delecta	×		×	×		×								×		
75	gracilis	×	×	×	×	×	×					×	×	×	×	×	×
76	helvetica	×					×					×	×		×	×	×
77	heteropleura min.	×		×			×			×		×	×	×	×	×	×
78	incerta navic.	×					×						×			×	
79	lanceolata	×	×	×	×							×	×		×	×	×
80	— cornuta	×											×				
81	— ventricosa	×											×				
82	lapponica	×										×	×	×	×	×	
83	microcephala	×			×		×					×	×			×	
84	naviculiformis	×		×	×	×	×		×	×		×	×	×	×	×	×
85	parva	×		×	×	×	×		×		×	×	×	×	×	×	×
86	prostrata	×	×	×	×							×					
87	sinuata	×	×	×		×	×		×		×		×		×	×	
88	stauroneiformis								×	×						×	
89	turgida	×		×	×	×	×									×	
90	ventricosa	×	×	×	×	×	×		×	×	×	×	×	×	×	×	×
	Denticula																
91	elegans	×			×							×	×		×	×	
92	subtilis	×	×	×	×								×			×	
93	tenuis	×	×	×	×								×			×	
	Diatoma																
94	hiemale	×		×	×		×					×	×	×	×	×	×
95	elongatum	×	×	×	×		×					×	×			×	
96	— minus	×			×							×	×				
97	— tenue	×			×					×	×	×	×			×	×
98	vulgare	×	×	×	×		×				×	×	×	×	×	×	
	Diatomella																
99	Balfouriana	×			×		×		×	×	×	×	×	×	×	×	
	Diploneis																
100	Boldtiana	×										×	×	×			
101	— robusta	×										×					
102	elliptica	×	×	×	×	×	×				×	×	×	×	×	×	×
103	ovalis	×			×	×	×	×	×			×	×	×	×	×	×

		Universal distribution										Distribution in the different parts of Iceland					
		Eur.	Af.	As.	Am.	Aust.	Grl.	J.M.	B.E.	Spb.	Fz.J.	S.	S.W.	N.W.	N.	E.	s.I.
104	ovalis oblongella	×	×	×	×							×	×	×	×	×	×
105	— pumila	×		×									×				
106	Puella	×	×												×	×	
107	subovalis				×	×							×				
	Epithemia																
108	Argus	×	×	×	×							×	×		×	×	×
109	Hyndmanni	×										×			×	×	
110	Sorex	×	×	×								×	×		×	×	×
111	— amphiceph.						×					×			×	×	×
112	turgida	×	×	×	×		×					×	×	×	×	×	×
113	— anom.	×														×	
114	— capitata	×														×	
115	Zebra	×	×	×	×							×	×	×	×	×	×
116	— longicornis	×	×	×	×							×				×	
117	— longissima	×											×			×	
118	— proboscidea	×										×	×		×	×	
	Eunotia																
119	Arcus	×	×	×	×		×			×		×	×		×	×	
120	— bidens	×					×					×	×			×	
121	— minor	×					×					×				×	
122	— tenella	×											×				
123	— uncinata	×														×	
124	bidentula	×											×			×	
125	Diodon	×	×	×	×		×			×			×	×	×	×	
126	— diminuta	×											×			×	
127	elegans	×											×				
128	exigua	×			×								×				
129	Faba densestr.	×					×						×		×	×	
130	flexuosa	×														×	
131	gracilis	×	×		×		×	×	×	×	×		×		×	×	
132	impressa ang.	×											×	×	×	×	
133	lunaris	×	×	×	×		×	×			×	×	×	×	×	×	×
134	— alpina	×		×	×								×				
135	— bilunaris	×														×	
136	— subarcuata	×					×					×	×				
137	major	×					×						×			×	
138	— bidens	×														×	
139	Monodon	×					×									×	
140	Nymanniana	×			×		×						×			×	
141	paludosa	×													×	×	
142	parallela	×		×	×		×			×	×		×	×	×		
143	pectinalis	×	×	×	×		×						×	×	×	×	

		Universal distribution										Distribution in the different parts of Iceland					
		Eur.	Af.	As.	Am.	Aust.	Grl.	J.M.	B.E.	Spb.	Fz.J.	S.	S.W.	N.W.	N.	E.	s.l.
144	pectinalis minor	×	×	×	×		×				×		×			×	
145	— stricta	×										×	×			×	
146	polyglyphis	×										×	×	×		×	
147	prærupta	×					×					×	×	×	×	×	
148	— bidens	×					×	×			×	×	×		×	×	
149	— bigibba	×					×				×	×	×		×	×	
150	— curta	×			×		×				×	×	×	×	×	×	
151	— — laticeps	×					×	×			×				×	×	
152	robusta Diad.	×			×		×			×			×		×	×	
153	tridentula permin.	×					×						×			×	
154	Triodon	×			×		×			×		×	×		×	×	
155	Veneris	×										×					
156	— obtusiusc.	×											×				
	Fragilaria																
57	capucina	×	×	×	×		×			×	×	×					
58	— acuminata	×		×	×							×					
59	— acuta	×			×							×	×				
60	— lanceolata	×			×							×					
61	— mesolepta	×										×					
62	construens	×	×	×	×		×		×			×	×		×	×	
63	— binodis	×	×		×							×	×	×		×	
64	— pumila.	×		×								×					
65	— semibin.	×										×					
66	— venter	×	×	×	×		×					×	×		×	×	
67	crotonensis	×											×		×	×	
68	intermedia	×		×			×					×	×		×	×	×
69	lapponica	×					×					×					
70	mutabilis	×	×	×	×		×					×	×		×	×	×
71	— elliptica	×		×	×							×	×			×	
72	— intercedens	×			×							×	×	×		×	
73	— minutiss.	×			×							×			×	×	
74	parasitica	×	×	×								×	×		×	×	
75	producta								×	×		×	×	×	×	×	
76	Smithiana	×										×					
77	undata	×					×					×			×	×	
78	virescens	×	×	×	×							×	×	×	×	×	×
79	— exigua	×										×			×	×	×
	Frustulia																
80	rhomboides saxon.	×	×	×	×	×	×		×	×		×	×		×	×	
81	— leptoceph.						×					×	×		×		
82	vulgaris	×	×	×	×	×	×					×	×	×	×	×	×

		Universal distribution										Distribution in the different parts of Iceland					
		Eur.	Af.	As.	Am.	Aust.	Grl.	J.M.	B.E.	Spb.	Fz.J.	S.	S.W.	N.W.	N.	E.	s.I.
	Gomphonema																
183	acuminatum	×	×	×	×		×					×	×		×	×	
184	— coronatum	×	×	×	×		×					×	×	×		×	×
185	— elongatum	×	×	×	×		×					×					
186	— pusilla	×	×	×	×		×					×	×			×	
187	— trigonocephala	×	×	×	×		×					×			×		
188	angustatum prod.	×	×	×	×		×		×	×	×	×	×	×	×	×	
189	gracile aurit.	×	×		×				×			×	×	×	×	×	
190	— dichot.	×	×	×	×	×						×	×		×	×	
191	— navicul.	×	×	×		×							×		×	×	×
192	intricatum	×	×	×	×				×			×					
193	— dichotom.	×			×	×							×				
194	— Vibrio	×		×										×			
195	Lagerheimi	×											×				
196	lanceolatum insigne	×	×	×	×	×						×	×				
197	olivaceum	×	×	×	×		×					×	×		×	×	
198	— calcareum	×			×							×					
199	— stauroneif.	×		×								×					
200	parvulum	×	×	×	×	×	×				×	×	×	×	×	×	×
201	Salinarum	×										×					
202	subclavatum	×	×	×	×	×						×	×	×	×	×	×
203	— montanum	×	×		×										×	×	
204	— Mustela	×	×	×					×	×		×	×		×	×	
205	— subtile	×			×											×	
	Gyrosigma																
206	acuminatum	×	×	×									×	×	×		
207	attenuatum	×	×	×	×								×		×		
	Hantzschia																
208	amphioxys	×	×	×	×		×	×	×	×	×	×	×	×	×	×	×
209	— constricta	×														×	
210	— elongata	×	×		×	×						×	×		×	×	
211	dubravicensis	×														×	
212	virgata leptoc.	×										×					
	Mastogloia																
213	elliptica Dansei	×	×		×	×							×	×	×	×	
214	Grevillei	×	×		×											×	
215	Smithi lacust.	×											×				
	Melosira																
216	ambigua	×	×	×								×				×	
217	arenaria	×		×									×				
218	crenulata	×	×	×	×							×	×		×	×	
219	distans alpig.	×					×					×	×	×	×	×	
220	— nivalis	×											×	×	×	×	

		Universal distribution										Distribution in the different parts of Iceland					
		Eur.	Af.	As.	Am.	Aust.	Grl.	J.M.	B.E.	Spb.	Fz.J.	S.	S.W.	N.W.	N.	E.	s.l.
221	granulata	×	×	×	×		×				×	×	×		×	×	
222	islandica												×			×	
223	italica tenuis	×	×		×		×					×	×	×	×	×	
224	— tenuissima	×	×									×	×		×	×	
225	lævis	×							×			×	×			×	
226	Roeseana	×					×	×		×		×	×		×	×	
227	Varennarum	×											×			×	
228	varians	×	×	×	×		×					×	×	×	×	×	×
	Meridion																
229	circulare	×	×	×	×		×					×	×	×	×	×	
	Navicula																
230	amphibola	×		×	×		×		×	×	×	×	×		×	×	
231	anglica	×	×	×	×		×					×	×		×	×	
232	— minuta	×		×	×							×					
233	— subsal.	×					×					×	×	×		×	
234	Atomus circ.			×								×	×				
235	bacilliform.	×		×	×	×						×	×		×	×	
236	Bacillum	×		×	×	×						×	×		×	×	
237	— lepida	×			×							×					
238	— minor	×				×								×			
239	cincta	×	×	×	×		×	×	×		×	×	×	×	×	×	×
240	— angusta	×		×	×	×								×			
241	— Heufleri	×	×		×							×					
242	cocconeiformis	×		×	×		×	×	×	×		×	×		×	×	
243	contenta biceps	×		×			×					×	×		×	×	
244	crucicula	×	×	×		×	×						×	×		×	
245	— capitata	×										×					
246	cryptocephala	×	×	×	×		×					×	×		×	×	×
247	— exilis	×		×	×							×	×		×	×	×
248	cuspidata	×	×	×	×	×			×			×	×		×	×	
249	— Heribaudi	×											×				
250	— ambigua	×	×	×	×	×	×					×	×		×	×	
251	dicephala	×	×	×	×		×					×	×		×	×	×
252	Gastrum	×	×	×	×	×	×					×					
253	— exigua	×				×						×	×		×	×	
254	gibbula								×	×			×		×		
255	gracilis	×	×	×	×		×								×	×	
256	— schizonem.	×										×				×	
257	Heufleriana	×					×				×	×			×	×	
258	hungarica	×		×	×				×			×	×		×	×	
259	— capitata	×		×					×				×		×	×	
260	integra	×										×					

		Universal distribution										Distribution in the different parts of Iceland					
		Eur.	Af.	As.	Am.	Aust.	Grl.	J.M.	B.E.	Spb.	Fz.J.	S.	S.W	N.W.	N.	E.	s.I.
261	lacustris	×			×							×				×	
262	lanceolata	×	×		×	×	×					×	×				
263	— Cymbula	×		×									×			×	
264	— latior	×										×					
265	— phyllepta	×										×					
266	lucidula	×		×			×					×			×		
267	Ludloviana				×							×	×			×	
268	minuscula	×		×								×					
269	mutica Cohni	×	×	×	×	×	×	×		×	×	×	×	×	×	×	
270	— Göppert	×		×	×		×									×	
271	nivalis	×	×			×	×				×				×		
272	oblonga	×	×	×	×	×							×				
273	pelliculosa	×											×				
274	peregrina	×	×	×	×								×		×	×	
275	— Menisculus	×	×	×	×							×	×			×	
276	— Meniscus	×	×	×	×							×	×		×	×	
277	— polaris	×					×		×	×			×		×		
278	protracta	×	×									×	×			×	
279	Pseudobacillum	×	×	×		×	×					×	×			×	
280	— lanceolata	×													×		
281	Pupula	×	×	×	×	×	×					×	×		×	×	
282	pusilla	×	×	×	×	×	×	×				×	×	×	×	×	
283	radiosa	×	×	×	×		×		×	×		×	×	×	×	×	×
284	Reinhardti	×		×	×		×		×			×			×	×	
285	— Yenissey			×												×	
286	rhyncoceph	×	×	×	×	×	×		×			×	×		×	×	×
287	— amphic.	×				×							×		×		
288	Rotæana	×				×	×	×	×	×	×		×		×	×	
289	— oblongel	×											×		×	×	×
290	Salinarum	×	×		×					×		×					
291	Semen	×			×						×	×	×	×	×	×	
292	Seminulum	×		×	×		×		×	×	×	×					
293	— fragilar	×														×	
294	subtilissima	×								×			×				
295	Tuscula	×	×	×	×		×		×	×			×		×	×	
296	viridula	×	×	×	×	×	×						×		×	×	
297	— slesvic.	×										×	×	×	×	×	
298	vulpina	×		×	×	×	×					×	×			×	
	Neidium																
299	affine amphir	×				×	×		×	×		×	×		×	×	×
300	— longiceps	×					×									×	
301	— undulata	×														×	
302	bisulcatum	×	×	×	×		×	×	×	×	×	×	×		×	×	×

		Universal distribution										Distribution in the different parts of Iceland					
		Eur.	Af.	As.	Am.	Aust.	Grl.	J.M.	B.E.	Spb.	Fz.J.	S.	S.W.	N.W.	N.	E.	s.l.
303	dilatatum	×										×	×			×	
304	dubium	×		×	×	×						×			×	×	
305	fasciatum	×														×	
306	Hitchcockii	×		×	×	×										×	
307	incurva	×														×	
308	Iridis	×	×	×	×	×	×				×		×			×	
309	productum	×		×	×								×		×		
	Nitzschia																
310	amphibia	×	×		×							×	×		×	×	×
311	— acutiusc.	×			×	×						×					
312	— Frauenf.	×			×	×						×	×		×	×	
313	angustata	×		×	×							×	×			×	
314	apiculata	×		×	×		×		×			×	×			×	×
315	commutata	×	×	×								×	×		×		
316	debilis	×					×	×		×	×	×					
317	Denticula	×	×	×	×		×			×		×	×	×	×	×	×
318	dissipata	×	×	×	×		×			×		×	×				
319	Frustulum	×	×		×		×	×		×	×	×			×	×	
320	Hantzschiana glacial.	×					×			×	×	×				×	
321	Heufleriana	×							×		×					×	
322	intermedia	×			×							×	×			×	
323	Kittli	×										×	×		×	×	
324	Kützingiana	×			×				×							×	
325	linearis	×	×	×	×		×					×	×	×	×	×	
326	Nathorsti						×	×			×	×			×		
327	Palea	×	×	×	×						×	×	×	×	×	×	
328	— fonticola	×		×								×	×		×		
329	— minuta	×					×	×			×	×				×	
330	— tenuirost.	×					×	×	×			×	×		×	×	×
331	serians	×		×									×				
332	Sigma	×	×	×	×	×	×						×				
333	– Clausi	×					×				×	×	×			×	
334	sigmoidea	×	×	×	×							×	×		×	×	
335	sinuata	×		×	×						×	×	×	×	×	×	×
336	stagnorum	×	×	×												×	
337	thermalis	×	×	×								×	×			×	
338	— minor	×					×				×	×	×	×	×	×	
339	subtilis	×	×		×								×				
340	Tryblion. Vict.	×		×	×	×							×		×		
341	vitrea recta	×		×	×		×					×					
342	— salin.	×	×		×							×					
343	Oestrupi	×										×					

		Universal distribution										Distribution in the different parts of Iceland					
		Eur.	Af.	As.	Am.	Aust.	Grl.	J.M.	B.E.	Spb.	Fz.J.	S.	S.W.	N.W.	N.	E.	s.I.
	Pinnularia																
344	acrosphæria	×	×	×	×								×		×	×	
345	æstuarii	×			×										×		
346	alpina	×														×	
347	appendiculata	×	×	×	×	×	×					×	×		×	×	
348	— budensis	×				×						×			×	×	
349	Balfouriana	×				×					×	×	×		×	×	
350	borealis	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
351	— brevicost.	×													×		
352	— linearis	×										×	×		×	×	
353	Brauni	×	×	×	×	×										×	
354	Brebissoni	×	×	×	×							×	×		×	×	×
355	— diminuta	×			×		×					×	×		×	×	×
356	— linearis	×										×					
357	brevicostata	×		×								×	×	×	×	×	×
358	— leptostauron	×											×			×	
359	Dactylus	×	×		×									×			
360	distinguenda	×	×	×	×	×						×	×				
361	divergens ellipt.	×	×		×	×	×				×	×	×	×	×	×	
362	— elongata	×											×				
363	divergentissima	×		×	×	×	×	×		×		×	×			×	
364	flexuosa	×		×	×	×										×	
365	gracillima	×		×			×	×			×	×	×			×	
366	hemiptera	×	×	×	×											×	
367	— interrupta	×		×								×	×				
368	intermedia	×				×	×		×	×	×		×		×	×	
369	interrupta stauroneif.	×		×	×	×	×					×	×	×	×	×	
370	— biceps	×		×	×	×	×			×	×	×	×		×	×	
371	icostauron	×			×		×					×		×		×	×
372	karelica	×														×	
373	lata	×		×	×	×	×	×			×	×	×	×	×	×	×
374	— minor			×				×		×	×				×	×	
375	Legumen	×	×	×	×	×	×								×		
376	leptosoma	×					×						×		×		
377	major	×	×	×	×	×						×	×	×	×	×	×
378	— linearis	×	×		×								×				
379	mesogongyla	×			×		×					×	×	×	×	×	
380	— interrupta	×					×				×	×				×	
381	mesolepta angusta	×			×							×	×	×	×	×	
382	— polyonca	×										×	×			×	
383	— stauroneif.	×	×		×		×	×			×	×	×	×		×	
384	microstauron	×	×	×	×	×	×	×		×	×	×	×	×		×	
385	molaris	×		×	×	×									×	×	
386	nobilis	×		×	×							×	×			×	×

		Universal distribution										Distribution in the different parts of Iceland					
		Eur.	Af.	As.	Am.	Aust.	Grl.	J.M.	B.E.	Spb.	Fz.J.	S.	S.W.	N.W.	N.	E.	s.l.
387	nodosa	×			×											×	
388	Oculus	×					×					×	×		×	×	
389	parallela crassa	×											×				
390	parva	×		×	×	×	×					×	×		×	×	
391	— Lagerst.								×	×		×	×		×	×	
392	Paulensis				×		×									×	
393	platyceph.	×					×	×					×				
394	secernenda				×											×	
395	stauroptera	×		×	×	×					×	×	×		×	×	×
396	— interr.	×	×	×	×	×	×				×	×	×	×	×	×	
397	stomatoph.	×	×		×	×	×					×	×	×	×	×	
398	streptoraphe	×			×		×					×	×	×	×	×	
399	— minor	×					×						×			×	
400	subcapitata	×	×	×	×	×	×	×		×	×	×	×	×	×	×	
401	— paucistr.	×										×					
402	sublinearis	×					×	×				×	×		×	×	
403	subsolaris	×	×		×	×	×						×				
404	viridis	×	×	×	×	×						×	×	×	×	×	×
405	— commut.	×			×	×	×					×	×	×	×	×	×
406	— fallax	×			×	×	×				×	×	×			×	
407	— intermedia	×	×	×		×	×	×					×		×		
408	— leptogong.	×											×			×	
409	— rupestris	×			×		×				×	×	×	×	×	×	
	Rhizosolenia																
410	eriensis	×			×								×				
411	paludosa	×											×				
	Rhoicosphenia																
412	curvata	×	×	×	×	×	×			×	×	×	×	×	×	×	×
	Rhopalodia																
413	gibba	×	×	×	×		×					×	×	×	×	×	×
414	gibberula	×	×	×	×							×	×	×	×	×	
415	— rupestris	×	×		×							×	×	×	×	×	
416	gracilis		×									×			×	×	
417	parallela	×	×	×	×							×	×	×	×	×	
418	uncinata		×										×				
419	ventricosa	×	×	×	×		×					×	×	×	×	×	×
	Stauroneis																
420	acuta	×		×	×	×	×				×		×		×		
421	anceps	×	×	×	×	×	×	×	×	×	×	×	×		×	×	
422	— birostris	×			×											×	

		Universal distribution										Distribution in the different parts of Iceland					
		Eur.	Af.	As.	Am.	Aust.	Grl.	J.M.	B.E.	Spb.	Fz.J.	S.	S.W.	N.W.	N.	E.	s.l.
423	anceps gracilis	×			×							×	×		×	×	
424	— hyalina	×				×										×	
425	— linearis	×				×								×		×	
426	— siberica			×	×							×	×			×	
427	javanica	×		×	×	×	×						×			×	
428	Legumen	×	×	×	×		×					×	×	×	×	×	
429	obtusa							×		×	×		×				
430	parvula prod.	×					×					×	×	×	×	×	
431	Phoenicenteron	×	×	×	×	×	×					×	×	×	×	×	×
432	— amphil.	×	×			×						×	×	×	×	×	
433	Smithi	×		×	×							×				×	
	Stenopterobia																
434	intermedia	×	×		×		×						×				
	Stephanodiscus																
435	Astræa	×	×	×			×				×	×					
	Surirella																
436	biseriata	×	×	×	×							×	×	×	×	×	
437	Engleri ang.		×									×	×				
438	linearis	×	×	×	×					×		×	×		×	×	
439	— constricta	×			×							×	×		×	×	
440	Mölleriana	×		×	×							×	×		×	×	
441	ovalis angusta	×	×	×	×		×			×	×	×	×		×	×	
442	— minuta	×	×	×	×		×		×			×	×		×	×	
443	— ovata	×	×	×	×		×		×	×	×	×	×	×	×	×	
444	— pandurif.	×										×	×			×	
445	— pinnata	×								×		×	×	×	×	×	
446	robusta	×										×					
447	— splendida	×	×		×							×					
448	turgida	×											×				
	Synedra																
449	Acus	×	×	×	×							×	×				
450	— delicatiss.	×		×	×							×	×		×	×	
451	mesoleja	×										×	×		×		
452	amphiceph.	×			×								×				
453	— austriaca	×										×	×	×			
454	capitata	×		×								×	×		×	×	
455	famelica minusc.	×										×	×			×	
456	familiaris major	×											×		×		
457	pulchella	×	×	×	×		×					×	×		×	×	
458	— navicul.	×													×		

		Universal distribution										Distribution in the different parts of Iceland					
		Eur.	Af.	As.	Am.	Aust.	Grl.	J.M.	B.E.	Spb.	Fz.J.	S.	S.W.	N.W.	N.	E.	s. I.
459	radians	×		×			×					×	×			×	
460	rostrata	×										×	×			×	
461	rumpens frag.	×			×							×	×	×	×	×	×
462	Ulna	×	×	×	×		×					×	×	×	×	×	
463	— amphir.	×										×					
464	— danica	×	×									×	×		×	×	
465	— longiss.	×	×									×				×	
	Tabellaria																
466	fenestrata	×	×	×	×		×					×	×	×	×	×	
467	flocculosa	×	×	×	×		×	×	×	×	×	×	×	×	×	×	×
	Tetracyclus																
468	emarginatus	×										×	×		×	×	
	Total...	445	184	223	251	104	192	49	54	69	76	299	332	104	240	328	71
	°/o	95	39	48	54	22	41	10	12	15	16	64	71	22	51	70	15

From this it appears that the distribution is very similar to that of the rest of Europe, as 95 °/o of the Icelandic forms also occur there; next come Asia and America with about 50 °/o. As for the Arctic regions, Greenland stands highest with 41 °/o. In Iceland the number of species is greatest and almost the same in S.W. and E., about 70 °/o; from these parts the greatest number of samples originate, viz. 148 and 191 respectively.

Forms found in 100 samples or more.

		Number of samples	%			Number of samples	%
1	Meridion circulare......	347	61	16	Gomphon. parvul.	160	28
2	Navicula radiosa	286	50	17	Amphora ovalis	159	28
3	Epithemia Zebra	264	46	18	Caloneis Silic..........	151	27
4	Diatoma hiemale	258	45	19	Pinnul. vir. com.........	148	26
5	Cymbella ventricosa	247	43	20	Syn. Ulna danica	148	26
6	Gomphonema subclav...	222	39	21	Diploneis ellipt.........	140	25
7	Rhopalodia gibba.......	216	38	22	Achnanth. lanceol.... ..	139	25
8	Pinnularia viridis	214	38	23	Epithemia turg.........	139	25
9	Synedra Ulna typ.......	207	36	24	Cocconeis Placent.......	126	22
10	Cymbella parva	200	35	25	Ceratoneis Arcus	126	22
11	Rhopal. ventric.	196	34	26	Melos. ital. tenuis.......	123	22
12	Pinnul. borealis	195	34	27	Frustulia vulg....... ..	116	21
13	Tabellaria floccul.	192	34	28	Pinnul. major	111	20
14	Hantzschia amph.......	176	31	29	Tabell. fenestr.	108	19
15	Diatomella Balf........	168	29	30	Cymb. Cistula..........	100	18

Characterising forms in 10 samples or more.

1	Meridion circulare......	50	6	Epithemiæ sp. diversæ ..	22
2	Diatoma hiemale	43	7	Cymbellæ sp. diversæ ...	17
3	Synedra Ulna danica....	41	8	Fragilariæ sp. diversæ...	16
4	Melosiræ sp. diversæ....	37	9	Ceratoneis Arcus	10
5	Synedra Ulna typica....	36			

This table shows that the forms most characteristic to the Icelandic flora of fresh-water diatoms are: Meridion, Diatoma, Synedra and Melosira. Comparing the two lists it further appears, that the fact of a form being met with in a great number of samples not necessarily means that it is generally characterising; for inst., Navicula radiosa marked no. 2 in the first list only characterised two samples; Cymbella ventricosa, Pinnularia viridis, Gomphonema subclavatum each only one sample, while Pinnularia borealis and Hantzschia amphioxys did not characterise any.

HOT SPRINGS

As "hot springs" I have only included those which on the labels have distinctly been marked as such. I have of these 30 samples from 13 localities, viz.

from S.: Grafarbakki (1 sampl.), Minni Laxá (4 sampl.), Torfastaðir (4 sampl.).
» S.W.: Hrossholt (1 sampl.), Reykjavík (4 sampl.).
» N.W.: Hrútafjörður (1 sampl.), Reykjanes (3 sampl.), Steingrimsfjörður (1 sampl.).
» N.: Akureyri (2 sampl.), Hrafnagil (4 sampl.), Hrisey (1 sampl.), Laugafells Laug (3 sampl.), Reykjarfjörður (1 sampl.).

In these I have found the following forms:

	Achnanthes (17)	Number of hot springs
1	coarctata	1
2	exigua	1
3	*exilis	1
4	lanceolata	9
5	— færöensis	2
6	minutissima	3
	Total...	17

	Amphora (8)	
1	coffæiformis	1
2	*ovalis	6
3	— Pediculus	3
4	protracta gall.	2
5	veneta	1
	Total...	13

	Anomoeoneis (5)	
1	exilis	1
2	zellensis	1
	Total...	2

	Caloneis (14)	Number of hot springs
1	*amphisbæna	1
2	fasciata	2
3	*Silicula gen.	10
4	— alpestris	5
5	— inflata	2
	Total...	20

	Ceratoneis (1)	
1	Arcus	8
	Total...	8

	Cocconeis (5)	
1	flexella	2
2	Placentula	7
	Total...	9

	Cymatopleura (2)	
1	Solea	2
	Total...	2

	Cymbella (31)	Number of hot springs
1	æqualis	1
2	aspera	1
3	Cistula	1
4	cymbiform.	2
5	gracilis	2
6	helvetica	2
7	heteropl. min.	2
8	incert. navic.	1
9	*lanceolata	2
10	lapponica	1
11	microcephala	1
12	naviculif.	3
13	parva	9
14	ventricosa	5
	Total...	33

	Denticula (3)	
1	*elegans	1
	Total...	1

Diatoma (5)

		Number of hot springs
1	*hiemale	10
2	*tenue	1
	Total...	11

Diatomella (1)

		Number of hot springs
1	Balfouriana	7
	Total...	7

Diploneis (8)

		Number of hot springs
1	*elliptica	18
2	ovalis	1
3	— oblongella	5
4	— pumila	1
	Total...	25

Epithemia (11)

		Number of hot springs
1	*Argus	4
2	Sorex amphic.	1
3	*turgida	3
4	*Zebra	15
5	— longiss.	1
6	— proboscidea	4
	Total...	28

Eunotia (38)

		Number of hot springs
1	Faba densestr.	1
2	gracilis	1
3	impressa ang.	2
4	lunaris	2
5	major	1
6	pedinal. minor	1
7	polyglyphis	1
8	prærupta	3
9	— curta	5
10	robusta Diad.	1
11	Triodon	1
	Total...	19

Fragilaria (23)

		Number of hot springs
1	construens	1
2	intermedia	2
3	mutabilis	1
4	— intercedens	1
5	virescens exig.	1
	Total...	6

Frustulia (3)

		Number of hot springs
1	rhomb. saxon.	2
2	— leptoceph.	1
3	*vulgaris	10
	Total...	13

Gomphonema (23)

		Number of hot springs
1	*acuminatum	2
2	— f. coronata	1
3	— f. trigonoc.	2
4	angust. prod.	3
5	constrictum	1
6	gracile aurit	4
7	— dichotom.	2
8	— navicul.	1
9	parvulum	5
10	subclavatum	4
	Total...	25

Hantzschia (5)

		Number of hot springs
1	amphioxys	9
2	— elongata	1
3	truncata	1
	Total...	11

Mastogloia (3)

		Number of hot springs
1	ellipt. Dans.	5
2	*Smithi lacust.	1
	Total...	6

Melosira

		Number of hot springs
1	distans niv.	1
2	ital. tenuis	2
3	varians	4
	Total...	7

Meridion (1)

		Number of hot springs
1	circulare	12
	Total...	12

Navicula (69)

		Number of hot springs
1	anglica	2
2	cincta	2
3	— angusta	1
4	contenta biceps	1
5	cryptocephala	2
6	— exilis	1
7	cusp. ambig.	1
8	dicephala	7
9	— undulata	1
10	gracilis	1
11	— schizonem.	1
12	hungar. capit.	1
13	mutica Cohni	3
14	nivalis	4
15	pereg. Meniscus	1
16	Pupula	3
17	pusilla	5
18	*radiosa	8
19	rhyncoceph.	1
20	Rotæana obl.	1
21	Semen	2
22	virid. slesvic.	2
	Total...	51

Neidium (11)

		Number of hot springs
1	affine amph.	5
2	bisulc.	1
3	dubium	2
	Total...	8

Nitzschia (34)

		Number of hot springs
1	amphibia	17
2	— Frauenf.	1
3	angustata	1
4	commut.	1
5	Denticula	4
6	Frustulum	1
7	linearis	2
8	Nathorsti	1
9	Palea	2
10	— fonticola	1
11	— tenuirostris	1
12	Sigma Clausi	2
13	sigmoidea	1
14	*sinuata	4
15	*thermalis	3
16	— minor	1
	Total...	43

		Number of hot springs
	Pinnularia (66)	
1	*appendicul. . . .	2
2	— budensis	2
3	Balfouriana . . .	2
4	Brandeli lin. . .	1
5	*Brebissoni	1
6	— diminuta	1
7	*borealis	17
8	— brevicostata	1
9	brevicostata . . .	3
10	diverg. ellipt. . .	1
11	intermedia	1
12	interr. staurf. . .	5
13	lata	4
14	Legumen	1
15	— longa . . .	1
16	leptosoma	3
17	major	4
18	mesogong.	3
19	*mesolept. staurf.	5
20	— angusta .	1
21	Microstauron . .	1
22	molaris	1
23	subcapit.	2
24	staur opt. gen. . .	2
25	staur opt. interr.	2
26	stomatophora .	2
27	streptoraphe . .	3
28	*viridis gen. . . .	10
29	— commut. .	6
30	— rupestris .	3
	Total . . .	91
	Rhoicosphenia (1	
1	curvata	9
	Total . . .	9
	Rhopalodia (7)	
1	*gibba	11
2	gibberula	13
3	— rupestris	6
4	parallela	5
5	ventricosa	9
	Total . . .	44
	Stauroneis (4)	
1	anceps	1
2	*Phoenicenteron	1
	Total . . .	2
	Surirella (13	
1	ovalis minuta .	2
2	— ovata . .	5
	Total . . .	7
	Synedra (17)	
1	delicat. mesol. .	1
2	capitata	1
3	pulchella	1
4	rostrata	1
5	rump. fragil. . .	3
6	Ulna typica . . .	11
7	— danica . . .	7
	Total . . .	25
	Tabellaria (2)	
1	fenestrata	2
2	flocculosa	10
	Total . . .	12

Of the forms included in above list are those found previously in hot springs in Iceland (see "La flore algologique d'eau douce de L'Islande par M. Emile Belloc. Paris 1894" p. 9—12) marked * (in all 23). The figures in brackets opposite the names of the genera, give the number of species and variants of the respective genus found in the material dealt with.

In most of the samples from hot springs, I have found Diatoms with endochrome.

I have found the following marine forms in 5 of the hot springs situated in N.W. and N., near the coast.

		Reykjanes N.W.	Hrisey N.	Hrefnagil N.	Steingrims-fjörður	Reykjar-fjörður
		Number of samples	Number of samples	Number of samples	Number of samples	Number of samples
1	Achn. brevipes	2			1	
2	— — intermed.		1			
3	Amph. marina		1		1	
4	Biddulph aur.	2	1		1	1
5	Cal. Liber lin.	3				
6	Coccon. cost.	2				
7	— Scut.		1			
8	— — staurf. . .	2				
9	Coscin. excent.				1	
10	Dipl. interrupta	3				
11	Gramm. isl.				1	
12	Melos. numm.		1		1	
13	Navic. bottnica				1	
14	Rhabd. arc.			1		
15	— min.	3	1	1		
16	Rhopal. Musc.	2			1	
17	Schiz. ram.	2				
18	Syn. aff	2				
19	Trach. asp. interm. . . .				1	

The editors regret the presence of a few discrepancies between the list and the tables which they have not been able to remove. Possibly there may be other incorrectnesses which the author might have rectified, when going through the proof-sheets.

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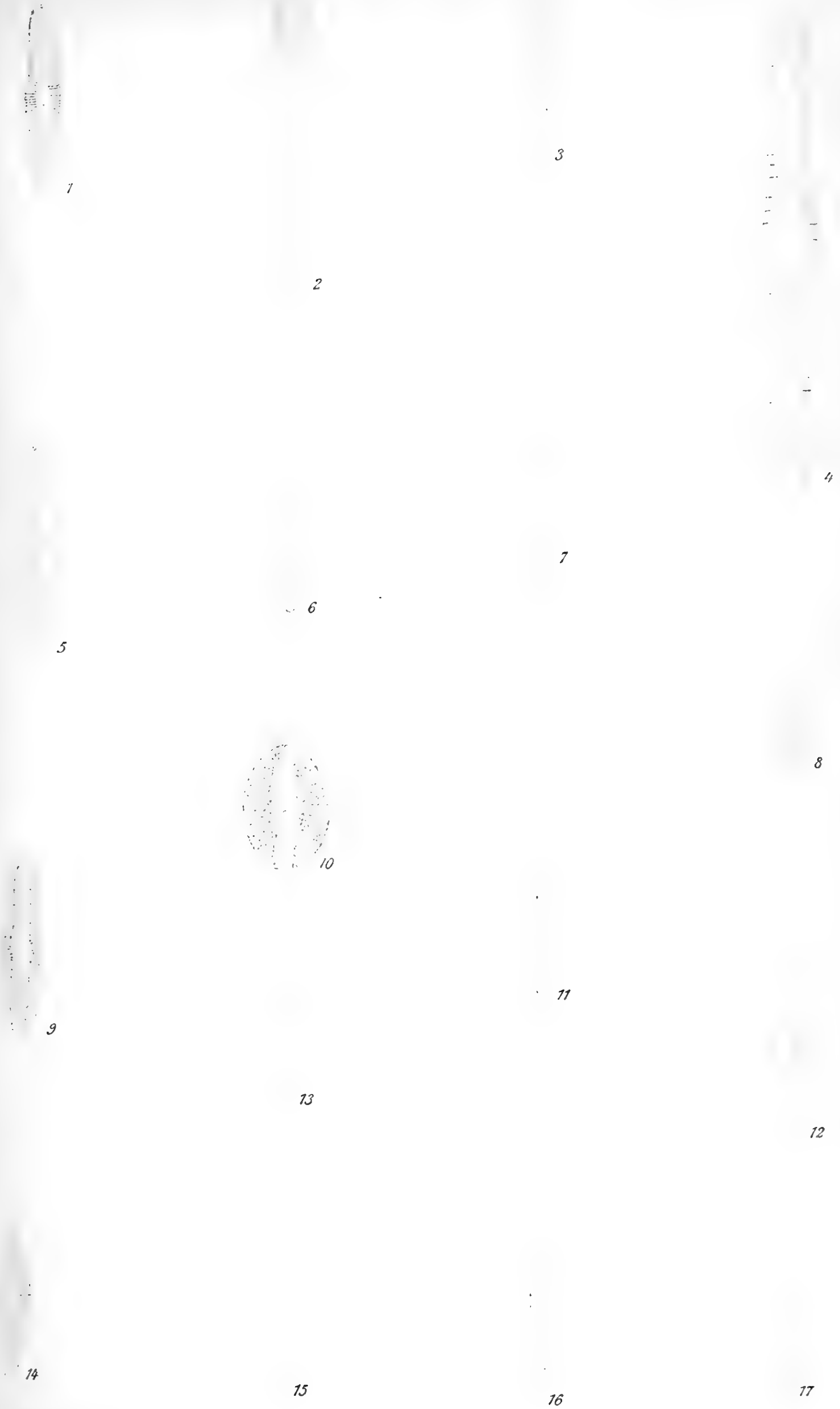
EXPLANATION OF PLATES

All the figures were drawn with a magnification of 100 diameters and reduced in reproduction to 670 diameters

PLATE I.

Fig. 1. Caloneis Fedderseni sp. nov.
— 2. Caloneis islandica sp. nov.
— 3. Caloneis Jonssoni sp. nov.
— 4. Caloneis procera sp. nov.
— 5. Neidium incurvum (Greg.) Øst.
— 6. Neidium islandicum sp. nov.
— 7. Neidium lineare sp. nov.
— 8. Neidium panduriforme sp. nov.
— 9. Diploneis ovalis (Hilse) Cl. f. subinflata.
— 10. Diploneis subovalis Cl.
— 11. Frustulia islandica sp. nov.
— 12. Navicula Bacillum Ehr. var. densestriata var. nov.
— 13. Stauroneis anceps Ehr. var. elliptica var. nov.
— 14. Stauroneis bifissa sp. nov.
— 15. Stauroneis elegantula sp. nov.
— 16. Stauroneis parvula Grun. var. capitata var. nov.
— 17. Stauroneis perexilis sp. nov.

PLATE I.



E. Østrup del.

PLATE II.

Fig. 18. Stauroneis Stefanssoni sp. nov.
— 19. Cymbella Cistula Hempr. var. Caldogastensis Prud.
— 20. Cymbella dubia sp. nov.
— 21. Cymbella islandica sp. nov.
— 22. Cymbella Jonssoni sp. nov.
— 23. Cymbella linearis sp. nov.
— 24. Cymbella marginata sp. nov.
— 25. Cymbella recta sp. nov.
— 26. Cymbella subconstricta sp. nov.
— 27. Gomphonema irregulare sp. nov.
— 28. Gomphonema islandicum sp. nov.
— 29. Gomphonema medio-constrictum sp. nov.

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PLATE III.

Fig. 30. Navicula anguste-fasciata sp. nov.
— 31. Navicula Boyei sp. nov.
— 32. Navicula curte-striata sp. nov.
— 33. Navicula dicephala (Ehr.) W. Sm. var. undulata var. nov.
— 34. Navicula exilior sp. nov.
— 35. Navicula Fustis sp. nov.
— 36. Navicula islandica sp. nov.
— 37. Navicula Jonssoni sp. nov.
— 38. Navicula lyrigera sp. nov.
— 39. Navicula Ostenfeldi sp. nov.
— 40. Navicula pinnularioides sp. nov.
— 41. Navicula semifasciata sp. nov.
— 42. Navicula spatiata sp. nov.
— 43. Navicula Thingvallæ sp. nov.
— 44. Pinnularia leptosoma Grun. var. undulata var. nov.
— 45. Pinnularia perexilis sp. nov.
— 46. Pinnularia bryophila sp. nov.
— 47. Pinnularia islandica sp. nov.
— 48. Pinnularia karelica Cl. var. rostrata var. nov.
— 49. Pinnularia alpina W. Sm. var. linearis var. nov.
— 50. Pinnularia borealis Ehr. var. brevicostata Hust.
— 51. Pinnularia lata (Bréb.) Cl. forma minima.
— 52. Pinnularia Brandeli Cl.
— 53. Pinnularia densestriata sp. nov.
— 54. Pinnularia brevicostata Cl. var. islandica var. nov.

PLATE III.


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PLATE IV.

Fig. 55. Pinnularia parva (Greg.) Cl. var. minuta var. nov.
— 56. Pinnularia subundulata sp. nov.
— 57. Pinnularia Thoroddseni sp. nov.
— 58. Pinnularia gigantea sp. nov.
— 59. Amphora dubiosa sp. nov.
— 60. Achnanthes Boyei sp. nov.
— 61. Achnanthes coarctata (Bres.) Cl. forma.
— 62. Achnanthes lanceolata (Bres.) var. subinflata var. nov.
— 63. Surirella asymmetrica sp. nov.
— 64. Surirella granulata Ost. var. elliptica var. nov.
— 65. Surirella islandica sp. nov.
66. Surirella Jonssoni sp. nov.
67. Campylodiscus sp.

PLATE IV.

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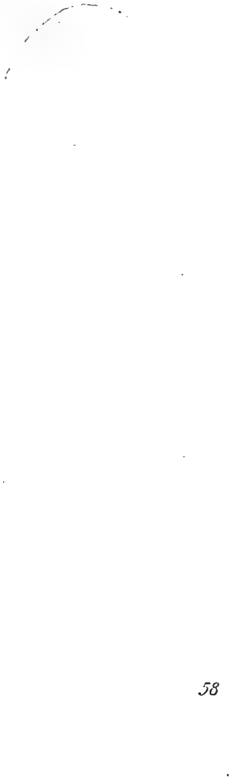

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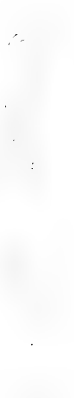

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PLATE V.

Fig. 68. Hantzschia dubravicensis Grun.
— 69. Hantzschia truncata sp. nov.
— 70. Hantzschia forma abnormis.
— 71. Nitzschia angustata (W. Sm.) Grun. forma.
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— 76. Synedra rumpens Ktz. var. islandica var. nov.
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— 78. Fragilaria Baculus sp. nov.
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— 82. Fragilaria undata W. Sm. forma.
— 83. Denticula islandica sp. nov.
— 84. Melosira Stefanssoni sp. nov.

PLATE V.


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84b

E. Østrup del.

ORCHIDACEAE QUAEDAM AMERICANAE.

VON

FR. KRÄNZLIN
BERLIN

Særtryk af
VIDENSK. MEDDEL. FRA DANSK NATURHIST. FORENING
Bd. 71

Arbejder fra den botaniske Have i København. Nr 87.

(Særtryk af Vidensk. Medd. fra Dansk naturh. Foren. Bd. 71.)

Orchidaceae quaedam Americanae.

Von

Fr. Kränzlin — Berlin.

Die Arten, welche ich hiermit publiziere, sind die Ausbeute einer ziemlich grossen, weit über 100 Nummern enthaltenden Sammlung, welche mir von dem Universitetets botaniske Museum in Kopenhagen zur Bestimmung zugesandt wurde. Alle Exemplare waren in Alcohol conserviert, die meisten waren auf Reisen gesammelt und z. T. recht bedeutend zurückgeschnitten, was besonders bei *Pleurothallis* störend empfunden wurde. Die meisten bewegen sich in bekannten Formenkreisen, als auffällig mag erscheinen, dass neue Arten aus so kleinen Gattungen wie *Warmingia*, *Macradenia* und *Amblostoma* dabei sind. Leider fehlten in mehreren Fällen genauere Angaben über Standort und Sammler; ich habe betreffs des ersteren auf Mexico, betreffs des letzteren aber auf Liebmann geraten, der an den schon bekannten Arten sehr stark beteiligt war. Sollte mir hier ein Irrtum passiert sein, so wiegt er sicherlich nicht allzu schwer, denn die hier beschriebenen Arten haben alle ein ausgesprochen zentralamerikanisches Gepräge.

Pleurothallis mandibularis Kränzl. n. sp. — [*Sicariae*?].

Caulis non praestat, summitas plantae tantum praesto est. Folium oblongum, basi vix v. non complicatum, obtusum, biapiculatum, ad 9 cm longum, 3,5 ad 4 cm latum, crassum, carnosum, subtus haud carinatum. Racemus a folio liber illoque brevior, basi vagina ancipite vestitus, ad 5 cm longus, pauciflorus, (— 10), bracteae ochreatae, ovaria subaequantes; flores extus tomentosi, parum aperti, carnosuli. Sepalum dorsale ligulatum, acutum, 10 mm longum, 2 mm latum; lateralia ovato-oblonga, dimidiata, fere apicem usque connata v. potius conglutinata, fere 1,2 cm longa, synsepalum obscurissime carinatum, 5 mm latum formantia. Petala lineari-spathulata, antice denticulata, tenera. Labellum sessile, late ovatum, obtusissimum, membranaceum, apice integrum (minime triapiculatum) callis 2 mandibulas ludentibus, crassis, tuberculosis, antice convergentibus, basi utrinque lobulo minuto, rotundato praeditum, 4 mm longum, 2 ad 2,25 mm latum. Gynostemium leviter incurvum, margo androclinii denticulatus. — De colore florum in alcohol conservatorum nil proferre audeo.

Wahrscheinlich aus Mexico stammend (Liebmann!).

Bemerkung. Ein Mittelding zwischen *Pleuroth. bicarinata* Lindl. und *Pl. circumplexa* Lindl. aber die erstere hat unbehaarte Blüten, die zweite vorn abgerundete, ganzrandige Petalen und ein breites, ziemlich tief ausgehöltes oberes Sepalum. — Es war leider bei dieser Art nicht möglich, zu sagen, ob die Pflanze unter die *Sicariae* Lindleys zu stellen sei, da beide (sonst gut erhaltene) Exemplare dicht unter dem Blatt abgeschnitten waren. Es finden sich natürlich auch Anklänge an *Pl. prolifera* (Lindl.) Herb. sowie an die brasilianische *Pl. saurocephala* Lodd., von einer Identität ist aber nirgends die Rede; immerhin stelle ich diese Art mit grossem Bedenken als neu auf; den Speziesnamen habe ich von den beiden dicken Schwielen entlehnt, welche dicht neben dem Rande des Labellum nach der Spitze zu verlaufen.

Pleurothallis Liebmanniana Kränzl. n. sp. [*Sicariae*?].

Caules vix ancipites, leviter compressi (summitas tantum praestat). Folium oblongum, obtusum, crassum, carnosum, apice minutissime triapiculatum, subtus non carinatum, sessile leviter concavum, ad 10 cm longum, 4 cm latum. Spicae complures succedaneae, dimidium folii aequantes v. paulo superantes, 5 cm longae, pauciflorae, folio appressae, bracteae 3 ad 4 mm longae, triangulae, acutae, quam ovaria multo breviores, ovaria turbinata, profunde sulcata, dense pilosa. Sepalum dorsale oblongo-lanceolatum, acutum, intus sub apice papillosum, extus dense velutinum ut etiam lateralia, illa in synsepalum, antice biapiculatum connata, basi in saccum brevissimum aucta, leviter falcata, omnia 8 ad 9 mm longa, dorsale 2 mm, synsepalum 3,5 mm latum. Petala lineari-spathulata, acuta, sub apice erosulo-denticulata, 1,5 ad 2 mm longa, vix ½ mm lata. Labellum breviter unguiculatum, toto ambitu ovatum, antice rotundatum, obtusissimum, basi auriculatum potius quam lobulatum, utrinque pone marginem tuberculato-callosum, callo utroque angustato, antice in callum majorem ante ipsum apicem labelli aucto, totum labellum cum ungue 2,5 mm longum, 2 mm latum. Gynostemium petalis aequilongum, superne dilatatum, denticulatum, fere illud *Trichopiliarum* referens. De colore nil constat.

Mexico, ohne genaueren Standort (Liebmann, ohne n.!).

Bemerkung. Dem äusseren Aussehen nach *Pl. prolifera* Herb. sehr ähnlich, aber in allen Merkmalen der Blüte abweichend. Das Labellum hat hinsichtlich der Verteilung der Calli nicht seines Gleichen, es sind 2 basale, die nach vorn hin sich in schmale, convergierende Streifen verschmälern, welche ihrerseits die Verbindung mit einer grösseren Callusbildung vor der Spitze der Labellums herstellen. Die Säule hat Ähnlichkeit mit der einer *Trichopilia*, aber dies Merkmal ist, ebenso wie die ziemlich winzigen, vorn gezähnelten Petalen bei Pleurothallis nicht selten. Das im übrigen sehr gut erhaltene Exemplar war so kurz unter dem Blatteinsatz abgeschnitten, dass es nicht absolut sicher ist, ob der Stengel abgerundet oder scharf zweischneidig ist, das Merkmal, auf welches hin Lindley die Abteilung „*Sicariae*“ aufstellte. Das Blatt ist sehr dick und sehr fleischig. Über die Blütenfarbe wage ich nichts zu sagen; der Alcohol, in welchem das Exemplar Jahre lang gelegen hatte, zeigte eine hellbraune Farbe, etwa wie dünner Kaffee.

Restrepia Liebmanniana Kränzl. n. sp. — [*Pleurothallidiformes*].

Plantula pusilla, caespitifica, radices pro rata longae, caules numerosi, circ. 5 mm alti, basi vaginis 2 superpositis, ochreatis, superne retusis vestiti, monophylli. Folia lanceolata, acuta, manifeste marginata, basi contracta, quasi petiolata, apice triapiculata, satis firma, subcoriacea, 1 ad 1,3 cm longa, ad 4 mm lata. Pedunculi filiformes, basi vagina brevissima, acuta cincti, semper uniflori, floribus tamen succedaneis, bractea ovata, acuta, pedicellum longe non aequans, tota inflorescentia a basi florem usque 3 ad 4 cm longa, pedicelli ipsi 5 mm longi. Ovarium jam sub anthesi crassiusculum, 3,5 mm longum, 2 mm crassum, sexcostatum, costis valde prominentibus, parum undulatis. Sepala lanceolata, omnia libera, inter se aequalia, in caudam filiformem producta 5,5 mm longa, circ. 1,5 mm lata. Petala lanceolata, acuminata, margine distanter ciliolata, vix 2 mm longa. Labellum tota ambitu lineare, in tertia superiore dente acuto paulum prosiliente praeditum, antice convexum, apice obtusum, tota superficie, praesertim inter dentes laterales pilosum, 2 mm longum. Gynostemium breve, acutum, androclinium minute dentatum; Flores purpurascentes?

Restrepia Liebmanniana. ¹/₁.

Mexico. Mirador (Liebmann!).

Bemerkung. Die Pflanze zeigt schwache Anklänge an *R. ujarensis* Rchb. f., sie hat die gleiche Grösse und dieselben Blätter. Die ganze Anlage aber der Blüte sowie ihre ganze innere Struktur sind völlig verschieden. Ich hatte nur 2 Exemplare zur Verfügung, die zum Glück alle beide gut erhalten waren. Eigentümlich und bei *Restrepia* nicht allgemein üblich sind die 6 stark hervortretenden Flügel des Ovariums. Das ganze Gewächs zeigt starke Anklänge an *Pleurothallis*, so unter anderem an *Pl. aristata* Hook., es ist aber, wie ein einziger Blick auf die vegetativen Teile allein schon zeigt, eine echte *Restrepia*.

Sobralia polyphylla Kränzl. n. sp. [§ A. *Brasolia* Rchb. f.].

Caulis strictus, elatus, tenuis, circ. 45 cm altus, foliosissimus, vaginae foliorum subancipites, granulosae, 1,5 cm longae, laminae articulatae (rarius tamen deciduae) gramineae, strictissimae, e basi paulo latiore sensim augustatae, acuminatae, apice ipso inaequaliter bilobae, ad 15 cm longae, basi 6 ad 7 mm latae, subtus carinatae, nervis utrinque 12 ad 13 valde prominentibus percursae. Inflorescentia unica ex axilla quadam apici proxima oriens, brevis, pauciflora, fractiflexa, bracteae pro rata conspicuae, late ovatae, obtusae, cucullatae, 3 mm longae et latae, persistentes, rubrae (?). Sepala late ovata, basi excavata, ambo mentulum duplex, brevissimum formantia, acuta. Petala mihi non visa. Labellum e basi cuneata dilatatum, oblongum, antice obscure trilobum, basi lineis subparallelis percursum, pilis crystallinis elegantissimis ornatum, in disco lineis incrassatis tuberculosis praeditum, margine undulatum, totum perigonium mihi purpureum visum, circ. 5 ad 6 mm longum, Gynostemium mihi non visum, ovarium extus crystallino-papillosum.

Mexico: Mirador (Liebmann!).

Bemerkung: Wer die Abbildung von *Ponera australis* Cogn. in der Flora Brasil. zur Hand hat oder kennt, der hat ein frappant ähnliches Bild des Gesamthabitus der Planze. Die erste und zwar sehr wichtige Abweichung liegt nun in der Anlage des wenigblütigen Blütenstandes, welcher hier dicht unter den obersten Blättern entspringt. Soweit der äusserst schlechte Zustand derselben noch ein Urteil erlaubte, war er etwas unregelmässig im Zickzack gebrochen, die Deckblätter breit, kurz und kahnförmig, die Ovarien und die Basis der Blüten aussen dicht mit krystallhellen Papillen besetzt. Die Blüten waren leider in trostlosem Zustand, von einer einzigen habe ich den basalen Teil untersuchen können, dieser zeigte, dass die beiden seitlichen Sepalen am Grunde ausgehöhlt waren, ferner war das Labellum noch zur Not erkennbar, er hatte an der Basis einen Überzug von äusserst zierlichen krystallhellen Haaren, auf dem Discus jedoch strahlenförmig verlaufende dick-papillose Leisten, der Rand war entschieden gewellt, die Umrissform im ganzen wohl nahezu kreisförmig oder sehr breit eirund mit schwach entwickelter Teilung. Petalen und Säule waren völlig zerstört. Man könnte angesichts der winzigen Blüten an *Elleanthus* denken, aber ich möchte dies ablehnen, denn die Basis des Labellums war zufällig gut erhalten und hier fehlten die beiden für *Elleanthus* so charakteristischen Buckel und jede dem ähnliche Bildung. Über dies Merkmal kann kein Zweifel obwalten. — Haben wir es hier mit etwa ähnlichem wie *S. stenophylla* Lindl. zu tun? Diese ist allerdings nur aus Demerara bekannt, aber die leider nur sehr ungenügende (gleichfalls auf schlechte Materialien gemachte) Diagnose in den „Folia“ passt beinahe Wort für Wort, nur dass ich „sepalis angustissimis“ anfechten müsste, denn von den Sepalen war die Basis leidlich erhalten und diese war ganz sicher breit, im übrigen wäre noch die Kleinheit der Blüten zu erwähnen, welche für eine Sobralia unverhältnissmässig winzig sind. Leider ist im Herbar Lindley keine Analyse dieser Art vorhanden, auch Lindley hatte nur „one withered unexaminable flower“ gesehen. — Eine Notiz über den Sammler fehlte, das Spannblatt trug nur das eine Wort „Mirador“.

Camaridium xylobiichilum Kränzl. n. sp.

Sympodia satis abbreviata, cataphylla mox in folia evoluta, folia congesta, late oblonga, apice obtuse biloba, infima 5 cm longa, arcte convoluta, basi 2 cm lata, maxima 20 cm longa, 4 cm lata. Pseudobulbi oblongi, subancipites, monophylli, unicus mihi visus 4,5 cm longus, 2 cm latus, 1,5 cm crassus, folium illius e basi arcte complicata petiolum ludente oblongum, apice bilobulum, ad 17 cm longum, 3,5 cm latum. Flores singuli e cataphyllorum axillis orientes, satis longe pedicellati, pedicello ad 6 cm longo, basi ipsa cataphyllis hyalinis longe acuminatis vestiti, uniflori, bractea propria brevissima, annularis, superne retusa, 3 mm longa, ovarium crassiusculum, 2,5 ad 4 cm longum, 6-sulcatum. Sepalum dorsale ovato-oblongum obtusum, lateralia tota basi connata, potius triangula, omnia 2,5 cm longa, basi 1,4 cm lata. Petala, augustiora (c. 1 cm lata 2 cm longa) supra gynostemium conniventia. Labellum elongato-rhombeum, e basi angustiore sensim dilatatum, vix trilobum dicendum, margine in dimidio inferiore paulo elevato, apice reflexum obtusum, cartilagineum, more *Xylobiorum* quorundam sulcatum, papilloso-scabrum, callus simplex in dimidio basilari vix v. non sulcatus, totum labellum 2,2 cm longum, medio 7 ad 8 mm latum, cartilagineum. Gynostemium crassum, latiusculum, in dorso carinatum, anthera magna, crassa, tota superficie papillosa (etiam margine, quo ciliata appareat). De colore nil scimus.

Heimat und Sammler unbekannt.

Bemerkung. Eine neue Art, welche ich mit grossem Bedenken aufstelle. Soweit Diagnosen in Betracht kommen können, ist sie nicht unter den bisher beschriebenen, wobei ich bemerke, dass mir nur *C. Biolleyi* Schlechter unbekannt ist, die aber z. Z. auch im Index Kewensis nicht zitiert wird. Von allen bisher beschriebenen zeichnet sich diese hier durch den gedrängten Aufbau und die grossen Blüten aus. Der Sympodialstamm, den man sonst bei *Camaridium* langgestreckt zu sehen gewöhnt ist, hat hier eine Länge von ein paar Zentimetern und ist dicht beblättert. Lang und dicht bescheidet ist jedesmal der Blütenschaft, der ein minimaler ringförmiger Deckblatt und darüber den langen Fruchtknoten trägt. Die Blüte selbst hat, abgesehen von den grösseren Abmessungen, gar nichts characteristisches ausgenommen etwa die papillose Anthere. Ich benutze Artnamen wie „*grandiflorum*“ nicht gern und habe hier den Vergleich mit dem Labellum von *Xylobium* herangezogen, obwohl auch dieser nicht allzuviel besagt, denn derartige Labellen sind bei allem, was sich um *Maxillaria* herum gruppiert, nicht allzu selten.

Macradenia mexicana Kränzl. n. sp. — [*Eumacradenia*].

Pseudobulbi et folia mihi non visa, adsunt solummodo summitates racemorum. Racemi ut videtur erecti, pauci-v. pluriflori, satis densiflori, bracteae ovato-lanceolatae, acuminatae, 5 ad 6 mm longae, 2 ad 2,5 mm latae, pedicelli cum ovariis ad 1 cm longi. Sepalum dorsale oblongum, obtusum, concavum, trinervium, sepala lateralia ovato-oblonga, basi paulum inaequalia, profunde concava, acutiora, omnia sub anthesi ringentia, 3 ad 4 mm longa, ad 2 mm lata. Petala oblongo-ligulata, obtusa, sepalis aequilonga, 1,25 mm lata. Labellum profunde cucullatum, simplex, toto ambitu obovatum, rotundatum, hand in lobulum linearem productum, ecallosum, in disco utrinque linea elevatula gyrosa, fere ellipsin formante instructum, 2 mm longum. Gynostemium apicem versus incrassatum, membranaceo-marginatum, leviter denticulatum, androclinium, amplum, postice rostro longo praeditum, rostellum triangulum, longe productum; anthera et pollinia mihi non visa.

Mexico (Liebmann ohne n. (?) Material in Alcohol).

Bemerkung. Von den bisher beschriebenen Arten unterscheidet sich diese hier durch das vollständige Fehlen des mittleren Abschnittes der Lippe, welcher bekanntlich auch bei den dreiteiligen Lippen der andren Arten ein schmales, ziemlich unbedeutendes Anhängsel ist, ausserdem sind die Abmessungen der Blüte auffallend klein. Hiervon abgesehen bestehen einige Ähnlichkeitspunkte mit *M. lutescens* Lindl. Die Säule hat besonders von der Seite gesehen die Eigenheit zweier rüsselförmiger Fortsätze, der obere mutet an wie ein Filament der — übrigens leicht abfälligen — Anthere; der untere ist das an der Basis ziemlich breite, alsdann dreieckige Rostellum. — Die ganze Pflanze ist ein ziemlich unansehnliches Gewächs; ihr Vorkommen in Mexico ist, nach dem, was wir sonst über die Verbreitung der Gattung wissen, nicht weiter erstaunlich.

Warmingia holopetala Kränzl. n. sp.

Pseudobulbi et folia mihi haud visa, racemus brevis, ad 6 cm longus, circ. 10-florus, bracteae parvae, triangulae, acuminatae, ad 4 mm longae, pedicelli cum ovariis curvati, 4 ad 5 mm longi. Sepala anguste lanceolata, longe acuminata, fere 1,2 cm longa, basin versus 2 mm lata. Petala lanceolata, acuminata, aequilonga, medio 2,5 mm lata, toto margine integra (nec ciliata nec denticulata). Labelli lobi laterales late trianguli v. potius trapezoidei, angulo externo obtusato-rotundati, margine integri, tenui-membranacei, lobus intermedius anguste linearis, calli 2 satis elevati, subcartilaginei a basi oblique apicem versus lobi cujusque decurrentes, totum labellum 1,2 cm longum, basi 5 mm latum. Gynostemium valde curvatum, stelidiis 2 cochleatis, palparum instar porrectis praeditum. Flores certe albidi, tenerrimi.

Brasilien. Minas Geraës bei Lagoa Santa (Warming!)

Bemerkung. Diese Art ist zweifellos weder *W. Eugenii* Reichb. f. noch *W. Loefgrenii* Cogn., sofern die Diagnosen und

Abbildungen beider Arten Glauben verdienen. Der Speziesname, welchen ich gewählt habe, enthält bereits einen markanten Unterschied, denn die beiden bisher bekannten Arten haben gezähnte bzw. gewimperte Petalen. Der andere Unterschied findet sich in dem Bau der Lippe, diese hat hier breite, dünnhäutige Seitenlappen, ohne eine Spur von Zähnelung am Rande mit 2 ziemlich hohen, schief nach vorn verlaufenden Kielen. Drittens sind die Blüten ganz erheblich kleiner als bei den beiden andern Arten. Sehr eigentümlich sind die beiden Stelidien, welche wie die Taster eines Insekts vorgestreckt sind.

Amblostoma tridactylum Rchb. f. var. **mexicanum** Kränzl. n. var.

Caulis et folia mihi non visa, adsunt ramuli 2 forsan ejusdem paniculae, 12 ad 15 cm longi, in parte superiore floriferi, pluri-ad multiflori, satis laxiflori, bracteae minutae, triangulæ, acutae, quam pedicelli cum ovariis 6 mm longi bene breviores, ovaria leviter triquetra. Sepala oblonga, acuta, aequalia v. lateralia paulum obliqua, extus obscure carinata, ad 7 mm longa, 3 v. 3,5 mm lata, textura duriuscula, saepius tuberculoso-incrassata. Petala obovata v. subspathulata, acutiuscula, sepalis breviora, 5 mm longa, bene angustiora, ad 1,5 mm lata. Labellum basi cum gynostemio in cupulam breve connatum, a basi latiuscula paulum angustatum, deinde subdilatatum, antice trilobum, lobi laterales subspathulati, incurvi, obtusi, lobus intermedius late triangulus, brevissimus, obtusus, calli satis obscuri 2 per discum decurrentes, lobus intermedius callis 3 brevissimis praeditus, totum labellum 5 mm longum, basi 2 mm, antice lobulis lateralibus explanatis 3,5 mm latum, sub anthesi gynostemii apicem amplectens. Gynostemium pro flore satis conspicuum, androclinium postice lobulo (filamento?) lato, utrinque, lobulo minore rotundato (stelidio) instructum, anthera lata reniformis, exacte 4-locularis. — De colore nil constant.

Mexico (Liebmann ohne n. (?) Material in Alcohol!).

Bemerkung. Blütenzweige von der Grösse und dem Aussehen derer von *A. tridactylum* Rchb. f. Das Labellum im ganzen dem jener Art sehr ähnlich, aber der Mittellappen sehr kurz und breit; die Cupula zwischen der Säule und der Basis des Labellums kürzer als bei jener Art. Die Säule hat hinten ein breites lappenähnliches Anhängsel, die Anthere und das Androclinium sind auffallend breit und erstere deutlich vierfächerig. Die ganze Blüte ist der von *A. tridactylum* an Grösse und sonstigem Aussehen sehr ähnlich, aber über und über schorfig, wie es oft bei *Epidendrum* vorzukommen pflegt.

Habenaria tetrodon Kränl. n. sp. — [*Quadratae*].

Planta certe alta, summitas tantum adest. Folia suprema ovato-oblonga, acuta, longe vaginantia, ad 7 cm longa, basi 2,5 cm lata. Racemus 40 cm longus v. exeunte anthesi etiam longior, laxiflora, multiflora, bracteae ovatae, acutae, 1,8 cm longae, basi 7 ad 8 mm latae, rhachis profunde sulcata v. alte costata, pedicelli florum 1 cm longi, ovaria leviter curvata, 1 cm longa, tricostata, costa postica multo altiore. Sepalum dorsale profunde cucullatum, ambitu ovatum, superne retusum, obtusissimum, carinatum, 7 mm longum, basi (expansum) 5 ad 6 mm latum, sepala lateralia oblonga, obtusa, deflexa et leviter reflexa, 8 mm longa, 4 mm lata. Petala latissime linearia, superne paulum dilatata, antice obtuse tridentata, basi in dentem brevem sed conspicuum producta, 5,5 mm longa, superne 3,5 mm lata, dens basilaris vix 1 mm longus. Labellum late lineare, obtusum, margine revoluto convexum, basi utrinque dente illi petalorum aequali praeditum, 1 cm longum, ad 2 mm latum, carnosulum, calcar filiforme, leviter curvulum, 2 ad 2,2 cm longum, apice acutum. Processus stigmatici brevissimi, crassissimi, canales antherae longiores, ascendentes, caudiculae polliniorum longiores, fere verticaliter ascendentes, anthera profunde bipartita. Flores virides? labellum certe intensius coloratum.

Genauer Standort und Sammler unbekannt, aber sicher südamerikanisch.

Bemerkung. Diese Art bildet eine Zwischenform zwischen *H. quadrata* Lindl., *H. eustachya* Rchb. f. und *H. odontopetala* Rchb. f. Sie hat den langen Blütenstand der beiden ersten Arten. *H. quadrata* hat unbedingt einfache Petalen ohne Zahn an der Basis und ein einfaches Labellum, *H. eustachya* hat die Petalen dieser neuen Art, hat aber ebenfalls ein einfaches Labellum, *H. odontopetala* endlich hat starke Ähnlichkeit mit beiden, aber am Grunde der Petalen und des Labellums nur ausspringende Ecken. Die Underschiede sind klein aber hinlänglich markant, um eine neue Art zu rechtfertigen. — Ich hatte zur Verfügung ein Gipfelstück der Pflanze in Alcohol und dies war ausgezeichnet erhalten; leider fehlten mir alle Angaben; ich möchte auf Mexico als Heimat und auf Liebmann als Sammler raten. — Den Speziesnamen habe ich von den 4 kleinen Zipfeln der Petalen und des Labellums entlehnt, welche trotz ihrer Kleinheit deutlich hervortreten.

Habenaria amblyantha Kränzl n. sp. — [*Odontopetala*].

Caulis et folia mihi non visa, planta certe mediocris v. alta. Spica ad 15 cm longa, densiuscula, multiflora, bracteae ovato-lanceolatae, acuminatae, ovariae aequantes, apicem versus minute denticulatae, ± 1 cm longae, basi 3 mm latae. Sepalum dorsale profunde cucullatum, pro rata magnum, apice rotundatum, margine minute ciliolatum, 4,5 mm longum, vi expansum 4 mm latum, sepala lateralia deflexa, elliptica, concava, extus obscure carinata, obtusissima, apicem versus minute ciliolata, 5 mm longa, 2,5 mm lata. Petala e basi paulo tantum latiore paulum v. vix angustata, late ligulata, apice retusa, margine non ciliolata, basi non producta neque angulata, 3 mm longa, 1,5 lata. Labellum simplex, basi non angulatum, late ligulatum, obtusissimum, revolutum, 4 mm longum, 1,2 mm latum, calcar filiforme, paulum ampliatum, apice obtusum, 1,2 cm longum. Processus stigmatici breves, crassi, pistilliformes, canales antherae longiores, arrecti. — Flores luteo-virides v. virides. — Floret?

Ohne genaueren Standort aber wahrscheinlich von Liebmann in Mexico gesammelt.

Bemerkung. Die Pflanze ist leider nicht vollständig, ich hatte nur einen in Alcohol conservierten Blütenstand zur Verfügung, der aber war gut erhalten. — Die nächstverwandte Art ist *H. hexaptera* Lindl. und ich war zunächst geneigt, das Exemplar mit diesem zu identifizieren, aber es stimmt kein einziges Merkmal ganz genau, dazu sind die Abmessungen hier ganz entschieden kleinere. Die Andeutung einer Teilung der Petalen und des Labellums, von der sich bei *H. hexaptera* wenigstens noch Spuren finden, fehlt hier durchweg. Der grösste Teil der Blüte ist das obere Sepalum, welches von fern an das der Section *Platycoryne* erinnert; im übrigen ist diese Pflanze ganz und gar ein *Odontopetalum.* Alle Blütenteile sind vorn abgerundet oder sehr stumpf und ich habe daraufhin den Speciesnamen geprägt. Dies mag sonst auch noch vorkommen, ich erinnere mich aber nicht, es so ausgesprochen gesehen zu haben. — Was *Platycoryne* angeht, so hat diese neuerdings wieder zur Gattung zurückerhobene Sektion durchweg die Merkmale der echten Habenarien. Das grosse dorsale Sepalum findet sich anderswo auch, wenn auch nicht so gross. Es wäre gut, wenn sich einzelne Gruppen von dieser noch grade unbequem grossen Gattung abtrennen liessen, nur müsste es dann auf bessere Merkmale hin geschehen.

4--2--1920.

Andelsbogtrykkeriet i Odense.

THE STRUCTURE AND BIOLOGY OF ARCTIC FLOWERING PLANTS.

12.

A List of Arctic Caryophyllaceæ,

with some synonyms.

By

C. H. Ostenfeld.

1920.

Reprinted from »MEDDELELSER OM GRÖNLAND« Vol. XXXVII

Arbejder fra den botaniske Have i København. Nr. 88.

Hitherto, the following papers have been published in "Meddelelser om Grønland":

Vol. XXXVI:

Vol. XXXVII:

1. **Moehringia lateriflora** (L.) Fenzl, Verbr. Alsin. tab. zu S. 18 (1833); *Arenaria l.* L. Sp. pl. 423 (1753).

2. **Merckia physodes** Fisch. ap. Cham. & Schlecht. in Linnæa I. 59 (1826); *Arenaria ph.* Fisch. in D.C. Prodr. I, 413 (1824).

3. **Arenaria ciliata** L. Sp. pl. 425 (1753).

1. subsp. **norvegica** (Gunn.) Fries, Mant. II, 34 (1839); *A. norvegica* Gunnerus, Fl. Norv. II, 144 (1772), tab. 9, fig. 7—9; *A. humifusa* Wahlenb., Fl. Lapp. 129 (1812); *A. ciliata*, β, *humifusa* Lange, Consp. Fl. Groenl. 27 (1880).

2. subsp. **pseudofrigida** Ostf. & Dahl, Nyt Magaz. Naturv. LV, 217 (1918).

4. **Stellaria media** (L.) Vill., Hist. pl. Dauph. III, 615 (1789); Lange, Consp. Fl. Groenl. 27 (1880).

5. **Stellaria longipes** Goldie, Edinb. Philisoph. Journ. VI, 327 (1822); Lange, Consp. Fl. Groenl. 29 (1880); *S. Edwardsii* R. Br., Chlor. Melvill. 13 (1823).

6. **Stellaria borealis** Bigel., Fl. Boston. ed. 2, 182 (1824); Lange, Consp. Fl. Groenl. 28 (1880); *S. alpestris* Hartm., Handb. Scand. Fl. ed. 2, 132 (1832); *S. calycantha* Bong., Veget. Ins. Sitcha 127 (1853).

7. **Stellaria humifusa** Rottb., Kiobenh. Selsk. Skrift. X, 447 (1770), tab. 4, fig. 14; Lange, Consp. Fl. Groenl. 28 (1880).

8. **Stellaria crassifolia** Ehrh., Hannov. Magaz. VIII, 116 (1784).

9. **Stellaria longifolia** Mühlenb. in Willd. Enum. Hort. Berol. 479 (1809).

10. **Stellaria graminea** L. Sp. pl. 422 (1753).

11. **Cerastium trigynum** Vill., Prosp. 48 (1779); Lange, Consp. Fl. Groenl. 30 (1880); *Stellaria cerastioides* L. Sp. pl. 422 (1753); *C. cerastioides* Britton, Mem. Torr. Bot. Club. V, 150 (1894); (?) *C. lapponicum* Crantz, Instit. II, 402 (1766); Lindman, Svensk Fanerog. Fl. 240 (1918).

12. **Cerastium nigrescens** Edmondston, Fl. of Shetland 29 (1845); *C. Edmondstonii* (Watson) Murb. & Ostf., Bot. Notis. 246 (1898); *C. latifolium* auctt., non L.; *C. latifolium*, β, *Edmondstonii* Watson, in Edmondston, Fl. of Shetland 29 (1845); *C. arcticum* Lange, Fl. Dan. Fasc. 50 (1880), tab. 2962, ex parte, non Lange, Consp. Fl. Groenl. 31 (1880).

13. **C. Regelii** Ostf., Vidensk. Selsk. Skr. Kristiania 1909, No. 8, 10 (1910); *C. alpinum*, γ, *cæspitosum* Malmgren, Spetsb. Fanerog. fl., Öfvers. Sv. Vet. Akad. Förh. Stockholm 242 (1862).

14. **C. alpinum** L. Sp. pl. 438 (1753); Lange, Consp. Fl. Groenl. 31 (1880).

var. **lanatum** (Lam.) Hegetschw., Reisen 154 (1825); *C. lanatum* Lam., Encyclop. I, 680 (1783—84).

var. **pulvinatum** Simmons, Sec. Arct. Exp. Fram 1898—1902 No. 2, 122 (1906); *C. alpinum*, var. *cæspitosum* auctt., non Malmgren.

subsp. **Fischerianum** (Ser.) Torr. & Gray, Fl. North Am. I, 188 (1838); Ostenfeld, Vidensk. Selsk. Skr. Kristiania 1909, No. 8, 39 (1910); *C. Fischerianum* Seringe, in D.C. Prodr. I, 419 (1824).

15. **Cerastium arvense** L. Sp. pl. 438 (1753); Lange, Consp. Fl. Groenl. II, 245 (1887).

16. **Cerastium cæspitosum** Gilib., Fl. Lithuan. V, 159 (1781); *C. vulgatum* L. Sp. pl. ed. 2, 267 (1762), non Fl.

Suecic. ed. 2 (1755), 158; *C. vulgare* Hartm., Handb. Scand. Fl. ed. 2, 182 (1820).

subsp. **fontanum** (Baumg.) Gürke, Pl. Eur. II, 223 (1899); *C. fontanum* Baumgarten, Stirp. Transilv. I, 425 (1816); *C. vulgatum*, **alpestre* Lindbl. in Fries, Summ. Veg. Scand. I 37 (1845); Lange, Consp. Fl. Groenl. 30 (1880); *C. vulgare*, subsp. *alpestre* Murb., Botan. Not., 253 (1898).

17. **Cerastium maximum** L. Sp. pl. 439 (1753).

18. **Honckenya peploides** (L.) Ehrh., Beitr. II, 181 (1788); *Arenaria p.* L. Sp. pl. 423 (1753); *Halianthus p.* Fries, Fl. Halland 75 (1817); *Ammodenia p.* Rupr., Fl. Samojed. cisural. 25 (1845).

var. **diffusa** (Hornem.); *Arenaria peploides diffusa* Hornem., Oecon. Plantel. ed. 3, 501 (1821); *Halianthus peploides* var. *diffusa* Lange, Comp. Fl. Groenl. 26 (1880).

19. **Minuartia verna** (L.) Hiern., Journ. of Bot. 37, 320 (1899); *Arenaria v.* L. Mant. I, 72 (1767); *Alsine verna* Wahlenb., Fl. Lapp. 129 (1812).

1. var. **hirta** (Wormsk.); *Alsine verna*, var. *hirta* Fenzl, in Ledeb. Fl. Ross. I, 349 (1842); *Arenaria hirta* Wormskiold, Fl. Dan. fasc. 28 (1819), tab. 1646; *Arenaria propinqua* Richardson, in Frankl. Journ. App. 17 (1823); *A. hirta*, β, *pubescens* Cham. & Schlecht., Linnæa I, 56 (1826); *Alsine verna*, γ, *hirta* et δ, *propinqua* Lange, Consp. Fl. Groenl. 24 (1880).

2. var. **rubella** (Wahlenb.); *Alsine rubella* Wahlenb. Fl. lapp. 128 (1812); *A. verna*, var. *rubella* Hartm., Scand. Fl. ed. 6, 149 (1854); *A. verna*, β, *rubella* Lange, Consp. Fl. Groenl. 24 (1880); *Arenaria hirta*, α, *glabrata* Cham. & Schlecht., Linnæa I, 56 (1826).

20. **Minuartia Rossii** (R. Br.) Graebn., in Ascherson & Graebner, Synops. Mitteleurop. Fl., Bd. V, 772 (1918); *Arenaria Rossii* R. Br., Chloris Melvill. 14 (1823); *Alsine R.*

Fenzl, Verbr. Alsin. tab. zu S. 18 (1833); Lange, Consp. Fl. Groenl. 25 (1880).

21. **Minuartia stricta** (Sw.) Hiern., Journ. of Bot. 37, 320 (1899); *Spergula stricta* Swartz, Vetensk. Akad. Handl., Stockholm, 20, 227 (1799); *Alsine s.* Wahlenb., Fl. lappon. 127 (1812); Lange, Consp. Fl. Groenl. 25 (1880).

22. **Minuartia arctica** (Stev.) Graebn., in Ascherson & Graebner, Synops. Mitteleurop. Fl., Bd. V, 772 (1918); *Arenaria arctica* Stev., in D.C. Prodr. I, 404 (1824).

23. **Minuartia macrocarpa** (Pursh) n. comb.; *Arenaria macrocarpa* Pursh, Fl. Am. Septentr. 1, 318 (1814); *Alsine m.* Fenzl, Verbr. Alsin., tab. zu S. 18 (1833); Ostenfeld, in Vid. Selsk. Skr. Kristiania, 1909, No. 8, 37 (1910).

24. **Minuartia biflora** (L.) Schinz & Thell., Bull. Herb. Boiss., 2 sér. VII, 403 (1907); *Stellaria biflora* L. Sp. pl. 422 (1753); *Alsine b.* Wahlenb., Fl. Lappon. 128 (1812); Lange, Consp. Fl. Groenl. 23 (1880).

25. **Minuartia groenlandica** (Retz.) n. comb.; *Stellaria groenlandica* Retz., Fl. Scand. ed. 2, 107 (1795); *Arenaria g.* Spreng., Syst. II, 402 (1825); *Alsine g.* Gray, Manuel, ed. 2, 58 (1856); Lange, Consp. Fl. Groenl. 26 (1880).

26. **Sagina cæspitosa** (J. Vahl) Lange, Tillæg No. 6 ad Rink, Grønland Bd. II, 33 (1857); Consp. Fl. Groenl. 22 (1880); *Spergula* (*Arenaria*) *cæspitosa* J. Vahl, Fl. Dan. fasc. 39 (1840), tab. 2289; ? *Spergula saginoides*, var. *nivalis* Lindbl., Physiogr. Sällsk. Skr. 328 (1837—38).

27. **Sagina intermedia** Fenzl, in Ledeb. Fl. Ross. I, 339 (1842); *S. nivalis* Lange, Consp. Fl. Groenl. 22 (1880), et auctt.; Fries, Mant. III, 31 (1842) ex parte.

23. **Sagina Linnæi** Presl, Reliq. Haenk. II, 14 (1831); Lange, Consp. Fl. Groenl. 21 (1880); *Spergula saginoides* L. Sp. pl. 441 (1753); *Sagina saginoides* Dalla Torre, Anl. Beob.

Alpenpfl. 189 (1882); *S. saxatilis* Wimm., Fl. Schles. 193 (1832).

29. **Sagina procumbens** L. Sp. pl. 128 (1753); Lange, Consp. Fl. Groenl. 21 (1880).

30. **Sagina nodosa** (L.) Fenzl, in Ledeb., Fl. Ross. I, 340 (1842); Lange, Consp. Fl. Groenl. 23 (1880); *Spergula nodosa* L. Sp. pl. 440 (1753).

31. **Dianthus alpinus** L. Sp. pl., 412 (1753).

32. **Dianthus superbus** L. Sp. pl. ed. 2, 589 (1762).

33. **Silene acaulis** L. Sp. pl. ed. 2, 603 (1762); Lange, Consp. Fl. Groenl. 19 (1880).

34. **Silene tenuis** Willd., Enum. Hort. Berol. 474 (1809).

35. **Viscaria alpina** (L.) G. Don, Gen. Syst. I, 415 (1831); Lange, Consp. Fl. Groenl. 19 (1880); *Lychnis a.* L. Sp. pl. 436 (1753).

36. **Melandrium apetalum** (L.) Fenzl, in Ledeb., Fl. Ross. I, 326 (1842); Lange, Consp. Fl. Groenl. 19 (1880); *Lychnis apetala* L. Sp. pl. 437 (1753); *Wahlbergella a.* Fries, Summa Veg. Scand. 56 (1845).

37. **Melandrium affine** J. Vahl, Fl. Dan. fasc. 40, 5 (1843); *Lychnis aff.* J. Vahl, in Fries, Mant. III (1842); *M. involucratum* (Cham. & Schlecht.), β, *affine* Rohrbach, Linnæa 216 (1869); Lange, Consp. Fl. Groenl. 20 (1880); *Wahlbergella aff.* Fries, Summa Veget. Scand. 56 (1845).

38. **Melandrium triflorum** (R. Br.) J. Vahl, Fl. Dan. fasc. 40 (1843), tab. 2356; Lange, Consp. Fl. Groenl. 20 (1880); *Lychnis triflora* R. Br., in Ross, Voy. (1819).

TYP. BIANCO LUNO. KBHVN.

THE STRUCTURE AND BIOLOGY OF ARCTIC FLOWERING PLANTS.

13.

Caryophyllaceæ.

By

Eug. Warming.

1920.

Reprinted from »MEDDELELSER OM GRÖNLAND«
Vol. XXXVII

Arbejder fra den botaniske Have i København. Nr. 89.

Hitherto, the following papers have been published in "Meddelelser om Grønland":

Vol. XXXVI:

Vol. XXXVII:

As an introduction to my description of the morphology, anatomy and flower-biology of the Arctic *Caryophyllaceæ*, Professor C. H. Ostenfeld has kindly prepared the preceding systematic list of the species.

My description, which follows, is based: —

(1) On the investigations made in the Arctic Herbarium of the Botanical Museum of the University of Copenhagen, and on the alcohol material belonging to the same Museum, which has, in the course of years, been collected by the numerous Danish scientific expeditions to Greenland, (P. Eberlin, N. Hartz, Th. Holm, Chr. Kruuse, Andr. Lundager, C. H. Ostenfeld, L. Kolderup Rosenvinge, C. Ryder, Eug. Warming, etc.).

To this may be added some material which was collected in Iceland by Helgi Jónsson and C. H. Ostenfeld, and in Scandinavia (Finmark, Dovre, Finse) by Eug. Warming and others, and a small amount brought home by Swedish Expeditions to Spitzbergen.

(2) On the investigations and notes which I have made on living material in Greenland, Scandinavia and the Færöes.

(3) On the numerous notes found in the literature on the subject, especially in the Danish, Norwegian and Swedish. With regard to these notes the reader is referred to the list of literature at the end of this treatise.

I have divided the following description into four sections, viz.

I. Morphology and Vegetative Propagation.
II. Leaf Anatomy.
III. Adaptations to the Environments.
IV. Flower Biology and Notes on Seed-production.

I. Morphology and Vegetative Propagation.

According to the duration of life, and the forms of the vegetative shoots and the combinations of them, etc., I divide the species — for the sake of a general survey — into the following groups: —

A. The *Melandrium* type. Spot-bound,[1] pollacanthic, semi-rosette plants.

B. The *Silene acaulis* type. Spot-bound species, of which the long-shoots have short internodes, and narrow leaves.

C. The *Sagina nodosa* type. Spot-bound, pollacanthic species, with shoots which must be described as long-shoots with elongated internodes, although the basal leaf-pairs are close-set. Monopodial rosette shoot, at least in some of the species. No propagation by means of aërial runners.

D. The *Cerastium alpinum* type. Spot-bound, pollacanthic species, the shoots of which also usually have shorter internodes at the base, and must be called long-shoots, but which have terminal flowers (sympodia), and on which aërial runners are developed. Vegetative propagation can take place by means of layers.

E. The *Cerastium arvense* type. Species with shoots like those of D, but which have both aërial and subterranean runners, and a more constant vegetative propagation by means of runners.

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[1] Spot-bound, that is, they have no horizontal shoots or runners, with which they can form "layers" (see Warming, 1884).

F. The *Stellaria crassifolia* type. Shoots like those of E, but with hibernacula.

G. The *Stellaria media* type. Hapaxanthic species.

It must be remarked, that there is absolutely no distinct limit between these groups — nor anywhere else in the plant-world — and it is possible that more exhaustive investigations will prove, that there are several more species with subterranean runners, than those quoted by me.

Fig. 1. *Melandrium apetalum.*

A. The Melandrium type.

Spot-bound, caespitose, pollacanthic species, with typical rosettes on semi-rosette shoots. The uppermost parts of the flowering shoots with elongated internodes usually protrude far above the rosettes (Fig. 1). No markedly pulvinate forms.

To this type belong the following *Sileneæ*: — *Melandrium affine*, *M. apetalum*, *M. triflorum*, *Viscaria alpina* and *Dianthus superbus*. Of non-Arctic: *Melandrium diurnum*, *Lychnis flos cuculi*, *Silene otites*, etc.

These are all perennial, usually vigorous herbs with a tap-root which remains during the whole life of the plant; but they are either devoid of or rarely provided with adventitious roots, which, when present, are insignificant. Vegetative propagation does not take place.

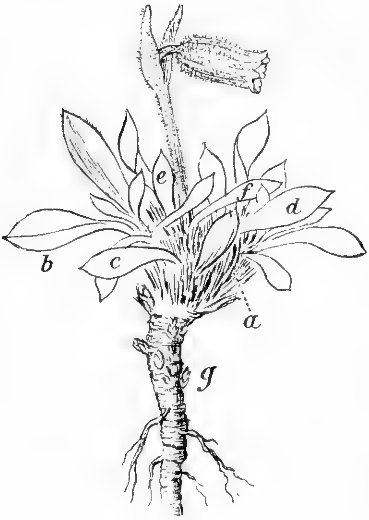

Fig. 2. *Melandrium apetalum* β *arcticum*. (Spitzbergen). *g*, Buds on the naked axis, either root-shoots or rather buds from the axils of rosette-leaves which have died and disappeared. *a*, Fragments of dead leaves. *b*—*e*, fresh leaves. Hairs omitted. (E. W.)

The larger the individuals are, the stronger is the tap-root, and the deeper does it grow down into the ground.

The shoots are semi-rosette-shoots, *i. e.* they have a typical rosette at their base, but otherwise have elongated internodes (long-shoots). The leaves are large when compared with those of the *Alsineæ*. Scale-leaves are absent. Lateral shoots, similar in structure to the main shoot, are developed from the axils of the rosette-leaves. All these shoots are erect or ascending. They are most frequently di-pleiocyclic, *i. e.* they remain 2—3 or more years in a vegetative stage, before their internodes elongate and flowers are developed; many undoubtedly remain throughout their whole life in the vegetative stage. On an older plant the basal part is therefore composed of barren shoots (rosette-shoots) and of flowering shoots or the basal, dead portions of such shoots (Fig. 2), since at the commencement of the cold season, the shoots die so far down, that only small basal portions remain alive, which bear the buds for the next year. This results in a complex of shoots and portions of shoots which are held together by the tap-root and which have formerly been called "Rhizoma multiceps", "Radix multiceps" or, by Hj. Nilsson, "pseudorhizom", "Skott-basis-Komplex". In 1918 I suggested the old name "mesocormus" for it ("caudex", "Mellemstok", the French "souche").

Plants, with the structure described above, are typically cæspitose in habit (*plantæ cæspitosæ*), and occur singly, often growing scattered on the ground.

The flowering shoots can, in the same species, e. g. in *Melandrium triflorum*, be either very short or long (for instance 25 cm.) — according to the prevailing conditions.

The germination, in some of the species, has been investigated by Sylvén and Warming. The cotyledons are epigeous and resemble, more or less, the rosette-leaves (cfr. Figs. 5, 8). The first rosette is found immediately above the cotyledons. On cultivating *Viscaria alpina* I found no development of lateral shoots in the year in which it germinated, but in the second year lateral rosettes occurred, and already in these there were buds for the lateral shoots of the 3rd order. Three-year-old plants of this species were already in flower; but otherwise the number of years necessary for a plant to spend in a vegetative stage before it can flower, undoubtedly varies greatly, according to the prevailing conditions. In nature the vegetative stage appears to last for several years (Sylvén).

Melandrium apetalum agrees in its main points with *Viscaria* (Sylvén).

Winter-stage. All the buds are open, and the youngest foliage-leaves are protected during the winter by the older, withering leaves. How many of these remain green during the winter, depends evidently on the prevailing conditions, for instance, if the plants are snow-covered during the winter, or are uncovered and perhaps exposed to cold and desiccative winds. Statements made by botanists regarding the appearance of one and the same species during winter, therefore vary somewhat. As regards *Viscaria* I made the following note in West Greenland, on June 28th, at the beginning of spring: "passes the winter in a green condition". Sylvén (p. 291) says the rosette of the young plant passes through the winter "in an open rosette-stage". As regards *Melandrium apetalum* Sylvén says that the rosette-shoot of the young plant appears to pass through the winter in a more or less green condition, and regarding *Wahlbergella angustiflora* from Lapmark: the plants reared under cultivation remained green during the winter (p. 290).

Foliage leaves which have remained green during the winter, undoubtedly die immediately upon the commencement of the following spring. The old, dead leaves may persist for a long time, until they gradually disappear, the cold Arctic climate having no great putrefactive power.

Lateral shoots may be somewhat arching, or even slightly prostrate, at their base. This appears to be most decided in *Dianthus superbus* in which, from the mesocorm, there may proceed obliquely-placed branches with elongated internodes on which there may even occur, here and there, slender adventitious roots, but it appears to be absolutely certain that no vegetative propagation takes place. Blytt (Norges Flora, p. 1073) mentions also these lateral shoots:

"numerous, short, sterile, leaf-bearing shoots," besides the "ascending or erect . . . stems." I have observed similar features in *Viscaria purpurea* (in Norway near Finse and in Denmark), and in *Viscaria alpina* there even appears to be an attempt towards the formation of scale-leaves on such shoots. In Denmark *Lychnis flos cuculi*, *Silene nutans* and *Melandrium dioecum* have similar shoots.

Pulvinate habit. Pulvinate forms develop easily from the typically cæspitose forms when the external conditions are unfavourable. When cold or strong wind checks the growth, the shoots become short and very much crowded, the entire mesocorm becomes very compact and closely set with branches, more or less semi-globular, and the flower-bearing portions of the shoots protrude only slightly above the surface of it. The pulvinate form is only a modification; to the same species may belong individuals with a divergently branched and long-branched mesocorm, and also dwarf-individuals with a pulvinate habit. The pulvinate form occurs at any rate in *Melandrium affine* and *apetalum.*

Adventitious Buds. On the naked vertical axis below the leaf-bearing mesocorm of old plants, small buds are sometimes seen, the origin of which may be doubtful (Fig. 2, *g*). Perhaps they are adventitious buds on the primary root, but it is more probable that they are axillary buds from former foliage-leaves on the main axis which buds have not had favourable conditions for their development. I have seen such buds in *Melandrium apetalum*, *M. affine* and *M. triflorum.*

B. The Silene acaulis type.

To this I refer only this one species, which is decidedly cæspitose in habit, and has a tap-root growing far down into the ground, but differs from the *Melandrium*-type in not having semi-rosette shoots, but long-shoots with short internodes. The primary root remains throughout the whole life of the plant, and can become very long. KRUUSE records the length as being 2 m, and SEIGNETTE almost 3 m.

The shoots may most properly be called long-shoots, and have close-set leaf-pairs, which do not cross each other at right angles, but grow in such a manner that, for instance, the 1st and the 4th leaf-pair stand perpendicularly above each other. Only a few (usually 4—5) fresh leaf-pairs occur simultaneously on each shoot, and these apparently form a small rosette at the end of the stem which is usually closely covered with old leaves and fragments of leaves (Fig. 3). The fresh leaves are immediately succeeded by the solitary, terminal flower (Fig. 3, *A*).

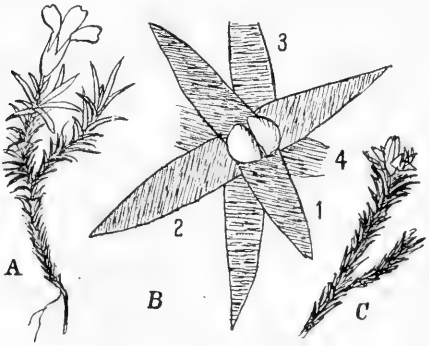

Fig. 3. *Silene acaulis.*
A, A branch (Norway). *B*, The apex of a branch seen from above; the leaf-pairs, following each other in succession, are indicated by figures, and are, moreover, shaded in various ways. In the centre are seen two fresh, young foliage-leaves, not yet unfolded (Iceland; H. Jónsson, 26. 3. 1894). *C*, A branch from northern Sweden. (E. W.)

From the base of the tap-root, leaf-shoots proceed in all directions, which shoots are more or less branched, and are almost equal in height and are, moreover, almost always densely crowded, so that a flattened, semi-globular cushion is produced. SCHRÖTER (pp. 582 and 583) calls this form "Flachpolster." The branching of the shoots in the interior of the cushion is well-illustrated in Mrs. THEKLA RESVOLL's Fig. 36, p. 144; a compact tuft is shown "opened" and the branches are spread out. There are scarcely any of the Arctic Caryophyllaceæ which are so typically pulvinate in habit as the present species. Many travellers have therefore described and illustrated these fresh-green, flatly-arched cushions, which during the flowering-period are covered with pink stars of 5 rays. Figures are found for instance in Bonnier, Lazniewski, Kerner (Pflanzenleben, Pl. 193), Börgesen (Botany of the Færöes), and in Feilden (Geog. Soc., April, 1898), C. Kruuse (1911, p. 358, Fig. 4) and others.

The shoots with their numerous old leaves, are usually so densely crowded in the cushions, that they form a spongy mass, which by its capillarity can absorb a great quantity of water. It is therefore very natural that adventitious roots are developed in their interior, which must to a certain degree take their nourishment from the old fragments of the plant's own leaves. But mention is also made of tolerably loose and divergently branched tufts, which may, for instance, have stems as long as 20 cm.; this is due to the nature of the station; as e. g. when the plant grows among damp moss, or in a particularly shady, damp locality.

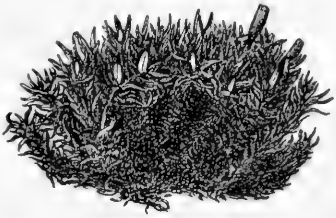

Fig. 4. *Silene acaulis.* A small portion of a tuft; about $^1/_1$. On some of the shoots the green leaves are seen, surrounded by dead leaves. (From Iceland; Helgi Jónsson; 31. 12. 1893.)

Tufts, eroded by the wind, are described and figured by Hartz and Kruuse. Kruuse (1912, Fig. 41, p. 270) writes: "The tufts reach a diameter of 30—40 cm and a height of 7—10 cm, but the windward is often eroded and dead." Kihlmann also records such tufts from Kola.

Vegetative propagation under natural conditions is not known to me, but as gardeners are able to divide the tufts, adventitious roots must be so vigorously developed, that propagation by layers can take place.

Winter-stage. HELGI JÓNSSON (1895, pp. 279 and 285) has described and figured shoots in the winter-stage (l. c. Fig. 3, B, reproduced in this treatise as Fig. 4), and I have, in Fig. 3, B, given an illustration of the apex of a shoot in the winter-stage. Imbedded between the dead (shaded) leaves are seen two young, erect, conical, fresh-green leaves, which cover still younger leaves. But the features evidently vary, according to the prevailing conditions; on a specimen from a spot recently bared of snow (Upernivik, May 10th; C. Ryder) I observed pale, flabby, dead leaves at the apex of the shoots, but far down between them fresh leaves occurred, some of which contained starch, and also flower-buds were found (Fig. 24). HELGI JÓNSSON also found starch in the living leaves in winter time. KJELLMAN writes (according to citation in Sylvén, p. 287) regarding young plants under cultivation: "The plant passes through the winter in a green condition, and at the end of the winter, continues its development just where it was interrupted by the commencement of winter," and SYLVÉN himself says: "The plant seems to pass the winter in an open rosette-stage; the outer leaves, however, appear to become brown and withered at an early stage."

The seedling has, according to KJELLMAN (1901), an epicotyl-shoot with elongated internodes. He says that "*S. acaulis* under cultivation belongs to the type with elongated internodes." SYLVÉN mentions (p. 287) the young plants as remaining in nature in a rosette-stage during the three first years, but as distinctly, although only slightly, elongating their internodes during the following years. TH. RESVOLL (1917; p. 141, Fig. 36) also found that the seedling develops a leaf-rosette, which during the year of germination produces "as many as 3 shoot-generations of lateral branches." Not until the 3rd year did the first individual flower. It consequently appears that the plant is on the point of transition to the semi-rosette stage.

Silene maritima, which so far belongs to the Arctic flora as it is found in Finmark and also in Iceland, appears to have exactly the same morphology as *S. venosa*, viz. a numerously branched mesocorm with erect long-shoots.

If any of the other species should be placed together with *Silene acaulis*, I believe it must be *Arenaria ciliata.*

C. The Sagina nodosa type.

To this group I refer *Minuartia biflora*, *M. arctica*, *M. hirta*, *M. groenlandica*, *M. macrocarpa*, *M. Rossii*, *M. stricta*, *M. verna* and the *Sagina*-species: *S. cæspitosa*, *S. intermedia*, *S. Linnæi*, *S. nodosa*, *S. procumbens*, and, for instance, the non-Arctic species, *S. saxatilis* and *S. subulata.* Arctic species, which I have not been able to investigate more closely, are *Alsine arctica* (Arctic America) and *A. macrocarpa.*

The above-mentioned species are generally low-growing plants, with the basal portions of the shoots close-set, and the flowering portions of the shoots protruding far outwards.

Primary root. Here also the primary root is, almost without exception (S. procumbens), the only root which is of any importance; it holds together the erect branches of the mesocorm. It remains during the whole life of the plant, and may be long, although it is most frequently slender, in accordance with the fact that the plants are small. Although adventitious roots may perhaps occur in all the species yet it appears that only in *S. procumbens* do they promote layering.

The characteristic feature in this group, when compared with all the others, as far as I have been able to see distinctly from the material to hand, is the fact that the primary shoot is monopodial; indeed, it remains vegetative throughout the whole life of the plant, and the flowering shoots occur as lateral shoots of short duration, upon it and upon the other monopodial shoots developed as lateral branches. As the mesocorm is short and has very short internodes, it bears a rosette of foliage-leaves, and for lateral shoots it has partly flowering shoots, with elongated internodes, and partly new monopodial rosette-shoots. In the middle of the mesocorm of a plant of the above-mentioned species, we therefore always find a rosette, which is formed of narrow, linear leaves, and below this rosette there are often a great number of laterally placed, flowering shoots. These lateral flowering shoots may be most appropriately called semi-rosette shoots. A specimen of such a plant is seen in the accompanying figure (Fig. 5) of *Sagina nodosa.*

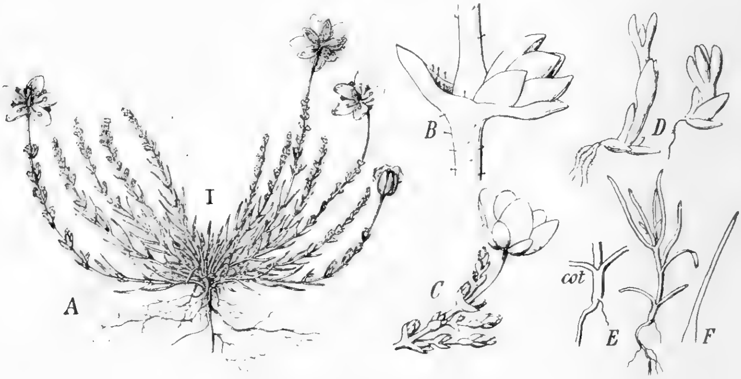

Fig. 5. *Sagina nodosa.*

A, (about $^1/_2$). In August; I, primary shoot. *B*, Bulbil in the axil of a subtending leaf. *C*, In the axil of one of the lower-most pair of leaves there is only a bulbil, in that of the other there is a small shoot and a bulbil as an accessory shoot; likewise in all the following leaf-axils. The branches are arranged according to the usual, peculiar *Caryophyllaceæ*-mode of branching. *D*, Germinating bulbils (October). *E*, Seedling. *F*, A foliage-leaf. (Material from Denmark). (E. W.)

A monopodial primary shoot and monopodial shoots of higher order are also found in *Sagina procumbens* and *S. subulata*, but hardly in all the *Sagina*-species; I do not think they are found in *S. apetala* for instance, nor in every species of *Minuartia*. It is often difficult to decide the exact condition, especially if the material to hand is not good. It is very desirable that the above-named and other species should be thoroughly investigated.

In monopodial species a terminal flower has exceptionally been found on the main axis, but it expands later than does the first flower on the lateral axes (Irmisch, Wydler). The monopodial structure has been treated of by the following authors: AL. BRAUN (Flora, 1843); IRMISCH (1848, pp. 529 and 561; Bot. Ztg., 1850, p. 297); WYDLER (Flora, 1851, p. 328; 1859, p. 314); GODRON (Flore de France, vol. 1, p. 245).

The leaf-pairs in the rosettes alternate with each other at acute angles, so that, for instance, first the 4th or 5th leaf-pair stands under the 1st.

The flowering lateral shoots appear, as a rule, to last for two years only (this was observed in *Minuartia biflora*, *groenlandica* and *verna*), but cases in which they last a longer time may undoubtedly occur.

In addition to the flowering lateral shoots, sterile monopodial shoots, like the primary axis, may also be developed. Sometimes, some of these become prostrate, for instance in *Sagina nodosa*, *S. procumbens*, *S. Linnæi*, *Minuartia biflora* and *M. verna*, and may then strike roots. With this there occurs a possibility for the formation of layers, and this may happen, at any rate in the non-Arctic *Sagina subulata*. As regards *Minuartia biflora* and *verna* THEKLA RESVOLL states decidedly that she has not observed vegetative propagation; but it is possible that this may take place once in a way in *M. verna*. In *Sagina procumbens*, on the other hand, vegetative propagation undoubtedly takes place by means of its rooting aërial shoots. To a certain degree it merits a special place, side by side with the *Stellaria*-type.

Sagina nodosa has a peculiar mode of propagation. In the axils of the foliage-leaves small, few-leaved shoots are developed (see Fig. 5): these shoots fall off and, on striking roots, form new individuals. For further details the reader is referred to the explanation of Fig. 5.

The Seedlings of *Sagina nodosa* immediately develop a rosette-shoot which sometimes forms branches during the first year. Its first internodes, however, are sometimes elongated (Fig. 5, *E*). In plants of *Minuartia stricta*, cultivated by me, small tufted plants were developed in the course of two months, lateral shoots with short internodes being quickly developed in some of the leaf-axils. In *M. biflora* THEKLA RESVOLL also found lateral shoots (Fig. 32), but SYLVÉN found none (loc. cit., p. 304). In other respects the seedlings of *Sagina Linnæi*, *Minuartia verna* and *M. intermedia* appear to correspond with those of *M. stricta* and *Sagina nodosa* (see Sylvén, p. 266 and Thekla Resvoll, Fig. 29).

As regards the time preceding the first flowering period THEKLA RESVOLL states, that it is not probable that *Sagina intermedia* flowers until the third year, but that *Minuartia verna*, when cultivated, had flowered in the 3rd year, and even in the 2nd year though sparingly, and that seedlings of *M. biflora*, when cultivated, flowered in the 3rd year; but, according to SYLVÉN, it appears that in nature the first vegetative-stage ("Forstærknings-Stadium") lasts for several years. It seems evident that the length of time is dependent on the prevailing conditions.

Pulvinate forms. The above-mentioned species are plants with a tufted habit, which may sometimes form dense cushions. In the same species the branch-systems may either be long and divergently placed, with flowers raised high above the ground, or they may be so short and crowded together that dense semi-globular or globular cushions are formed with flowers, lying almost upon the surface of the cushion, or resting upon it. In Fig. 6 three specimens are shown which belong to the form-cycle of *Minuartia verna*, and which show all these modifications within the same species. It is evident that the forms are dependent on the life-conditions prevailing in the stations.

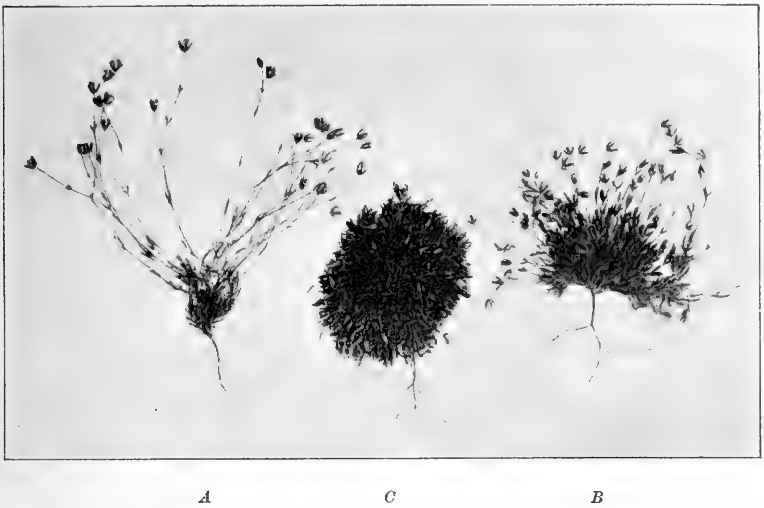

Fig. 6. *Minuartia verna* (reduced).
A, var. *hirta*. W. Greenland, 74°18′ N. lat. (C. Ryder). *B*, var. *hirta*. Scoresby Sound (N. Hartz). *C*, var. *rubella*. Spitzbergen (Hanna Resvoll Holmsen).

A pulvinate habit has been found to occur in *Minuartia verna* (Fig. 6), *M. biflora*, *M. Rossii* (Fig. 7), *Sagina Linnæi*, *S. cæspitosa*, *S. intermedia* and *S. procumbens* (as also in *S. subulata*). See figures in Simmons, Pl. 6, pp. 4—6 and in Ostenfeld and Lundager, p. 19. In his excellent treatise "Das Pflanzenleben der Alpen" C. SCHRÖTER (pp. 569—584) has given an account (accompanied by several figures) of plants with a pulvinate habit, and on p. 579 he has figured a cushion of *Alsine* (*Minuartia*) *sedoides*; he describes it as "halbkugelige Polster vom kahlem Azorella-Typus mit völlig glatter Oberfläche" . . . "Die Früchtchen sind in das Polster eingesenkt," etc. The species "gehört zu den letzten Pionieren der Vegetation."

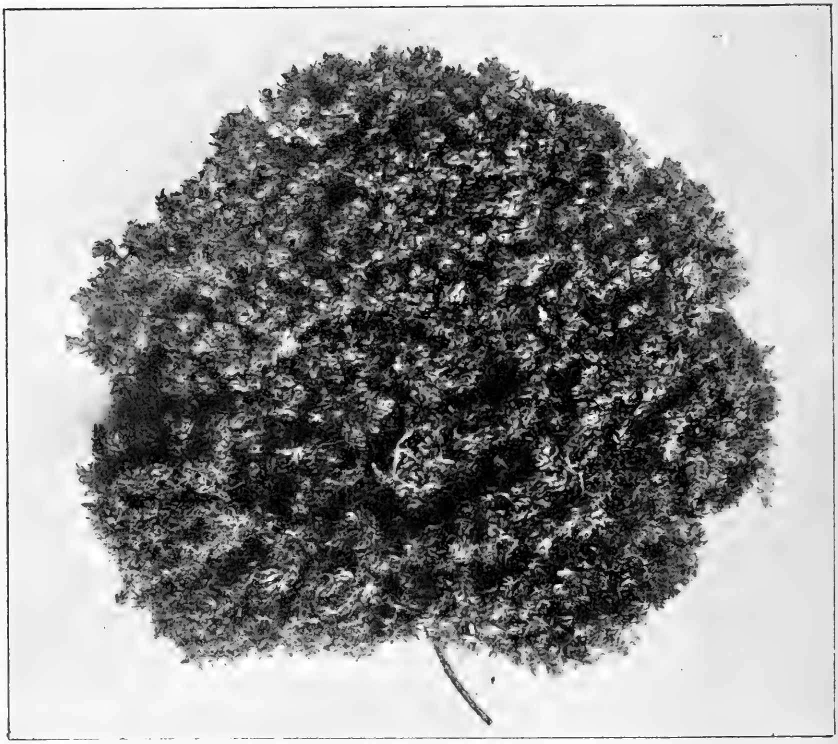

Fig. 7. *Minuartia Rossii.*
(Dragon Point; 21. 7. 1916; Thorild Wulff). A cushion seen from above. At the bottom the primary root is seen to protrude.

The Arctic cushions may be fairly flattened and carpetlike, without, however, being in reality "wandering." Slender, adventitious roots may occur in the interior of the cushions.

The Winter-stage. The same is the case here as in all the other Arctic Caryophyllaceæ: the buds are open; in the autumn there are fresh, green leaves, but during the winter many, or we may say, the majority of them, wither; nevertheless, the species may be called evergreen. At the commencement of spring, or of the time for the opening of the buds, the remaining leaves wither quickly. The degree of greenness of the plant is dependent on the station, especially if this is snow-covered or not.

D. The Cerastium alpinum type.

To this may be referred: *Cerastium alpinum*, *C. cæspitosum*, *C. nigrescens*, *C. Regelii* and *Arenaria ciliata*.

These also are typically spot-bound species, but there are no monopodial shoots, these being now if anything long-shoots with elongated internodes, even if the prevailing conditions may sometimes produce semi-rosette-like forms. Here also the internodes are shortest at the base of the shoots, and as branches arise more particularly from the base, mesocorms of the usual type are developed; the barren or flowering branches are held together by the primary root which remains during the whole life of the plant, but the branches of the mesocorm are not particularly close-set, and the basal shoots are often lying immediately upon the ground, spread out in all directions (cf. Fig. 9). This is probably an instance of psychrokliny, i. e. the direction of the stems is induced by the low temperature in accordance with Voechting's view. Added to this, the ground may possibly have been damp and this may have produced root-development; the pressure of the snow covering may also have had a part in it.

Adventitious roots are frequently developed on the prostrate shoots, but vegetative propagation does not take place, or rarely does so, through their agency.

Here also the habit of the plant is properly speaking tufted; to what a high degree the length of the shoots is dependent on the prevailing conditions, is evident from Sylvén's observations (*Cerastium alpinum*, pp. 299 and 300).

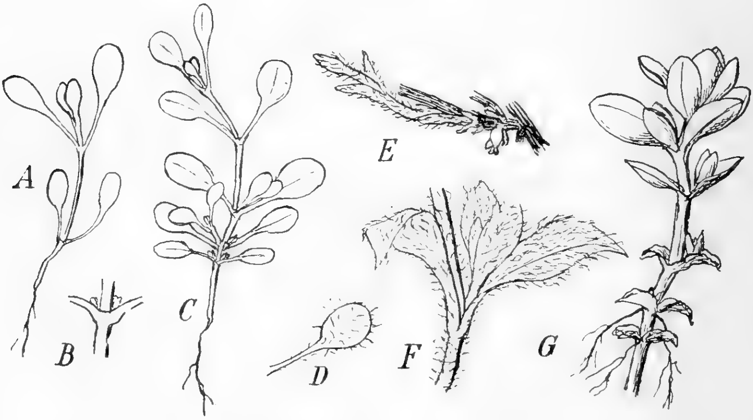

Fig. 8. *Cerastium alpinum.*

A, Young plant (from cultivation); about $^1/_1$. *B*, Basal portion of the cotyledons; buds are seen in both axils. *C*, Older plant (from cultivation; the internodes are less elongated than in *A*; after the cotyledons, the typical Caryophyllaceæ-branching appears, first with a vigorous shoot in the axil of the one leaf and a less vigorous in that of the opposite leaf, then with bud only in one of the axils of the two opposite leaves; in *A*—*C* the hairs are omitted. *D*, A leaf with its covering of hairs. *E*, Young shoot in spring. *F*, From N. E. Greenland; winter-stage, 21. 5. 1908 (A. Lundager). A pair of leaves with axillary shoot; there are no winter-buds nor any special covering for the buds. *G*, Branch of *Cerastium alpinum* γ *cæspitosum* (from E. Greenland). Secondary roots are developed; the hairs are omitted. (E. W.)

In nature the young plants appear to pass the winter "in a rosette-like-stage," he has, however, found the form *glabra* to develop in the first year" directly elongated internodes." The young plants which had been reared under cultivation had, on the other hand, an elongated, richly-branching and plagiotropic epicotyl-shoot." This was also the case with the young plants reared by me under cultivation (Fig. 8)

The commonly occurring Arctic species *Cerastium alpinum*, which varies exceedingly in colour and hairiness, may serve as a type. It may in certain conditions form very dense cushions, with short flowering shoots; but long, erect shoots, as much as 25 cm in length, may also be developed from the mesocorm (Fig. 9).

Fig. 9. *Cerastium alpinum.*
A, From W. Greenland, 29th July, 1884. *B*, f. *pulvinata.* From E. Greenland, 25th Aug., 1900. (Hartz and Kruuse).

Cerastium nigrescens appears to behave like *C. alpinum.* It may be divergently branched, with long, erect shoots — and this is the rule — or it may be densely branched, even

— in rare cases — so densely, that it becomes somewhat pulvinate.

C. caespitosum with its variety *alpestre* varies in the same manner as *C. alpinum* (Sylvén, p. 300). It has sometimes very long stems. *Cerastium Regelii* I have only seen divergently branched.

At the apex of the shoots a kind of rosette is often met with, in that the internodes here are short temporarily, and a kind of winter-bud is developed, as for instance in *Cerastium alpinum*; the youngest leaves and flower-buds of the latter must thereby and by means of the densely villous-haired leaves be provided with an excellent winter-covering (Fig. 8, F). It is not always that such a shoot-development appears.

Similar features are met with in *Arenaria ciliata*. The stems with elongated internodes may be erect, but may also be more or less prostrate and entangled, covered with white flowers. Pulvinate forms may develop, although not so decidedly as in the *Minuartia*'s and in *Silene*. In other respects, it most resembles the latter in the form of its branches and the position of its flowers. It may have several (apparently lateral) flowers upwards along a long axis. I regard this as a sympodium, but have observed cases which were doubtful.

Vegetative propagation it appears does not generally take place. Neither THEKLA RESVOLL nor I have observed such in *C. alpinum*, although this species may have adventitious roots (Fig. 8, *G*). SYLVÉN, however, mentions "subterranean runners with scale-leaves (or scale-foliage-leaves)" in *C. alpinum*. Nor has THEKLA RESVOLL found vegetative propagation to take place in *C. nigrescens* (*C. Edmonstonii*).

The seedlings. SYLVÉN found that seedlings of *Cerastium alpinum* when growing in nature hardly flowered "until after the lapse of 2 years." The seedlings of *Arenaria* *ciliata* β *norvegia* developed in Lappmark, in the year in which they germinated epicotyl-shoots with long internodes which often branched in the first year, but not until after the lapse of some years did they flower. Also under cultivation by me, they branched very soon.

Pulvinate forms. It is evident from what has been said regarding the form of the shoots, that there are not

Fig. 10. *Cerastium alpinum.*
The youngest part of the shoots are densely covered with woolly hairs.
(From Iceland; Helgi Jónsson; 16. 1. 1894.)

such good conditions for the development of a pulvinate habit as in the first three types. It does occur however (Fig. 9). *Cerastium caespitosum* has been found in East Greenand with globular cushions, and Porsild (Medd. om Grönl., vol. 50, p. 370, Fig. 12) has figured a form regarding which he says "it differs greatly from the numerous forms of the species;" "especially distinctive is the low, densely-tufted growth, and the glabrous, obtuse, rosette leaves, etc." There is also mention of dense tufts in *Cerastium nigrescens*, and regarding *Arenaria ciliata* Lundager records "dense and large tufts." But these forms are hardly typically pulvinate in habit.

Adventitious roots may be found in the interior of dense mesocorms.

Winter-stage. *Cerastium alpinum* appears to be particularly evergreen. HELGI JÓNSSON examined it in East Iceland on January 2nd; he mentions the dense hairy-covering of the protecting leaves (see Fig. 10). The living leaves contained starch. He found living leaves also on *C. caespitosum*, as SYLVÉN did in Central Sweden. Likewise, there evidently occur living leaves on *C. alpinum*, according to material preserved in alcohol, both at Upernivik on the west coast of Greenland (C. Ryder) and in N.E. Greenland (Lundager). But I found no starch in them. LUNDAGER and OSTENFELD (1917, p. 20) write about *C. alpinum* in N.E. Greenland: "When the flowering plant, in the autumn, is suddenly covered with snow, which remains during the winter, all the parts of it are so well preserved, that in the spring, when the snow has melted, they appear again and apparently are as fresh as if they had quite recently unfolded themselves."

The older branches, as in the other types, are apparently dead, because their bark is grey and wrinkled. This is most distinctly seen in the prostrate branches; but in the spring, fresh leaves develop from their terminal and lateral buds. It is true that the bark-layer is dead, but on loosening it, a fresh, green axis is found under it. In Denmark the same thing happens in nature. I have described and figured the wrinkled, older, subterranean runners which are also found in *Honckenya*. Perhaps this phenomenon should be regarded as a means of protecting the stem against transpiration due to cold winds.

E. The Cerastium arvense type.

This type differs from the preceding, by the fact that the prostrate shoots with elongated internodes, have not so short internodes at their base, that they may have there rosettes or rosette-like shoot-forms; also they develop roots so abundantly that they might justly be termed "creeping," and vegetative propagation (layering) must be able to take place both by means of aërial runners and — in some species — by subterranean runners. It is a further development of the *Cerastium alpinum* type.

To this I refer: *Cerastium trigynum*, *C. arvense*, *Moehringia lateriflora*, *Stellaria longipes*, *S. borealis* and *Honckenya peploides.* To these may be added of non-Arctic species, for instance *Stellaria graminea*, *S. nemorum* (Warming, 1918, Fig. 14), *S. holostea*, *S. uliginosa* and *S. glauca*, each with its special peculiarities.

When, under the *Cerastium alpinum* type, mention was made of pale, subterranean, plagiotropic shoots, they were probably aërial shoots which had been accidentally covered over with wind-carried soil and leaves, or had been developed in the shade. Those we are now discussing are, on the other hand, typical subterranean runners with elongated internodes, pale in colour, with scale-leaves and furnished with an apex which can push its way into the soil; but of course the boundary line between these two types is not sharp.

Cerastium trigynum we will first mention. It has, on the whole, the same mode of branching as *C. alpinum*, but the stems have their internodes, also those at the base, as a rule, elongated. Sylvén mentions, however, rosette-like shoots in the young plants in their first year, and Thekla Resvoll (loc. cit. p. 137, with Fig. 11) records that, in the snow-fields, the internodes of the primary shoot remain short even for a longer period. Branches, at any rate, are developed most abundantly at the base, and therefore, numerous branches proceed from a central point, which is the upper end of the primary root. They may, in some cases — at any rate as long as they are still short — be more or less erect, with curved and rooting branches, but soon they lay themselves upon the ground, spreading out in all directions and rooting as aërial shoots, and in a comparatively short time they may attain a length of 10—25 cm, or even more. Ultimately many slender adventitious roots are thereby fastened to the ground, and by this means vegetative propagation may take place (Fig. 11). The apices may be curved slightly upwards and the leaves may be unilaterally curved (Fig. 11). From these runners a few or several flowering shoots rise into the air; their duration of life is two years (Thekla Resvoll). Sometimes the shoots are so richly branched and so closely interwoven that broad, but low cushions may almost be formed.

Fig. 11. *Cerastium trigynum.*
A runner (about $^1/_1$). As far as to L, reckoned from the flower, the foliage-leaves are fresh, then come dead foliage-leaves which subtend small shoots. Two leaves have been magnified. (Iceland; C. H. Ostenfeld). (E. W.)

Cerastium arvense has erect or ascending long-shoots, with short, sterile shoots at its base. It also develops plagiotropic shoots quickly, and the seedling may, under cultivation, develop, in the year of germination, a richly branched shoot-system, with typical scale-leaf-bearing runners. It may be densely branched at its base.

Stellaria longipes. The primary root lives for a long time. This species has prostrate shoots with very long internodes, with a few or several adventitious roots, and with very distinct, long and thin, scale-leaf-bearing runners, each with a straight apex.

Stellaria borealis. The stems are thin, spreading and often very long. From the basal nodes there proceed typically pale, very slender subterranean runners — shoots bearing scale-leaves.

Moehringia lateriflora has long, thin, prostrate and rooting shoots, with long internodes, and, as far as could be observed, thin subterranean runners, with slender roots proceeding from the leaf-axils.

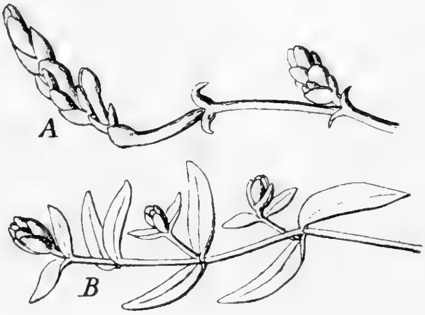

Fig. 12. *Stellaria crassifolia.* Its winter-buds are densely filled with starch. (From Tromsø). (E. W.)

Honckenya peploides is the species which has the most decidedly typical, strong and far-spreading subterranean runners. The Arctic specimens appear to agree exactly with the Danish as regards the peculiarities of their runners, their serially-placed axillary buds, their dwarf-shoots with as many as 45 close-set leaf-pairs, etc. (described and figured by Warming in 1877—79, see also 1891, 1906, 1918, Fig. 12).

The germination is described by Joh. Erikson (1896). When growing on beaches, the cotyledons and the lowermost internodes of the epicotyl stem are buried in the sand by the wind, and are thereby, and perhaps also by root-contraction, carried down into the ground. In each of the axils of the cotyledons, most frequently three serial buds are developed, the uppermost being the largest.

Pulvinate forms. In these species, in which the shoots with elongated internodes immediately become prostrate and spread out in all directions, the typical development of semi-globular cushions must be very difficult, if not impossible. In places where there is active growth, flat cake-shaped forms can however occur, being formed by the interwoven stems.

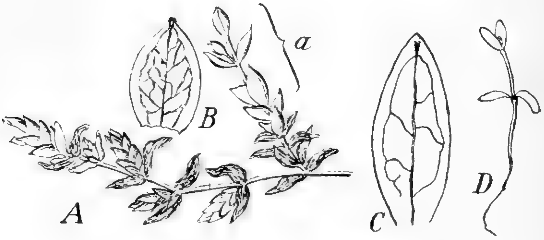

Fig. 13. *Stellaria humifusa.*
A, A branch with both dead and fresh leaves; *a*, a fresh-green portion. *B*, An old leaf, the veins are distinctly seen. (Upernivik). *C*, *D*, a leaf magnified and a seedling. (Egedesminde; 28. 7. 1884.) (E.W.)

F. The Stellaria crassifolia type.

To this I refer *Stellaria crassifolia* and — with doubt — *S. humifusa.*

This type, which is represented by *S. crassifolia*, differs from the *Cerastium arvense*-type by developing small aërial (and? subterranean) hibernacula, organs which live through the winter and consist of short, thick-leaved shoots, rich in starch (Fig. 12). They are developed during the autumn (late summer), are liberated the next year, and then grow out into new plants by developing adventitious roots. Otherwise it resembles *Cerastium trigynum* in its mode of growth; the leaf-shoots with long internodes proceed from the same root and lie prostrate along the ground, and are of a length of about 25 cm or perhaps even more; some are subterranean.

These hibernacula are described by NORMAN (1893) in his "Flora Arctica", p. 26 (Christiania Videnskabsselskab), and are figured by O. NORDSTEDT in 1909 (Bot. Notiser, p. 51).

The germination is described by SYLVÉN (p. 298). A seedling develops in the first year a plagiotropic, very richly branched aërial-shoot-system, of which some of the shoots often become subterranean by being covered with sand.

Stellaria humifusa should perhaps be most properly placed by the side of *Cerastium trigynum*. From the base of the primary stem proceed, as in *Cerastium trigynum*, numerous prostrate, richly branching and rooting, entangled branches. On these are found small, thick-leaved shoots, with short internodes, which are no doubt winter-shoots, and when the buds open in spring, they do not seem to elongate. In specimens collected on July 27th, far northwards (Upernivik), some of these shoots had unfolded and flowered, while others had not (see Fig. 13).

This species has a distinct, fairly long, but slender primary root. In addition to the creeping aërial shoots, subterranean shoots may occur.

With the exception of the above-mentioned short shoots, it is hardly to be called evergreen.

The shoots flower after a vegetative stage varying from two to several years.

G. The Stellaria media type.

The last growth-form is represented by the present species, which is widely distributed, but cannot be included among the truly Arctic species. It has, however, been found in several places in Greenland, north of the Arctic Circle, and, according to Porsild, far from present and former settlements, and in other places for instance together with *Ranunculus hyperboreus.*

It is a hapaxanthic, summer-or winter-annual species, and does not appear to deviate from this rule in Arctic countries. The fullest account of it has been given by Wittrock (1908). According to him, in Central Sweden, the winter-annuals may begin to flower even during the autumn; they continue flowering in the milder period of the winter and bring it to a termination in the spring, with an abundant seed-production. There, the winter-annuals are the most vigorous, owing to the fact that numerous adventitious roots are developed during the autumn, on account of the increased dampness of the soil. Wittrock's figure shows that the adventitious roots proceed from the leaf-axils, and that they may branch freely. A very distinct account of these conditions is given by Korsmo (Fig. in his valuable work "Ugræsplancher"). If the branches have been detached from the parent-stems, in some way or other, vegetative propagation may thereby take place. In such a case it may perhaps also become pollacanthic, as an observation made by Bonnier also seems to indicate.

Other species also, in addition to being pollacanthic, are sometimes described as hapaxanthic, for instance *Sagina procumbens* and *Sagina Linnaei.* It is not improbable that this may be the case.

II. Leaf Anatomy.

With regard to the anatomical structure of the Arctic leaves the reader is more particularly referred to Bonnier and Börgesen, and in "Meddelelser om Grönland", vols. 36 and 37, to a series of treatises by Henning E. Petersen,

O. Gallöe, A. Mentz, Knud Jessen and Mathiesen. See also Th. Holm; Lazniewski may also be consulted.

The foliage-leaves are dorsiventral or almost isolateral (central).

The difference in the leaves is evidently connected with their breadth and the direction of their growth. In the broad-leaved species (the *Melandrium*-type) dorsiventrality prevails with palisade-tissue on the ventral side; see for instance

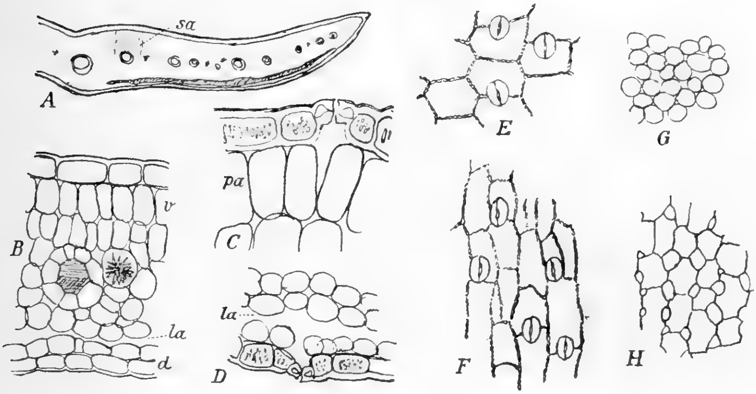

Fig. 14. *Viscaria alpina.*
(West Greenland; 24. 7. 1887; Lytzen.)
A, In the transverse section of the leaf is seen on the dorsal side a large lacuna, and on the ventral side a distinct palisade-tissue (*sa*); the crosses (xx) indicate cells with crystals of calcium oxalate; round the vascular bundles are sheaths. *B*, Transverse section of a leaf. *C* and *D*, Details from ventral and dorsal surfaces, more highly magnified. The epidermis of the ventral surface is distinctly higher than that of the dorsal surface; there are stomata on both surfaces. Pores are seen in the lateral walls of the epidermal cells. *E* and *F*, Epidermis of ventral and dorsal surfaces; the walls are highly porose. *G* and *H*, Section through the palisade-tissue and the spongy-tissue. (E. W.)

Viscaria alpina (Fig. 14 and the explanation of the figure); here the dorsiventrality is expressed by the fact that on the ventral side there are two layers of palisade-cells, while on the dorsal side there is a spongy-tissue of rounded cells, with a large lacuna (*la* Fig. 14, *A*, *B* and *D*); then again in the height of the epidermis of both surfaces (*B*, *C* and *D*); in the form of the epidermal cells (*E* and *F*); in the form of the cells of the mesophyll (*G* and *H*); and lastly in the height of the cells which form the sheaths of the vascular bundles, since these cells are higher on the dorsal than on the ventral side (*B*).

Similar, but not quite so decided dorsiventrality is found in *Melandrium involucratum* (Fig. 15, *A*, *B* and *C*, as also *E* and *F*).

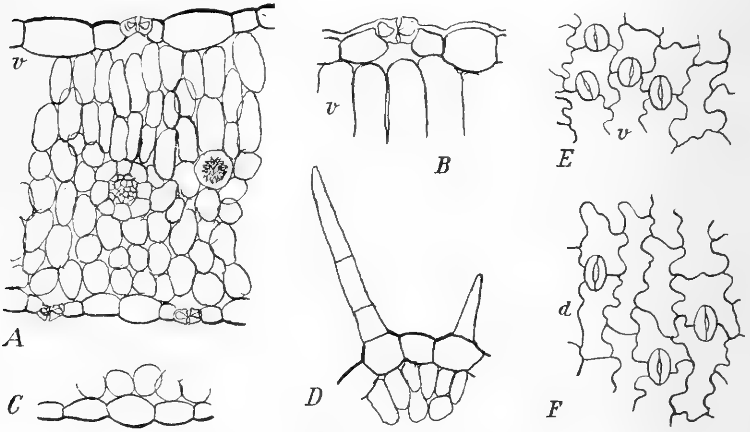

Fig. 15. *Melandrium involucratum.*
(From West Greenland; 30. 7. 1887; C. Ryder.)
A, Transverse section of leaf; the ventral side (*v*) has higher epidermis than has the dorsal side; compare the somewhat more highly magnified *B* and *C*. *D*, Hair. *E*, Epidermis of ventral surface and *F*, of dorsal surface. (E. W.)

Also in the much more narrow-leaved species *Silene acaulis* decided dorsiventrality is found; this is probably connected with the fact that the leaves are more or less horizontally placed (Fig. 3). Here also the dorsiventrality is expressed in the structure of the mesophyll (Fig. 16, *A*); in the epidermis (it is devoid of stomata and is higher on the dorsal than on the ventral side: *A*, *G*, *H* and *J*; a few stomata, however, may occur towards the edge of the leaf), and in the sheath round the vascular bundles (*A* and *D*). For the rest, these features may vary somewhat, probably according to the prevailing conditions of the surroundings, but, on the whole, I found the structure of the leaves to be similar in plants from W. and E. Greenland, Iceland and Norway.

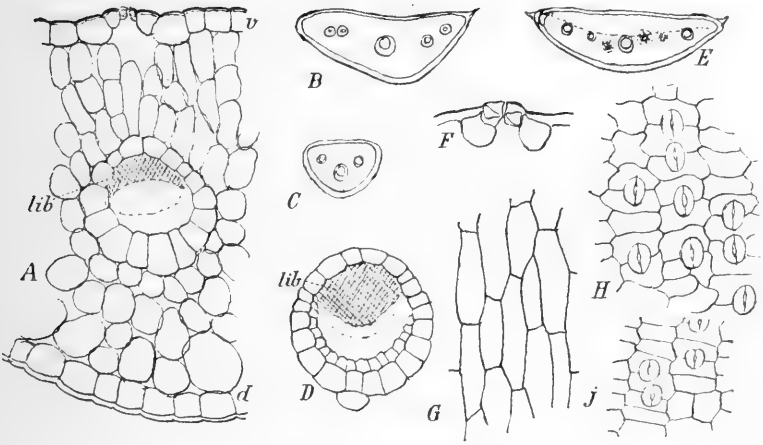

Fig. 16. *Silene acaulis.*
(From Iceland: *A*, *B*, *C*, *F*, *G* and *H*. From W. Greenland: *D* and *E*.) *A*, Transverse section of leaf; *lib*, bast; *d* is the dorsal surface, which has no stomata (see *G*) and is slightly higher than the ventral surface (*v*), which has numerous stomata (see *H*). The forms of the epidermal cells are seen in the same figures. *B* and *C*, Transverse sections of leaf. *D*, Transverse section of vascular bundle; *lib*, bast. *E*, Transverse section of leaf, four vascular bundles are seen and three cells with crystals of calcium oxalate. *F*, Stoma. *J*, Epidermis of ventral surface; the cell-walls are less undulating than in *H*. (E. W.)

That it depends on the direction of the leaves (their position with reference to the light) whether they become isolateral or dorsiventral, was also pointed out by me in 1891, in the case of the *Honckenya*; they are isolateral when directed upwards, and dorsiventral when horizontal.

The leaves of *Silene acaulis* are often somewhat oblique in transverse section (Fig. 16, *B*).

Cerastium alpinum also may have distinctly dorsiventral structure (Fig. 17); this is probably connected with the position of the fairly broad leaves which are found also in this species. The difference between the epidermis of the dorsal and the ventral surface is not so great as in the species already mentioned: there are stomata on both surfaces; but the epidermis of the ventral surface is somewhat thicker than that of the dorsal (Fig. 17, *K* and *L*). Whether the

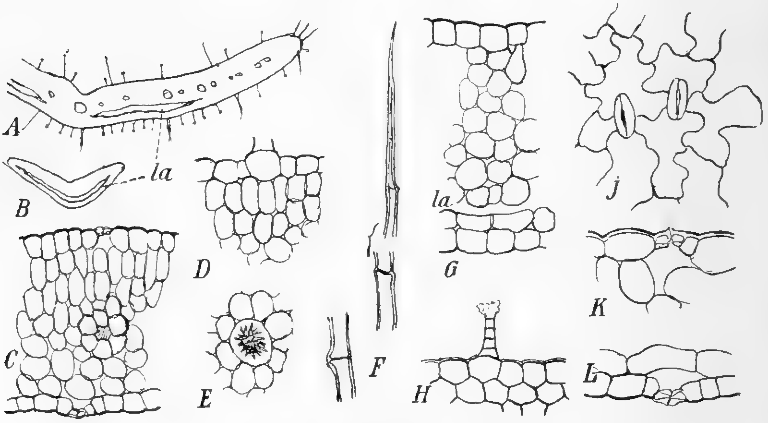

Fig. 17. *Cerastium alpinum.*
(From Greenland and Iceland.)

A, Transverse section of leaf, the two kinds of hair are indicated. There are two lacunæ (*la*). *B*, A similar section of a leaf from a bud. *C*, The transverse section shows that there are stomata on both surfaces, that palisade-cells are indicated in the thin-walled, lacunose mesophyll, and that there is a sheath around the vascular bundle. The epidermal cells are nearly of equal height on both surfaces, perhaps if anything, a little higher on the ventral surface. *D*, From ventral side. The base of a hair is seen. *E*, Cell with crystal of calcium oxalate. *F*, Three portions of one and the same hair. *G*, Transverse section of a leaf, recently cleared of snow; *la*, lacuna on the lower side. (Upernivik; 7. 5. 1887; C. Ryder.) *H*, A glandular hair (dorsal surface). *J*, Both leaf-surfaces have highly undulating epidermal cells and stomata. *K*, Epidermis and stoma of ventral surface. *L*, Same of dorsal surface. (E. W.)

high degree of isolaterality shown in Fig. 17, *G* is due to the fact, that this leaf had recently been cleared of snow, or to some other cause, I cannot tell. The specimens from Iceland showed essentially the same structure as those from Greenland.

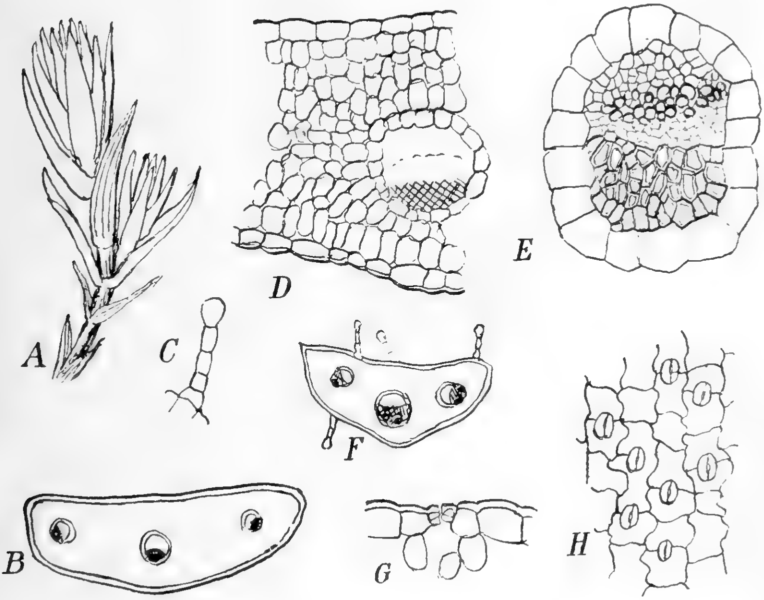

Fig. 18. *Minuartia verna.*
(From N.E. Greenland; 27. 6. 1908; A. Lundager.)
A, A small shoot with a branch. *B* and *F*, Transverse sections of leaf. There is strong bast tissue on the dorsal side of the vascular bundles. *C*, A glandular hair. *D*, Transverse section of leaf. The sheath of the vascular bundle is of the same thickness all round; see *E*, in which the bast tissue, sieve tissue and the tracheal tissue are shown. *G*, Epidermis with stoma. *H*, Epidermis of ventral surface. (E. W.)

In the *Minuartia verna* figured in Fig. 18, *D*, decided dorsiventrality also prevails, but here the palisade-tissue is on the dorsal side — probably in harmony with the erect position of the leaves (*A*).

In *Minuartia groenlandica* I found distinct palisade-tissue on the ventral side, but in the specimen investigated the leaves were, in contradistinction to those in *M. verna*, directed decidedly outwards. The epidermis of the dorsal surface was distinctly thicker than that of the ventral surface.

Stellaria humifusa (Fig. 19). According to the transverse sections shown in Fig. 19, *B* and *C*, this leaf is but slightly dorsiventral, but a closer observation proves the dorsiventrality to be stronger. The epidermis of the dorsal surface is but little thicker than that of the ventral surface (Fig. 19, *J* and *H*), but the ventral surface has cells with decidedly undulating walls (*D*), and is rich in stomata, while the dorsal surface has elongated cells with straight sides (*F*).

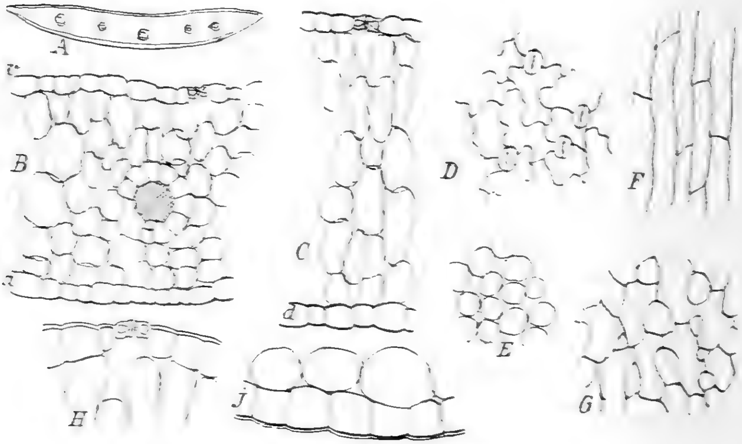

Fig. 19. *Stellaria humifusa*.
(From East Greenland: 15. 7. 1885: P. Eberlin.)
A, Transverse section of leaf. *B*, The same, more highly magnified: *v*, ventral surface; *d*, dorsal surface. *C*, A transverse section, the epidermal cells are nearly equal in height, which is seen more distinctly in the more highly magnified *H* (from the ventral surface) and *J* (from the dorsal surface). *D*, The epidermis of the ventral surface, and *E*, the underlying mesophyll-cells. *F*, The epidermis of the dorsal surface and *G* the underlying mesophyll. (E. W.)

Moreover, the mesophyll which lies under the epidermis differed on the two surfaces (*E* and *G*). In a specimen from S.E. Greenland there was almost homogeneous, but indistinct, palisade-tissue on both sides.

Similar weak dorsiventrality I found also in *Cerastium trigynum* (Fig. 20), and *Minuartia biflora*, which latter may however have decided isolaterality (Fig. 21, *K* and *B*), but it differs in the epidermis of the two surfaces, which, as it however appears, cannot be connected with the fact that the leaves may be directed upwards, with the ventral surface

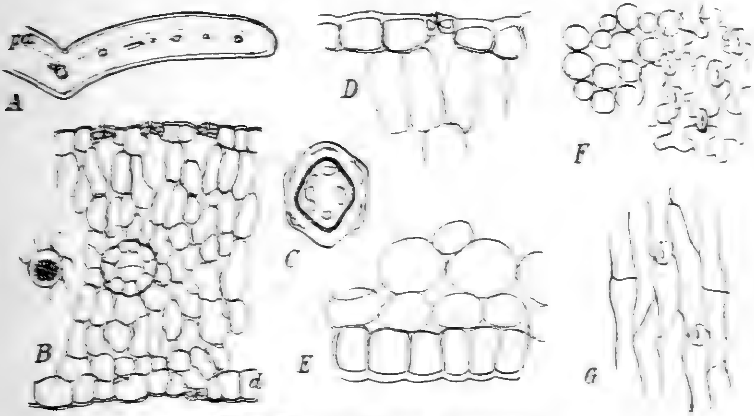

Fig. 20. *Cerastium trigynum.*
(From Iceland; C. H. Ostenfeld.)

A, Transverse section of leaf; *pa*, palisade-tissue. *B*, The transverse section shows the very lacunose structure of the thin-walled mesophyll; the epidermis of the dorsal surface (*d*) is higher than that of the ventral surface; there is a distinct sheath around the vascular bundle; there are about two layers of palisade-cells; *g*, a cell with crystal of calcium oxalate. *C*, Transverse section of stem. The black ring indicates the place of the mechanical tissue. There are five lacunæ in the cortex. *D*, From ventral side; epidermis and palisade-cells. *E*, From dorsal side. Magnification of *D* and *E* is the same, so that it is distinctly seen that the epidermis of the dorsal surface is thicker than that of the ventral surface. *F*, The epidermis of the ventral surface and transverse section of palisade-cells. *G*, The epidermis of the dorsal surface. (E. W.)

turned inwards, as in Fig. 21, *A*; they may also be directed straight out and curved backwards. More decided dorsiventrality with two layers of palisade-cells on the ventral side, was found in a specimen of *Cerastium trigynum* from Iceland.

Palisade-tissue on both sides I have moreover found in *Honckenya*; it was however highest on the ventral side. Stomata occur on both surfaces. According to Heinricher,

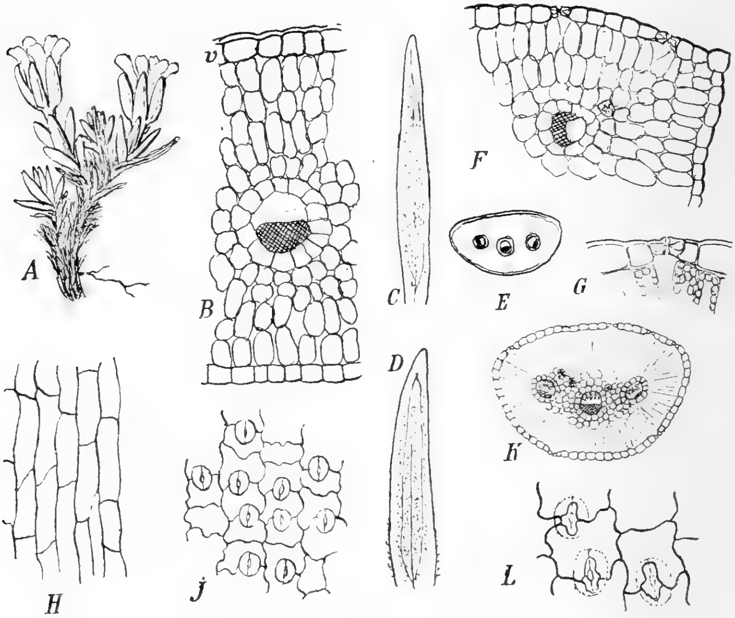

Fig. 21. *Minuartia biflora.*

A, From N.E. Greenland; 27. 6. 1908; A. Lundager. *B*, Transverse section of leaf; the cross-hatched part is the mechanical tissue; the two leaves, *C* and *D*, which belong to *B*, show the venation; the fine dots indicate cells with crystals of calcium oxalate. *E*, Transverse section of leaf. *F*, Margin of transverse section of a leaf; to this belongs the more highly magnified *G*. *H*, Epidermis of ventral surface. *J*, Epidermis of dorsal surface. *K*, Transverse section of leaf, centric structure. *L*, Epidermis of dorsal surface, seen from within, the outlines of the air-cavities under the stomata are distinctly seen.

From N.E. Greenland: *A*, *E*, *F*, *G*, *H*, *J* and L; from W. Greenland (Holsteinsborg; 4. 8. 1885; Rosenvinge): *B*, *C*, *D* and *K*. (E. W.)

isolaterality is, for the rest, common in the *Caryophyllaceæ*, which must be connected with the fact that the leaves in many of the species are narrow, and can therefore be illuminated equally on all sides.

With regard to the mesophyll in general, the following may moreover be remarked. VESQUE had already recorded in 1883 that the mesophyll in the *Caryophyllaceæ* consists of large cells, which are loosely connected so that it is rich is intercellular spaces, and "spongy" ("spongieux"). This is no doubt especially applicable to the Arctic species. This feature is not only found in the species figured above, but in as high a degree in *Cerastium nigrescens* and *Arenaria ciliata* (Figs. 22 and 23). In the latter figure it is even highly isolateral, with almost uniformly rounded cells. That it may be more compact is evident from what TH. HOLM says regarding it.

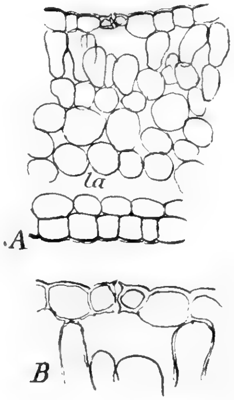

Fig. 22.
Cerastium nigrescens. (From Dovre; 15th June; E. W.)
A, The transverse section of leaf shows a very lacunose tissue, with palisade-cells, and a lacuna (*la*) in the spongy-tissue. *B*, Stoma of ventral surface. (E. W.)

"It has already been emphasized by others (BONNIER and BÖRGESEN) that it is a feature common to all the Arctic species, for the palisade-tissue to be most frequently imperfectly differentiated, the layers few in number, the height of the cells inconsiderable, and the intercellular spaces large — at any rate, not so strong and compact as in species from more southern — for instance Mediterranean — countries. BÖRGESEN even found no palisade-tissue at all in specimens of *Silene acaulis* (l. c. Fig. 12) and *Minuartia verna* f. *hirta*; see also *Arenaria ciliata* in TH. HOLM (Pl. XII, 2).

This is evidently a structure which is due to the faint light and the damp surroundings, and which contrasts strongly with the leaf-structure of the Alpine plants (Wagner and Börgesen).

In contradistinction to the Arctic *Caryophyllaceæ* we may refer e. g. to *Silene Otites* from dunes near Montpellier, which has palisade-tissue on both sides (Warming, Halofyt-studier, 1897, p. 203) and *Silene nicæensis* from Cadix (ibid., p. 198), together with *Honckenya* from Denmark which, when growing on sand strongly exposed to the sunlight, can have several layers of palisades on both sides (Warming, 1891, Fig. 12).

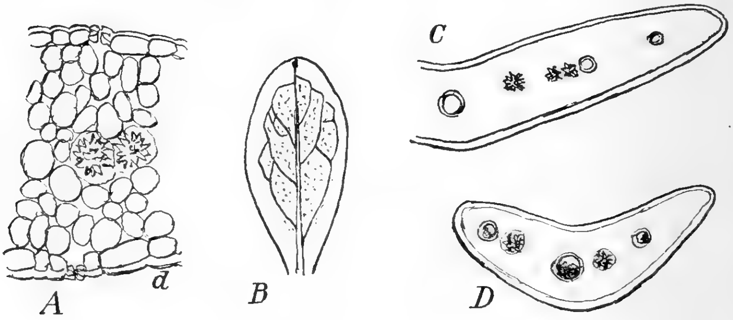

Fig. 23. *Arenaria ciliata.*
(From N. E. Greenland; 12. 7. 1908; A. Lundager.)
A, Transverse section of leaf; two cells with crystals of calcium oxalate. *B*, A leaf; the dots indicate cells with crystals. *C*, *D*, Transverse section of leaf, showing the crystals. (E. W.)

Many records as regards anatomical differences in plants from different countries, and variations in the same species from different habitats, and in different countries, are found in Heinricher, Börgesen, Warming and others. It is evident that the local conditions prevailing in the habitats, are in epharmony with the differences in the individuals. As an example of this, the reader is referred e. g. to Joh. Schmidt's experimental investigations of *Lathyrus maritimus* (Bot. Tidsskrift, Köbenhavn, 1899, p. 22).

The different points of information concerning the leaf-anatomy of Alpine plants, may profitably be compared with those concerning that of the Arctic leaves. SCHRÖDER, in his excellent work "Das Pflanzenleben der Alpen", mentions the first-named and gives a resumé of BONNIER's and WAGNER's results, which, in certain directions, show deviations from the Arctic species, especially as regards the palisade-tissue. When the Arctic plants have, on the whole, less differentiated palisade-tissue than the Alpine species, this must be especially attributed to the fainter light and the fogs in Arctic countries.

The fact that the mesophyll in Arctic plants is always thin-walled, and has abundant intercellular spaces, has been emphazied by previous authors, for instance BÖRGESEN and TH. HOLM; and is evident from numerous figures which a number of authors have published in the "Morphology and Biology of Arctic Plants", "Meddelelser om Grönland", Vols. 36 and 37 (for instance O. GALLÖE, 1910; KNUD JESSEN, 1911 and 1913; CARSTEN OLSEN, 1914; MATHIESEN, 1916; H. E. PETERSEN, 1908, and others). In this, according to WAGNER, there is a conformity with the Alpine species, a conformity which must be attributed to the greater moisture[1].

In *Cerastium arvense* (from willow copses in Kangardluarsuk in West Greenland) the spongy tissue was of an unusual character, consisting more or less of stellately branched cells, for which reason the lacunæ were particularly large. There was a distinct palisade-tissue with at least 3 cells in a vertical row. The epidermal cells had undulating walls and stomata on both surfaces.

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[1] For purposes of comparison see the anatomy of woody plants in WARMING (1887), H. E. PETFRSEN (1908), and MENTZ (1909).

A peculiar lacuna is found in the leaves of many of the species. It is caused by the sub-epidermal cell-layer of the dorsal surface separating, for a shorter or longer distance, from the mesophyll lying internal to these cell-layers. The cells bordering on the lacuna are rounded off inwardly towards it. I have already in 1884 pointed them out in *Silene acaulis*, *Arabis petræa*, *Dryas octopetala*, *Draba incana* and *Saxifraga oppositifolia*, and they are found figured by TH. HOLM in *Stellaria humifusa* (Pl. X, Figs. 2 and 8), *Salix reticulata* (Pl. XII, Fig. 12) and species of *Saxifraga* (Pl. X, Figs. 3 and 5). See also BÖRGESEN l. c. In HELGI JÓNSSON (1895, p. 291) we find the accompanying figure (Fig. 24), which shows a section through a bud of *Silene acaulis*. In the figures given above these lacunæ are shown in Fig. 14, *A* and *B* (*Viscaria alpina*); Fig. 17, *A*, *B* and *G* (*Cerastium alpinum*); Fig. 22 (*Cerastium nigrescens*). I have also observed them in *Dianthus superbus*. I cannot imagine that they are of any other use than as a protection against cold, since they must be bad heat-conductors.

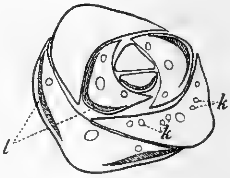

Fig. 24. *Silene acaulis*. (From Iceland; Helgi Jónsson.) Section through a bud. In each leaf three vascular bundles are seen; *k*, cells with crystals. On the dorsal side of the leaves air-containing lacunæ (*l*) are seen.

Crystals. With regard to the mesophyll, it may further be remarked, that in many species cells are found with crystals of calcium oxalate. They are situated in that layer of the leaves, in which the vascular strands are found, or at any rate, in close proximity to them. They are no doubt found in all the species. They are figured in Fig. 14, *A* and *B*; Fig. 15, *A*; Fig. 16, *E*; Fig. 17, *E*; Fig. 20, *B*; Fig. 23, *A*, *C* and *D*, and also in *B* where they are indicated by dots; their position is similarly indicated in Fig. 21, *C* and *D.* I have seen them also in *Silene venosa*, *Honckenya* and *Minuartia hirta* (accompanying the three vascular bundles), and several authors mention them for instance Vesque (1883, pp. 130 and 133), Russel and Heinricher (see Pl. 30, *Silene inflata*). There may be a difference in individuals of the same species; in specimens of *Silene acaulis* from Finse in Norway there were many crystals of calcium oxalate, more than in the Icelandic individuals. Whether this difference be due to the season of the year, or to the habitat, I am not prepared to say.

Mechanical tissue I have not found except in certain cases, and then within the sheath around the vascular bundle mentioned below, for instance, on the ventral side in *Silene acaulis* (Fig. 16, *A* and *D*), on the dorsal side of them in *Minuartia verna* (Fig. 18, *B*, *D*, *E* and *F*), *M. groenlandica* and *M. biflora* (Fig. 21), and on both the ventral and the dorsal side, or only on the dorsal side (of the erect leaves) of *Melandrium involucratum* (from Upernivik). Records of this are also to be found in Börgesen, Vesque, and others.

The epidermis always consists of one layer only, and the cell-walls are rather thin on all sides, but are naturally thickest on the outer side. The cuticle is thin. This must be an adaptation to the nature of the habitat, and can vary with it. W. Russel has demonstrated, that the leaves of *Dianthus prolifer* have much thicker epidermal walls in the Mediterranean countries, than near Paris, and therefore become much stiffer.

Only in *Viscaria alpina* did I find the walls of the epidermal cells to be somewhat thicker, and the lateral walls porose (Fig. 14, *C*, *D*, *E* and *F*). The outer walls of the epidermis were found to be thick in *Sagina nodosa* from dunes in Denmark.

That the dorsiventrality can be displayed in the various degrees of thickness of the epidermal cells of the ventral and dorsal surfaces, has been stated above. It appears, as already mentioned, to be correlated, with the direction of the leaves (the epidermis of the surface which is turned upwards or outwards being the highest).

The epidermal cells are arranged more or less regularly in longitudinal rows, at any rate in the narrow or linear leaves (see e. g. Fig. 14, *E* and *F*; Fig. 15, *E* and *F*; Fig. 16, *G*, *H* and *J*; Fig. 18, *H*; Fig. 19, *D* and *F*; Fig. 20, *G*; and Fig. 21, *H*, *J* and *L*).

The lateral walls of the cells, when seen from above, are sometimes highly undulating on both leaf-surfaces, although more highly on that surface which limits the spongy-tissue than on the other surface (Fig. 15, *E* and *F*); more frequently the epidermal cells of the one surface have undulating lateral walls, while those of the other have only slightly undulating or quite straight walls; as also the cells of this surface are more elongated (Fig. 14, *E* and *F*; Fig. 16, *G*, *H* and *J*; Fig. 19, *D* and *F*; Fig. 20, *F* and *G*; Fig. 21, *H*, *J* and *L*). The cells with very highly undulating walls are moreover very short. The undulations indicate more damp or more shady conditions.

The Stomata are lower than the other epidermal cells, and are placed on a level with the outer surface of the epidermis, or even project slightly above it (this is shown in many figures). Stomata may occur on both surfaces, sometimes almost equally in number. In other cases, the one surface has no stomata or only a few. In some cases they are most numerous on the dorsal surface, in others on the ventral surface, for instance in *Stellaria humifusa.* All these circumstances have been fully treated of by VESQUE, BÖRGESEN, WAGNER and BONNIER (see also TH. HOLM). As regards the number of stomata per unit of surface the reader may be referred, for instance, to Børgesen.

The apertures of the stomata, at all events in the narrow-leaved species, lie parallel with the longitudinal axis of the leaf.

That the guard-cells are surrounded by the other epidermal cells in a peculiar manner, was, as far as I know, first pointed out and figured by Vesque (Anm. sc. nat., 1883, 6. Sér., 15, p. 130): "Les stomates sont embrassés par deux cellules dont la cloison separatrice et perpendiculaire à l'ostiole". See the preceding Fig. 14, *E* and *F*; 15, *E* and *F*; 16, *H* and *J*; 17, *J*; 19, *D*; 20, *F*; and Fig. 21, *J* and *L*, all of which, in addition, show, here and there, a small deviation of minor importance, in that an aperture may be surrounded by 3—4 cells, but each end of the stoma is always limited by a more or less crescent-shaped cell.

Hairs are found in many of the species, in some even in such great numbers, that they become quite pilose, this is especially the case in *Cerastium alpinum*, which is otherwise exceedingly variable as regards the extent to which it is hairy. The hairs are of two kinds, both consisting of a single row of cells arising from a single epidermal cell, as already pointed out by Vesque (1883). The one kind of hair is thick-walled and dead (filled with air), and terminate in a point (Fig. 15, *D* and Fig. 17, *F*); they are specially numerous in the form *lanata* of *Cerastium alpinum*. Their function must be to protect the plant against excessive transpiration. The other kind of hair is secretory, and its terminal cell is globular (see for instance *Minuartia verna*, Fig. 18, *C*, and *Cerastium alpinum*, Fig. 17, *H* and *A*).

The Vascular bundles. It is, at all events in the narrow-leaved species, only a single bundle, which from the stem enters into the leaf, and there quickly develops a branch on each side, which may itself branch ogain (Fig. 21, *C*, *D* and Fig. 23, *B*). In the most narrow-leaved species this does not often happen, so that the entire number of bundles in a transverse-section will be three only (Figs. 18 and 21) — these are especially prominent in older leaves which have been emptied of their cell-contents, — but more frequently there are several, or even many, in the broadest-leaved specimens (Figs. 14, 17 and 20). As regards the vascular tissue, I have no particulars to communicate.

In some of the species mechanical tissue occurs on the ventral or dorsal side of the strongest vascular bundles, as mentioned above.

It appears to be an exceedingly constant characteristic in the *Caryophyllaceæ* to have around the vascular bundles a thin-walled, sharply differentiated sheath consisting of one layer of cells, which are almost square in transverse section; this is illustrated in most of the figures given above. In the majority of cases, the cells are of equal height, but cases may occur in which those of the dorsal surface are higher than those of the ventral (e. g. *Silene acaulis*, Fig. 16, *A*, *D*).

For further particulars regarding the anatomy of the *Caryophyllaceæ*, the reader is referred for instance to Regnault (1860; Ann. sc. nat., 4. Sér., 14); Seignette (Revue gen. I, p. 564); O. G. Petersen (Botan. Tidsskr., København, 1888); Heinricher (1884); Joh. Erikson (1896); Warming (1890, 1891, 1897) and Solereder. As regards the structure of the leaves in the Alps, see Wagner, Lazniewski and C. Schröeter.

III. Adaptions to the Environment.

The morphological and anatomical structure of plants is, in the first place, dependent upon their genetic relationships, but it will be difficult or rather impossible to demonstrate the origin or utility of their genetic peculiarities (for instance, why the leaves in the *Caryophyllaceæ* are opposite; the origin of the peculiar manner of branching with only one shoot, or at all events only one vigorous shoot, from each pair of leaves, and of the position of these shoots in a peculiar spiral; or the origin of the one-layered sheath, around the vascular bundle, just mentioned). As regards the *Caryophyllaceæ* VESQUE (1883, p. 133) has rightly stated that "La famille des Caryophyllées est des plus naturelles et des mieux limitées". This is true both as regards the morphological and the anatomical structure and, as far as I can see, cannot be explained ecologically. Also as regards the structure of the flowers, there are very great similiarities in the different genera.

In the second place, the peculiarities of plants are dependent upon the ecological factors of the habitat, i. e. the climatic and edaphic conditions which prevail there. It is consequently of importance that we should be accurately informed with regard to these points, but the truth is, we have information only about the general features of the climate and — possibly — of the soil. As regards the conditions which prevail in the special, local habitats in which the different individuals have been gathered we are, so to speak, never told anything. Unfortunately, there are many travelling botanists who find it sufficient to state, that such and such species have been found here and there, and to record the geographical situation; but as regards the conditions found to be prevailing in the habitats in question, they tell us nothing whatever. This is however a great drawback, for without doubt the ecological factors, or the differences which prevail in the habitats, are exactly that which sets a different stamp upon individuals of the same species.

Of the botanists who have given the fullest information with respect to the natural conditions prevailing in the habitats in Greenland, I must, as regards the *Caryophyllaceæ*, point out most particularly Jens Vahl (in the Arctic Herbarium belonging to the University of Copenhagen) and Chr. Kruuse (in his papers on the plant-growth on the east coast of Greenland in "Meddelelser om Grönland" Vols. 30 and 49). To mention the numerous data to hand, would take us too far; here it must suffice to refer to the Floras and especially to Joh. Lange's "Conspectus"; I therefore give the following short resumé.

With regard to the climate of the habitat, we know, in a general way, for instance, that it becomes drier the farther we proceed from the south up towards the north in Greenland, and from the coast towards the interior. See for instance the small map (after W. Krebs) reproduced in Gunnar Anderson (1900). But the rainfall is hardly of as much importance as is the water accessible to the plants ecpecially from the ground and the fogs.

The soil is usually rather damp. One hardly goes too far if one asserts that a great moisture of the soil is an essential characteristic of Arctic nature. This is evident from the many descriptions, for instance in Vahl ("in locis humidis", "in locis humidiusculis", "in locis turfosis", "in locis uliginosis", "in pratis", etc.), or the frequent occurrence, in Kruuse, Porsild, Lundager, and others, of expressions such as "on moist, barren ground", "on wet sand", "by preference in humid places", "near lakes or running water", "on sheltered, humid slope", "on moist rocky flats", "low-lying humid soil", "on damp, manured places", etc. Joh. Lange has, as a rule, given tolerably clear information in his "Conspectus" about the nature of the soil, and his statements are presumably based upon Jens Vahl's labels.

His statements also verify the opinion that the majority of the species grow upon tolerably damp ground, many of them even upon wet or boggy ground.

The cause of the general dampness of the ground, is apparent. It is, in the first place, the snow-covering, during the long winter, which lies over the whole country, so to speak, and which only disappears for a few summer-months, and then from a part of the coast-land only. The melting snow soaks into the soil and trickles down over the sloping ground, for a long time especially in those parts where the rays of the sun can only reach it with difficulty, for instance, on slopes facing the north. Different travellers have drawn attention to the fact that the northern sides of mountains or those sides of valleys facing the north, remain fresh and green much longer than those facing the south.

From the Alps we hear much about "die Schneethälchen" and their peculiar flora (for instance SCHRÖTER, BROCKMANN-JEROSCH and other Swiss botanists); also from Scandinavia (for instance TH. RESVOLL). These isolated snow-patches which lie long, many during the whole summer, retain a considerable amount of moisture for a long time, and may be prolonged sources of water which will trickle down over the land. Even if plants grow upon a sandy substratum, or even upon a rocky substratum, this will long be able to remain wet or damp. A stony or gravelly substratum also retains moisture for a long time, because the ground is protected from evaporation by the covering or imbedded stones.

Even if travellers record, with regard to an individual plant, that it has been found on "dry ground," one must not take for granted that the ground has not been damp — even very damp. With regard to those plants, which have possibly been recorded to have been gathered "on manured spots," we may also suppose with tolerable certainty, that the ground on which they grew contained much water. Some of the species, however, are not very particular in their demands, since they are recorded as growing in "all localities," or "everywhere," as for instance, *Cerastium alpinum* and *Silene acaulis.* The many varieties of the former perhaps stand in direct causal connection with small differences in the habitats.

Transpiration. A factor which is connected with what has been said above, and is of no less importance, is the extent of the transpiration and of the atmospheric humidity.

TH. WULFF stated (1912, p. 5) that "the Arctic Flora is of a decidedly xerophilous type." There are, it is true, decidedly xerophilous types in the Arctic vegetation, which I have probably been the first to record (1887) since I, in chapter 5 (pp. 105—127), treated of "The Adaptations of Heath-plants to Drought". It must, however, be remarked that the woody plants of the heath and the rocky-flat are what I especially treated, and amongst these one finds in reality a number of distinctly xerophilous types. I pointed out five different types of leaves, and even declared that similar types are met with in the steppes and in deserts — even in the Egyptian-Arabian desert, but I laid a great stress upon the fact that this essentially applied only to the woody plants of the heath.

By far the greater majority of the species in question are evergreens, this especially applies to the many woody plants proper, the foliage-leaves of which remain for more than one year. With regard to these one can speak of physiological dryness, but hardly with regard to low-growing herbs.

It is easy to understand that in woody plants the shoots must become xerophytic in structure, — which is, as usual, exhibited in the anatomical structure of the leaves, — because they are higher in growth than are herbs, and often may be without a snow-covering during the winter; their leaves will frequently be exposed to the desiccating power of cold and dry wind and this in a higher degree than those of herbs, and the cold soil will for a long time prevent the roots from absorbing water. The winter, in particular, is a very dry season of the year, and the higher the latitude, the drier it becomes; but the danger of desiccation is much less as regards the vegetative organs of herbs, because they are generally lower in growth, and are, in addition, often protected by the dwarf shrubs.

If we now regard the leaves of the *Caryophyllaceæ*, we find no such adaptation for withstanding desiccation. On the contrary, in the structure of their leaves they remind one more of those of aquatic plants, or of herbs which grow on damp, shady ground in woods.

The epidermis has no specially thickened and cuticularised outer walls. The stomata are situated very superficially, occur often on both surfaces, and in great abundance; the epidermal cells are most frequently highly undulating; the mesophyll is very lacunose; aqueous tissue does not occur; the epidermis is on the whole glabrous, and in *Cerastium alpinum* alone a denser covering of hairs is found; and hard bast occurs rarely and only in a few thicker vascular bundles. These results agree, as already mentioned, with those previously arrived at by several botanists, as regards Arctic plants in general.

The explanation is obvious: The rays of the sun are very oblique; the leaves are but slightly warmed, although the insolation may be very strong locally; the atmospheric humidity is great (80—85 $^0/_0$; see table in Börgesen); fogs and cloud-covered sky are very frequent, also during the summer; it is advantageous that transpiration is not lessened by special structural features, so that the water-current can flow rapidly through the leaves and the assimilation increase in vigour and compensate for the briefness of the summer, with its fogs and weak light. The transpiration cannot be assumed to be specially strong during summer. It is also easily compensated for by the water which is accessible to the herbs from the fogs and from the water-contents of the soil.

The precipitation undoubtedly varies greatly in the different regions. LUNDAGER records from Danmarks Havn in N.E. Greenland 28.4 mm for the summer (April—Sept.) and 117.2 mm for the winter. Only $^1/_{10}$ falls as rain. The inconsiderable amount of rainfall must undoubtedly be compensated for by the water-contents of the soil and the fogs.

THORILD WULFF has, in his paper of 1902, communicated some results of transpiration-experiments with Arctic plants made with the cobalt-test in the open in Spitzbergen, detached leaves being placed between cobalt-paper. WULFF particularly emphasizes the fact that the method is defective, but no other could be employed. The water from the snow of the habitat situated on a high level "provided for a homogeneous distribution of the moisture of the soil." Unfortunately, he did not investigate the temperature of the water and the soil, which of course plays an essential part as regards the amount of the transpiration. Among the ten species which were investigated, there was only one of *Caryophyllaceæ*, viz. *Cerastium alpinum*, the leaves of which were woolly with dense hairs. The transpiration was exceedingly slight, which WULFF thinks was essentially due to the hairy covering, "as the anatomy of the leaf rather favours the belief in an excessive transpiration than tells against it." Among the plants used for the experiment, *Cerastium alpi-*

num belonged to those which had the least transpiration, and the slightest growth. The result does not appear to have been very conclusive, but he says that, on the whole, the Arctic plants which were investigated had only slight transpiration, compared with plants from more southern regions. This must, beyond doubt, be due to the atmospheric humidity, which is certainly greater during the vegetative period than outside it. The leaf-structure of herbaceous plants agrees well with the humid air, the fogs and the abundant water-contents of the soil. As regards the physiological dryness in Arctic countries certainly too much has been said. THORILD WULFF generalized in too high a degree in saying, that the Arctic flora "is of a decidedly xerophytic type," although this is true only of the woody plants.

The above-mentioned conditions pertaining to the habitat also explain, at any rate some of the morphological conditions, e. g., that in so many cases adventitious roots are developed; that runners are formed may be due to the fact, that the low temperature has altered the growth-direction of the shoots (Psychrokliny: Vöchting, 1898; Lidforss, 1903), the moisture, perhaps in connection with the pressure of the snow, having favorised a development of adventitious roots. On the other hand, it must be the cold and desiccating winds which cause the frequently-occurring pulvinate growth; the shoots are arrested in their growth, and the branches become short and thick-set.

That the buds are open and that bud-scales are absent, I regard as a generic character. This results in conditions favourable to the development of the pulvinate habit, especially when the plants are covered with a layer of snow, which lasts throughout the winter; many leaves must be able to keep green for a long time, at all events until the snow has melted, and the youngest leaves are ready for quick expansive. In all Arctic *Caryophyllaceæ* it will certainly be found that the youngest leaves are, during the winter, protected by older leaves, which are more or less withered. That the peculiar condition of the protoplasm, and the different substances contained in the cells, can protect against the cold of the various seasons, must be taken for granted. With regard to this, however, I cannot give any new information.

IV. Flower-biology and Notes on Seed-production.

In by far the greater majority of the Arctic-flowering plants it appears that the flowers are formed during the year previous to that in which they open, and that they pass the winter in a more or less well-developed condition, — a circumstance which is a natural adaptation to the extreme brevity of the favourable season of the year (the extreme brevity of the summer-time).

In the foregoing papers in "Meddelelser om Grönland" belonging to this series, the fact that the flowers are formed during the year previous to that in which they open, has been specially pointed out in a number of species by KNUD JESSEN (Ranunculaceæ, Rosaceæ) and others, and for instance, as regards the *Caryophyllaceæ*, this is found to be the case in *Cerastium alpinum* in Iceland and the Færöes (Helgi Jónsson), *Silene acaulis* (*idem*), *Cerastium trigynum* in Norway (Th. Resvoll), *Melandrium apetalum* (*eadem*), and *Minuartia biflora.* On Greenland material, gathered on Aug.6th, I found buds which enclosed flowers for the next year.

As an example I give here (Figs. 25) some figs. of *Silene acaulis.* The material was gathered by C. RYDER near Upernivik on ground which had recently been bared of snow. The buds which were present had evidently passed through the winter. The buds were $^1/_2$ mm in transverse section;

they were doubtless male flowers, all the leaf-whorls of which were formed, also that of the pistil (Fig. 25, the small figure to the left). For further particulars, see explanation of the figure. On material from South Greenland, gathered on Aug. 29th, I also found buds which enclosed flowers for the next year. That flowers buried in the snow, on the melting of the latter in the ensuing year, sometimes emerge "as fresh to look at as newly expanded", is evident from what e. g. LUNDAGER writes (1912) about *Cerastium alpinum* found in N. E. Greenland, May 23rd, 1908 (loc. cit. p. 409).

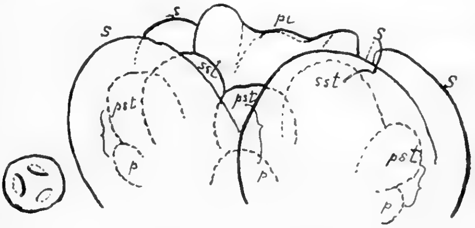

Fig. 25. *Silene acaulis.*
Young bud, highly magnified and made transparent, so that through the sepals (*s—s*), drawn with continuous lines, the calyx-stamens (*sst*), the petals (*p*) and the stamens (*pst*) placed opposite to them are seen. The pistil is in the middle; it is at the stage of development shown in the small figure. From Upernivik, 10. 5. 1887; C. Ryder. (E. W.)

In "Botanisk Forenings Festskrift" (Copenhagen, 1890), I published a series of notes on the flower-biology of the Arctic and Danish *Caryophyllaceæ*, accompanied by 29 figures. These notes, which were written in Danish, without any Resumé in a universally current European language, appear to me to have remained almost unknown. I have, therefore, no hesitation in reprinting here such parts of them as concern Arctic species. My notes are based, for the most part, on observations made in the field in northern countries, and afterwards supplemented by studies made on material preserved in alcohol.

I had been hoping to find some contribution towards the elucidation of the nature of gynodioecism, but this hope was not realised. It is to be hoped that others may be more fortunate in this respect, especially through experiments they may make.

I begin with the *Alsineæ* because I regard them as the most original type of *Caryophyllaceæ*: since their flowers are open and have polysepalous calyx and polypetalous corolla which are for the most part complete in number in all the whorls; can be visited by many kinds of insects; have many ovules in the ovary; and are hypogynous. From this prototype there issue on the one side the *Sileneæ*, the flowers of which have gamosepalous calyx and are in a higher degree adapted to pollination by special insects; and on the other side, the *Sclerantheæ*, with more or less reduced flowers.

1. Cerastium arvense. L.

Denmark. Gynodioecism; protandry. As the plant is propagated by underground runners, large patches are found covered with the one form only. The stigmatic papillæ extend almost to the base of the styles.

☿ are distinctly >[1] ♀, 13—15 mm in diam., petals 10—11 mm long, while ♀ are 10—12 mm in diam., petals 7—8 mm long. Highly protandrous with the ordinary process of development; the cal.-anth. are the first to open, the cal.-st. standing erect, then the cor.-anth., before the cal.-anth. are emptied, and the cal.-st. bend backwards; ultimately, the styles bend outwards, and the stigmatic papillæ grow out, as a rule before the pollen has fallen out entirely. Self-pollination may be able to take place. The anthers are usually

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[1] For brevety's sake the mathematical signs indicating relations of quantities are used. For the same reason the following abbreviations have been used: cal.-anth. for anthers opposite the sepals, cal.-st. for stamens opposite the sepals, cor.-st. for stamens opposite the petals, etc.

placed transversely to the filaments, with the pollen lying exposed on the side turned upwards (Fig. 26, a^1) or even entirely outwards.

In Germany, according to A. Schultz, ♀ are not rare and are often the only form to occur over entire tracts. I do not know how frequent it is in Denmark. The anthers are generally distinct and almost normal in form, but they are white, transparent and empty. Sometimes a few (I have seen 1—3) anthers are met with among the others which are yellowish, dehiscent, and contain pollen-grains; the latter appear, however, to be useless, only a few being round and smooth, while the majority vary in size, are angular and thick-walled, and are therefore distinctly abnormal. It is also usual for such flowers to be somewhat larger (petals 9—10 mm) than those which are more decidedly female. In the neighbourhood of Copenhagen there is a growth of *Cerastium arvense* in which the flowers vary between ☿ and ♀ and there fruit is sometimes set, but, as far as I have observed, rarely.

Greenland (about 67° N. lat.). ☿. Protandrous. Petals 8 mm, cal.-st. 5 and cor.-st. $4^{1}/_{2}$ mm. Ovary 2 mm. Consequently, somewhat small-flowered, but otherwise normal.

2. **Cerastium alpinum** L. (Fig. 26).

Almost as large-flowered as *C. arvense*, but has nevertheless a decidedly homogamous and self-pollinating flower, which fact must undoubtedly be correlated with its northern (Arctic) and its Alpine homes. In Greenland I observed that the flowers after a two-days rain were somewhat more drooping, and more closed than usual.

West Greenland (as far as about 73° N. lat.). Gynodioecism; Gynomonoecism. — ☿. Slight protandry with quickly ensuing homogamy and self-pollination (Fig. 26a, b^1). The relative length and position of the stamens and pistil is shown in the figures. Before the cor.-anth. are opened the styles may be covered with germinating pollen. I have even seen homogamy set in immediately, even before the flowers had expanded fully, and while the styles were still erect: in Fig. 1, *B*, b^1, b^2 the stigma is covered with germinating pollen although seven anthers are still closed. This

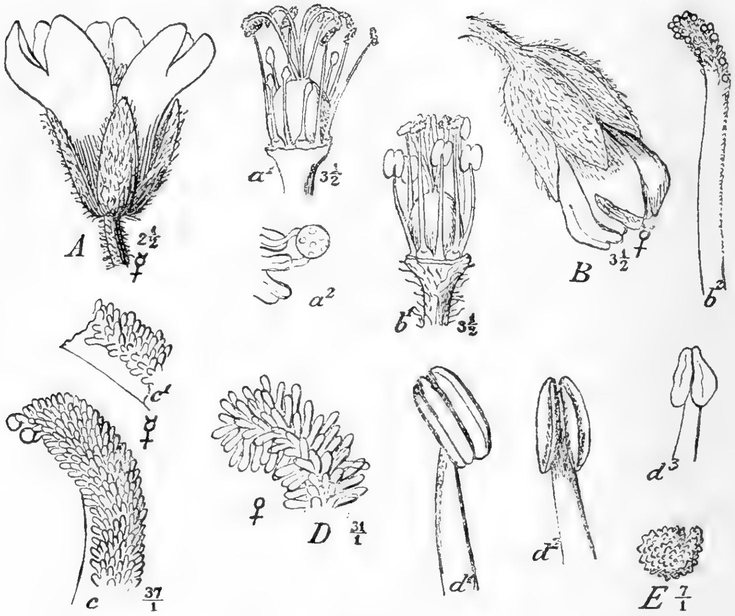

Fig. 26a. *Cerastium alpinum.*
From West Greenland (about 64°—70° N. lat.).
☿. — *A*, a^1, a^2: ☿ in which four cal.-st. and one cor.-st. are abortive (a^1). *B*: ☿, scarcely expanded, but the stigmas (b^2) are covered with germinating pollen; three cal.-anth. have opened, but the cor.-anth. (b^1) are still closed. *C*, Style of ☿ with pollen which has germinated; all the anthers have opened and are empty. c^1 shows the longest papillæ at this stage. — ♀. *D*, Style, $^{37}/_{1}$ and not $^{31}/_{1}$ (from beyond 73° N. lat.; C. Ryder), and d^1, d^2, d^3 stamens in various stages of reduction; d^1 has fibrous cells in the wall, but no pollen. *E*, Seed. (E. W.)

is almost self-pollination in the bud. In specimens from Upernivik (C. Ryder) the flowers were closed and the styles were closely surrounded by the anthers. — ♀ are very common in Greenland, as far as 73° N. lat. They are < ☿, the petals being 8 (to 10) mm in length (sometimes only slightly longer than the calyx), while in ☿ they are 11—12 mm long; the pistils appear to be the same, but the stigmatic papillæ are larger in ♀ (Fig. 26a, *D*) than in ☿ (Fig. C, c^1). The stamens may be abortive in varying degrees; the anthers may have a somewhat normal form, but be quite transparent, or the stamens might be, for instance, 4—4½ mm long and have yellowish anthers, which is, however, devoid of pollen (Fig. d^1—d^3). Near Godhavn I found one ♀ in the same tuft as ☿, consequently gynomonoecism. In several female flowers from Godhavn (69° N. lat.) I saw the stigmas densely covered with pollen-grains, so that insect-pollination must be able to take place.

Intermediate forms also occur, for instance, flowers with two normal stamens and the others sterile; or four cal.-st. and one cor.-st. abortive, or even eight normal and two quite abortive.

East Greenland. ☿ (gathered by P. Eberlin), agree with those from the west coast, but the flowers are smaller (petals 9 mm).

Fruit ripens in Greenland from the southern point up to at least Upernivik (seed, Fig. 26a, *E*).

Spitzbergen. ☿ (gathered by Nathorst; 1. 7. 1882), agree with those from Greenland. Fruit set, which ripens both here and I think in all other Arctic regions, e. g. Grinnel Land, Sabine Island, the north coast of Siberia, etc.

Var. β *cæspitosum* (Malmgr.), Fig. 26b, gathered by Nathorst. The specimens are very small (foliage-leaves 5 mm long and 3½ mm broad), quite glabrous; appear to have foliage-leaves which persist through the winter, and not to differ from the type in regard to the flowers.

Iceland. (Reykjavik). Protandry.

Norway. As in Greenland, sometimes even protogynous (Alten, about 70° N. lat.; Tromsö). Gynodioecism: Kongsvold (16. 7. 87).

Lindman is of opinion that the anthers are placed so far above the stigmas that self-pollination cannot take place until in the last stage, when the fully grown and revolute styles may reach the anthers. — Sweden: Slight protandry (Axell). — The Alps: Gynodioecism; protandrous (but ♀ much rarer than ☿: Ludwig). — Italy: Homogamy (Ricca).

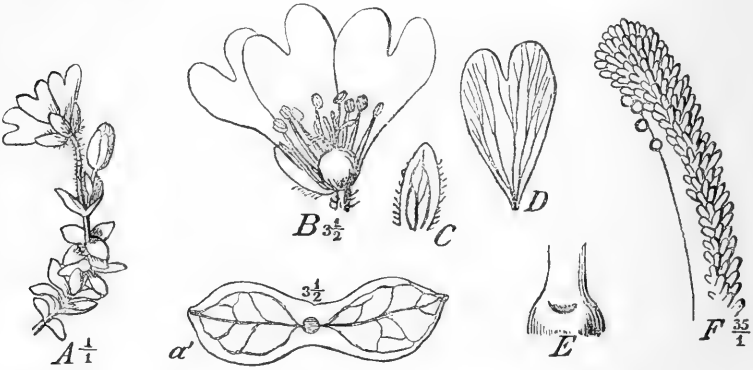

Fig. 26b. *Cerastium alpinum* β *cæspitosum* Malmgr. From Spitzbergen (Nathorst; 20. 8. 1882).

A, A branch, natural size; lower part quite glabrous and with very small, close-set foliage-leaves; upper part covered with long, scattered hairs (not glandular hairs). The lowermost leaves have persisted through the winter. a^1, A pair of foliage leaves. *B*, A flower opened and its parts spread out artificially. *C*, Sepal. *D*, Petal. *E*, The basal part of a cal.-st. *F*, Style with germinating pollen-grains. There was still some pollen left in the anthers of the flower of which the style is shown in Fig. *F*. (E. W.)

3. Cerastium latifolium. L.

Norway (Dovre; 15. 7. 1887). ☿ have petals about 8 mm in length; the stigmatic papillæ extend downwards only $^3/_4$ or $^4/_5$ the length of the style. Slight protandry, but homogamy soon ensues, and in the specimens investigated the styles were bending backwards so decidedly that they almost touched the petals and were more-or-less dipping into the pollen, so that self-pollination took place.

In one flower the styles were only slightly curved backwards, but were already covered with germinating pollen; of the anthers, only the cal.-anth. were open and had shed a little pollen. Here, consequently, a slight degree of protogyny, if anything, appears to have taken place.

Switzerland: Protandry, with ultimate self-pollination (H.M.).

4. **Cerastium trigynum** Vill. (Fig. 27).

(= *Stellaria cerastoides* L.)

Greenland: Gynodioecism with decidedly homogamous or slightly protandrous or slightly protogynous flowers. ☿ but rarely ♀; gynomonoecism rare. Self-pollination.

☿. The petals are only slightly outspread (Fig. 27, *A*) so that the flower becomes on the whole, bell-shaped; but it is possible that light and heat exercise some influence as regards this point. The flower is not infrequently somewhat irregular, some of the petals being smaller than the others. The petals grow decidedly during the flowering period; they are 6—10 mm long, but vary in length relatively to the sepals. The anthers and the stigmas attain almost the same height and are functional at the same time; as all the stamens simultaneously stand erect closely around the pistil, and the styles are more or less outwardly curved, self-pollination is inevitable (Fig. 27, *B*), and the numerous pollen-grains which are sometimes seen upon the styles (Fig. *C*) are also indicative of this; contact has also been directly observed (Fig. *B*). In fully developed buds the anthers are quite ripe, and they often dehisce immediately after the bud has been artificially opened; I have even found them dehisced in the bud itself, and as the stigmas also are fully developed, I do not doubt that as a rule self-pollination takes place immediately after the opening of the bud. The stigmatic papillæ extend almost to the base of the styles; the latter

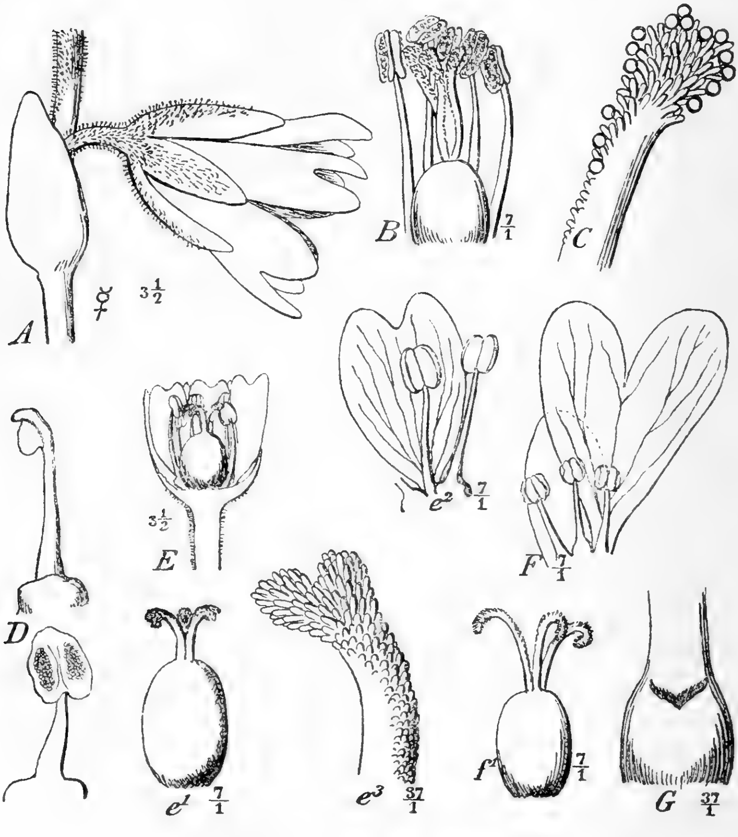

Fig. 27. *Cerastium trigynum.*

A—C, from West Greenland (gathered partly by Rosenvinge). *A*: ☿; length of petals 7—8 mm; styles erect. *B*, *C*: Parts of the same flower; self-pollination (6. 8. 1884).

D—E, from East Greenland (P. Eberlin; 30. 7. and 5. 8. 1885). *D*, Two abortive stamens; one contains some pollen. *E* with e^1—e^3: a remarkable, small-flowered form; all the cal.-st. are open and are partially empty; cor.-st. still full of pollen, but are in the act of opening.

F, *G*, from Norway (Tromsö). *F*, f^1: ♀ with quite transparent anthers which are, however, almost normal in form. *G*, base of a stamen.

are usually somewhat club-shaped, becoming broader at the apex, or even 2-lobed (Fig. 27 *C*; e^3). According to Lindman the flower has a sweet perfume (Dovre), in Greenland I made the note "White, scentless."

A remarkably small-flowered form was gathered by P. Eberlin in East Greenland (Kutek; 5. 8. 1884); it is figured in Fig. 27, *E*. The petals are in their last stage only 6 mm long and of the same length as the calyx.

♀ occur, but rarely, as far as I can see. I have seen specimens from East Greenland, the stamens of which are shown in Fig. *D*, but as some of the stamens appeared to be normal, these flowers were consequently perhaps not purely ♀.

Gynomonoecism: In the same tuft I found ☿ and ♀ with large rudiments of stamens.

Fruit is set in Greenland, for instance at 67°—70° N. lat. A ♀ was found pollinated, so that insects must certainly be of assistance there.

Norway. Gynodioecism (Tromsö, 21. 7. 1885); ☿ homogamous (West Finmark; Dovre; Tronfjæld); in all its parts as in Greenland. — ♀ has sometimes clear, transparent anthers, devoid of pollen, sometimes less decidedly reduced, and the same plant may show diversity of floral condition (Fig. 27, *F*). —Lindman: Homogamy, regular self-pollination.

I found transitional forms from ☿ to ♀ near Hammersfest, for instance, three rudimentary cal.-st., the rest normal; but I found cal.-st. < cor.-st. in a flower which occurred on a plant which had otherwise entirely ♀ flowers. In flowers I have most frequently found the cal.-st. to be the shortest. ☿ also occurred in which the stamens were so short that the backwardly-bent styles were not in contact with them, and in several ☿ the cal.-st. were < cor.-st.; but the contrary is the rule.

The Alps. Homogamy; in unfavourable weather self-pollinating to a high degree; specimens with partially shrunken stamens occur (H. M.). Italy. Homogamy (Ricca). — The flower appears to be exactly similar everywhere. Abortive stamens have hitherto been recorded only from Greenland and Norway.

5. **Cerastium vulgatium** L. (C. *triviale* Lin Nr.)

Denmark. Gynodioecism. ☿ slightly protandrous or almost homogamous; self-pollination takes place by the stigmas coming into contact with the anthers of the erect stamens. Sometimes all the cal.-anth. may be open, while the styles are still rolled up in the middle of the flower. The stamens usually stand more or less erect, especially the cal.-st. The anthers are white. The flower varies in diameter according to its age; at first it is about 5 mm in diameter, and afterwards as much as 8 mm. The styles bend to the right in the flower.

In a few cases protogyny appears to occur.

♀ with stamens aborted in varying degrees, some about 2 mm long, with rather large and almost normal anthers, others only 1—$1^1/_2$ mm long with transparent anthers which are, however, somewhat normal in form. Styles large, twisted (to the right), papillose down to their base, and filling the throat of the corolla. The corolla somewhat smaller than in ☿, the petals being $3^1/_2$—$4^1/_2$ mm, while those in ☿ are 5—7, most frequently 5—6 mm. The pistil is not, on the whole, more vigorous than in ☿, if anything smaller; the ovary is about 2 mm long in both. ♀ plants are rarer than ☿.

Specimens with partially aborted stamens occur.

Iceland (Reykjavik; 1884). Gynodioecism. ♀: petals 5 mm, cal.-st. 3 mm, ovary 2 mm and styles 2 mm. Some flowers had normal anthers, that is, they opened and contained pollen, which, however, appeared to be almost useless.

Sweden. Slight protandry; fertilized by self-pollination (Axell). Germany. Gynodioecism; Gynomonoecism. Slight protandry, rarely pure homogamy (H. M.; A. S.); in Riesengebirge A. Schulz observed in the same individual both decidedly homogamous and entirely protandrous flowers; entirely ♀ are said to be rare. — This species is one of those in which ♀ flowers seem to be rare; they are not much smaller than the ☿ flowers.

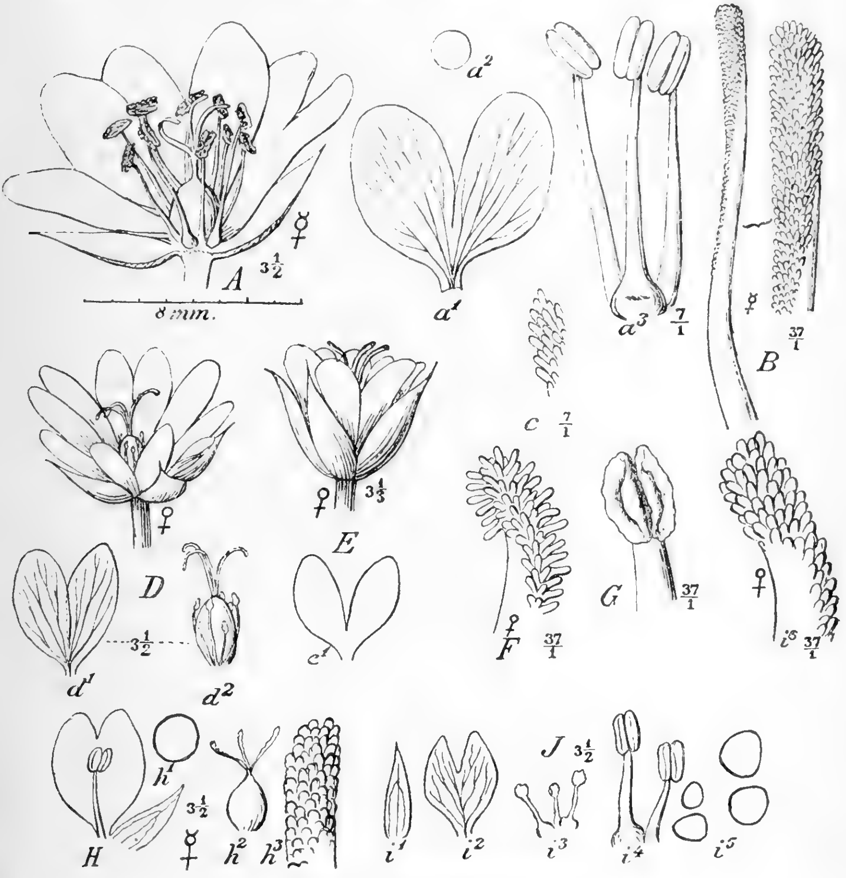

Fig. 28. *Stellaria longipes.*

☿. — *A*, from Greenland (about 69° N. lat.); *a*², pollen grain. *B*, from ☿ in its last stage. (differently magnified). *C*, Most fully developed papillæ from ☿ observed by me.

♀. — *D*, *d*¹, *d*², and *E*, *e*¹: ♀ flowers from West Greenland (about 67° N. lat.). *F*: Stigmatic papillæ of ♀ (longer than those of ☿ shown in *C*); from Greenland (about 67° N. lat.). *G*: Cor.-st. of ♀ from about 69° N. lat.

H, *h*¹ (Pollen), *h*² and *h*³ from ☿ from Spitzbergen. *J*, *i*¹—*i*⁶, from ♀ from Spitzbergen. (E. W.)

6. **Stellaria longipes** Goldie (*St. Edwardsii* R. Br.) Fig. 28.

Greenland. Gynodioecism; ☿ > ♀. Slightly protandrous or homogamous flowers.

☿ appear to be more or less decidedly protandrous or decidedly homogamous. The specimen figured in Fig. 28, *A* had all its anthers open, but the stigmas were still unripe. In the fully developed flower the stamens stand at a distance from the pistil, so that the anthers are not in contact with the stigmas which are never markedly revolute. The flower secretes honey abundantly. I am not prepared to say whether self-pollination takes place regularly, but judging from the position of the parts of the flower, there does not appear to be anything to prevent this, and the anthers are not empty when the stigmas ripen. The stigmatic papillæ extend half the distance down the styles (Fig. 28 *B*). The number of the styles varies, being sometimes as many as four.

♀ occur as far north as Upernivik (about 73° N. lat.), according to material gathered by C. Ryder (3. 9. 1886). They are much smaller than ☿ (compare Fig. 28, *D* and *E* with *A*, or, for instance, the petals d^1, e^1 with a^1); while ☿ is as much as 13—14 mm in diameter, ♀ is only 7—10 mm; the petals of ☿ are 7—$7^1/_2$ mm, of ♀ 5—6 mm. But otherwise the ♀ flowers vary as regards the relative size of the parts. Specimens occur in which the petals are longer than the calyx, others in which they are of equal length. The stamens (Fig. *G*) are smaller than, or at most of the same size as the ovary (Fig. *D*). The pistil is so large in proportion to the corolla that the apices of the styles protrude (Fig. *D*, *E*). The stigmatic papillæ are longer in ♀ than in ☿ (Fig. *F* and i^6 compared with *B* and *c*). I have no note of having seen ripe fruit from Greenland.

Spitzbergen. Gynodioecism; ☿ > ♀ (Fig. 28, *H* and *J*). It is remarkable the small size which the flowers (sometimes?) attain here, which can be seen by comparing Fig. *H—J* (from Spitzbergen) with the others which are from Greenland. The anthers and pollen-grains however are almost equal in size (see a^2 and h^1). The petals in some of the specimens investigated were less deeply cleft than usual (Fig. *H*, i^2). ☿ are protandrous, the corolla is > the calyx (Fig. *H*). — ♀: the length of the corolla is equal to that of the calyx (Fig. i^1 and i^2), about 4 mm. The stamens may have rudimentary pollen-grains of varying size and form (Fig. i^5,

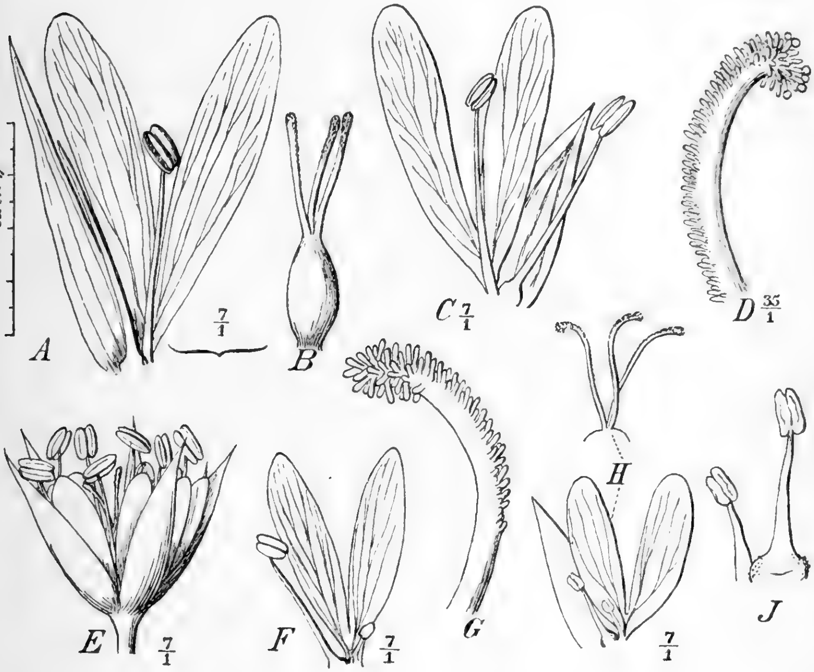

Fig. 29. *Stellaria graminea.*

A, *B*, from ☿ from Altenfjord, gathered late in the evening of 14. 7. 1885. Markedly protandrous, the stigmas still far from ripe. *C—J*, from Denmark. *C*, *D*, *E*: ☿. *F*: Intermediate form. *G*, *H*, *J*: ♀ (Scale given applies to *A*, *B*, *C*, *E*, *F* and *H*). (E. W.).

some are perhaps sometimes normal); but in the highest degree of reduction the anthers are transparent, without the least trace of pollen-grains. The stigmatic papillæ are also here longer than in ☿ (see Fig. i^6 and h^3).

7. **Stellaria graminea** L. p. p. (Fig. 29).

Denmark. Gynodioecism; ☿ > ♀, distinctly or less distinctly protandrous.

☿: Protandry, with the stamens performing movements towards the middle of the flower and back again. The anthers turn more or less outwards or even backwards. As a rule self-pollination may ultimately take place, but I have seen flowers which had lost their anthers before the styles spread out. The anthers are flesh-coloured or become ultimately somewhat brownish, the pollen is yellow in colour. The styles are covered with stigmatic papillæ along the upper $^3/_4$ of their length (Fig. 29, *G*). At first they are bent inwards or almost rolled up, ultimately spread out, scarcely rolled backwards. The flower varies greatly in size and length relatively to the calyx (Fig. *C* and for instance *E*); this is also still more noticeable when compared with flowers from other countries, for instance Fig. *A* from Finmark.

♀ appears to be as common as ☿. Its size relatively to ☿ is seen by comparing Fig. 29, *H* (♀) with *C* and *E*. The petals in ♀ are $3^1/_2$—$4^1/_2$, rarely $5^1/_2$—6 mm; in ☿ 5—7. ♀ is about 5—6 mm in diameter, while ☿ is 9—13 mm, but near Copenhagen ☿ are found which measure $3^1/_2$—4 mm in diameter, and have petals $2^1/_2$ mm in length, i. e. smaller than the calyx. It should be borne in mind that the petals grow in size during the flowering period. In some of the flowers the anthers (Fig. *J*) are quite transparent with crystals of calcium oxalate, in others the anthers are of a yellowish colour, or only their one-half is so coloured, and pollen has begun to develop within them. Several variations may be found in the same tuft. The styles project beyond the corolla.

Intermediate forms are often found in which a few or several stamens are aborted, and the others are normal (Fig. *F*).

There does not seem to be much difference between the stigmatic papillæ of ☿ and ♀ (Fig. 29, *D* and *G*).

Norway (Altenfjord). Gynodioecism, ☿ > ♀. Protandry. ☿: petals about 5 mm; corolla when approaching 3rd stage 9—10 mm in diameter.

A particularly large form is shown in Fig. 29, *A*.

8. **Stellaria media** (L.) Vill.

I have occupied myself very little with this species as I expect it to be fully treated by another writer. The following is for the most part taken from the literature on the subject.

The flowers open and close according to the weather; Vaucher states that the flower lasts for one day only. Gynodioecism, Gynomonoecism. ☿: Protandrous in various degrees, self-pollination found especially in plants which flower during winter. As is well-known it flowers all the year round, even during the whole of autumn and winter, and sets fruit continually, probably in the closed flowers, thus forming a transition to cleistogamy (as regards *S. Boraeana* Jord., which is said to be a form of *S. media*, see A. Schulz; it is cleistogamous, with petals either small or absent, like *S. media* var. *brachypetala*, and with 2—3 stamens). Here self-pollination appears to give excellent results.

The flowers vary considerably in size and in the length of the petals relatively to the calyx. Lange mentions a form *apetala*. Some of the flowers, viz. the largest, have all the

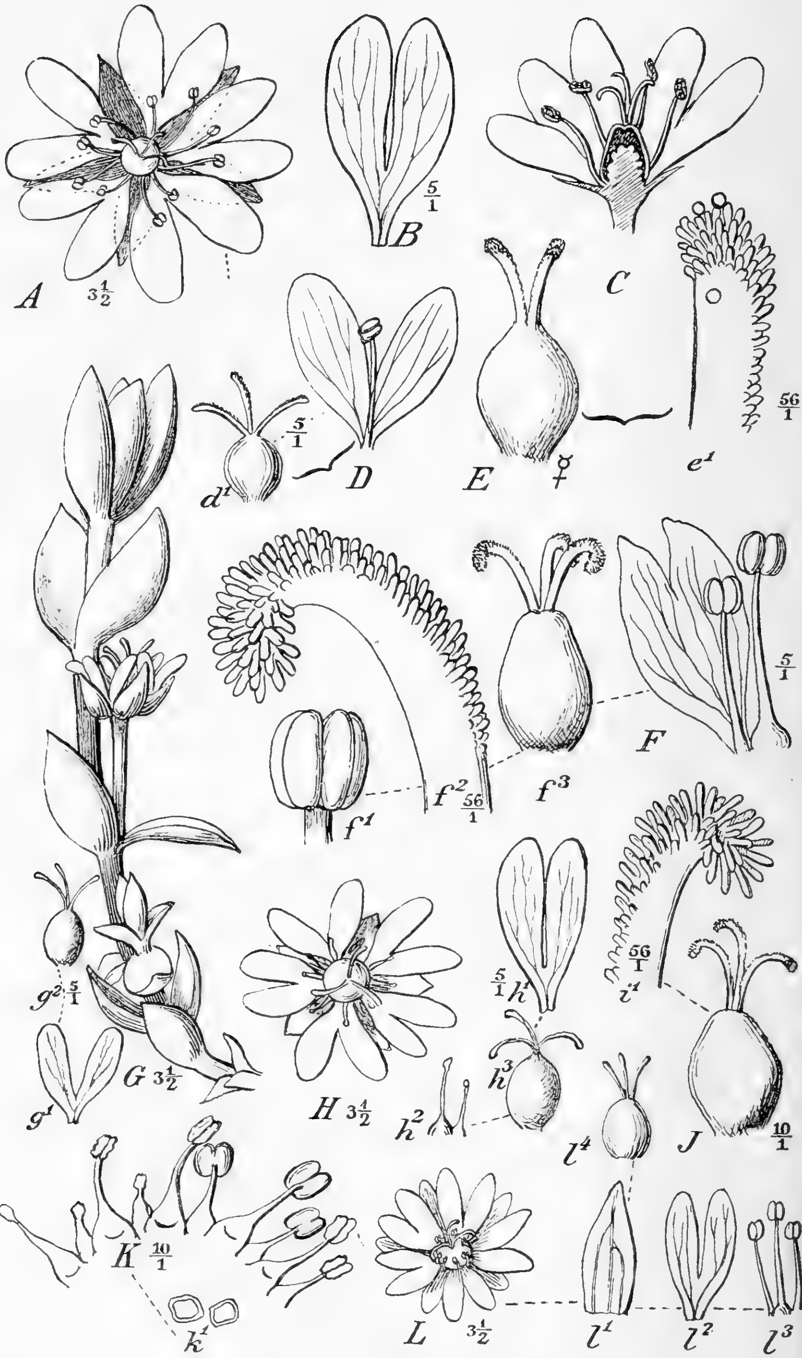

Fig. 30. *Stellaria humifusa.*

☿: *A—F*, *L*. ♀: *G—K*.

A—C: ☿ from Greenland (about 68° N. lat.). *D*, Parts of ☿ from East Finmark. *E*, dimerous pistil with ripe stigmas, e^1 (Greenland). *F*, Different parts of ☿ from East Greenland (P. Eberlin); protogynous, the anthers not yet opened, but the stigmas well-developed. (The petals vary somewhat in form, which is an unimportant detail; in the same glass, specimens were found with petals of the usual forms).

G: from West Greenland (about 67° N. lat.); ♀. *H*, from the same place, larger ♀ flower (compare the two flowers, both mag. 3½; also compare h^1 with g^1). *J*, from Greenland. *K*, from West Greenland; ♀ with stamens abortive in various degrees; pollen-grains formed in the three largest anthers, but thick-walled and irregular in form (k^1).

L: ☿ from Spitzbergen (Nathorst; 6. 8. 1882). (E. W.)

10 stamens. But the number is reduced in the smaller flowers and especially in those that flower during autumn and winter; it is in the first instance the cor.-st. which are subject to this reduction, but afterwards the cal.-st. also often share the same fate, so that the number of functional stamens may be as few as two (H. M. in Weit. Beob.). But the nectaries of the suppressed cal.-st. usually remain. According, however, to VAUCHER and A. SCHULZ the nectaries may also vanish, or, at any rate, they fail to secrete honey, even if present.

BENNETT and others have shown that they are self-fertilizing during winter or in cold weather and so display a transition to cleistogamy.

♀ are rare according to A. SCHULZ. According to LOEW a few ♀ are to be found on hermaphrodite plants.

West Greenland (about 65° N. lat.). Appear to agree exactly with European forms.

9. **Stellaria humifusa.** Rottb. (Fig. 30).

West and East Greenland. Gynodioecism; gynomonoecism, ☿ > ♀; protandry, as a rare exception protogyny (East Greenland), then homogamy.

☿. Protandry with the ordinary movements of the stamens and styles; the cal.-anth. open immediately on the flower expanding. The anthers turn transversely (Fig. 30, *C*). But as a rule homogamy no doubt ensues very soon, and the backwardly bent styles are in contact with the anthers. Protogyny has been observed in specimens from East Greenland (Fig. 30, *F*, f^1—f^3); the petals were, in addition, less deeply cleft than is ordinarily the case. The styles may number from 2 to 4 (Fig. *E*); in consequence of the long stigmatic papillæ at the apex they are rather club-shaped both in ☿ and ♀. The papillæ extend about $^1/_2$ or $^2/_3$ way down the styles.

♀ are considerably smaller than ☿ (compare Fig. *A* (☿) with *H* and *G* (♀). The petals are 3—5 mm in ♀, but $4^1/_2$—5—6 mm in ☿ (sepals 4 mm). The diameter of the ♀ is 5—6 mm, but that of the ☿ 7—12 mm. The smallest of the ♀ flowers (from about 67° N. lat.) is figured in Fig. *G*; the sepals and petals are about $2^1/_2$ mm in length. The stamens have transparent, quite empty anthers; a few may be found with worthless pollen (angular, thick-walled and smaller than is normal; Fig. *K*, k^1). The nectaries are not reduced in size (Fig. *K*). The stigmatic papillæ are longer in ♀ than in ☿ (see Fig. i^1 and e^1). The ovaries are equal in size (see Fig. h^3 and d^1), or smaller in the ♀ (see Fig. g^2 and d^1). I have noted down a single case of gynomonoecism (Godhavn).

Intermediate forms occur with a few or several abortive stamens and the rest normal; as for instance one normal and nine barren. In Fig. *K* there are three anthers which are apparently normal (one cal.-st. and two cor.-st.), but the pollen-grains are thick-walled and irregularly angular (k^1).

I have not observed any fruit which had set; it is possible that the species has compensation in its profuse vegetative shoot-formation.

Norway. Protandry with ensuing homogamy; the styles become functional almost simultaneously with or a little after the cor.-st. (Altenfjord, 10. 7. 1885).

Russia (Kola). ☿: petals $4^1/_2$ mm, slightly longer than the sepals. Diameter about 7 mm. Slight protandry with ensuing homogamy.

Spitzbergen. Gynodioecism. The very small flowers which occur here are remarkable. In Fig. 30, *L* are shown parts of a ☿ with the same magnification as *A* and *C*. Sepals and petals are here somewhat more than 3 mm. Pistil small with rather erect styles, which have papillæ only at their apex. The anthers are normal, open. Can this be a form transitional to ♂? An equally small ☿ has been found in Greenland. The ♀ flowers are even somewhat smaller; the sepals and petals $2^1/_2$ mm, but the stigmatic papillæ upon the slender styles are almost of the usual length. Th. Fries states also that the flowers are smaller and the petals narrower in specimens from Spitzbergen than in those found on the coasts of Finmark.

10. **Stellaria borealis** Bigel. (Fig. 31).

Gynodioecism. Homogamy, self-pollination. 3, 4, 5 styles (Fig. 31, *C*, *E*). Perigynous (Fig. *A*, *G*).

Greenland (about 65° N. lat.). ☿: Corolla absent. The whole flower 3—4 mm in diameter. Homogamy. Peculiar to this species are the long styles which curve backwards and are thrust among the stamens, so that they touch the anthers (Fig. *A*, *C*, *E*); the styles have stigmatic papillæ down to their base (Fig. *D*). Sometimes 1—3 stamens are abortive. In specimens from Greenland, collected by Rosenvinge the anthers were attacked by *Ustilago antherarum* and the pistil was checked in its development.

Norway (Dovre, Altenfjord). Homogamy. ☿: Diameter as in Greenland, sometimes as much as 5 mm. Petals most frequently absent, but they may be present and are then much smaller than the sepals. Stamens 10, with palish-brown anthers. Self-pollination as in Greenland, the styles being directly in contact with the anthers.

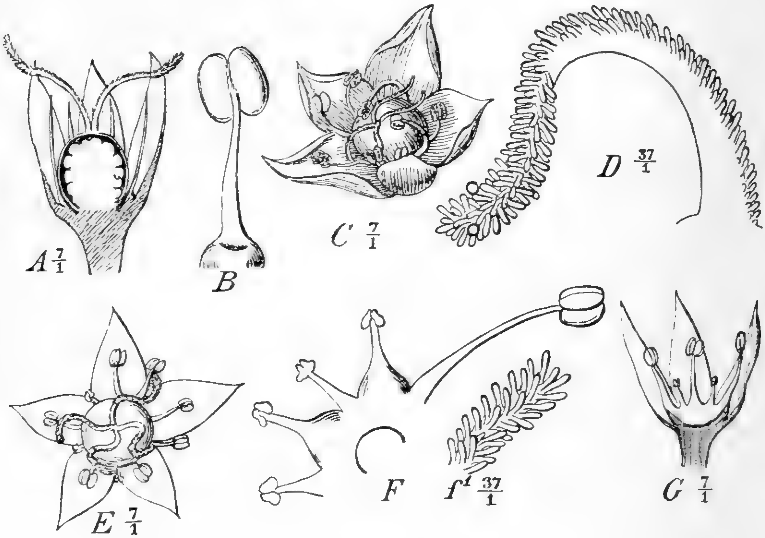

Fig. 31. *Stellaria borealis.*

A—C: ☿ from Greenland. *D*: ☿ from Dovre. *E—G*, from Kola (Dr. Brotherus).

A: ☿, the anthers have fallen off. *C*, Nine anthers have opened and are partially in contact with the widely outspread styles. *E—G*, A few or several stamens abortive. (E. W.).

Russia (Kola, material from Dr. F. V. BROTHERUS). Fig. *E*, *F*, *G*). Agree with those mentioned above, were also devoid of corolla. But there occurred in addition:

♀ and forms intermediate between ☿ and ♀ with stamens partially abortive; in Fig. *F*, they were all abortive excepting one (a cor.-st.); in Fig. *G*, the cor.-st. were abortive. The nectaries were not reduced, even when the filaments and anthers were reduced (Fig. *F*, *G*). The styles have perhaps somewhat larger stigmatic papillæ than in ☿ (compare *f*¹ and *D*).

According to Lindman, in Norway and Sweden, *Stellaria Friesiana* Ser. var. *alpestris* Fr. greatly resembles *S. boreale* on account of its long styles, papillose a long way down; but it is either protandrous or protogynous. Self-pollination takes place easily.

Sagina. Linnæi Presl.

My own investigations are too incomplete to be recorded. LUDWIG records gynodimorphism ("undeutlich"). A. SCHULZ records that there are two forms which differ as regards the size of the flowers. a: *decandra* Fenzl (*macrocarpa* Rchb.), petals = or slightly > than sepals. Most frequently 10 stamens. Homogamy and self-pollination. ♀ occur singly. — b: *micantha* Fenzl. which is, for instance in Riesengebirge, much commoner than *decandra*; the petals not even half as long as the sepals. Some, but rarely all, of the cor.-st. are always undeveloped. ♀ occur singly. Pollination often takes place in the closed flower. The flower is closed during dull, rainy weather, and even then self-pollination takes place with good result; consequently, this form approaches cleistogamy. See also A. SCHULZ in "Sitzungsber. naturf. Freunde", 1888, no. 4, p. 184, where he states that in 1886 he was staying several weeks in Hampelbande, but never saw an expanded flower, although several patches of ground were thickly covered with the plant; and the same was the case in 1887 "im westlichen Theile des Gebirges." Forma *decandra*, on the other hand, had always open flowers. — In Greenland it sets entirely ripe fruit.

11. Sagina procumbens L. (Fig. 32).

The flowers do not open in dull or in cold weather.

Denmark; Greenland. I have figured some Greenland specimens in Fig. 32, *A*—*E*, for comparison with our European specimens.

☿: Petals, small, $1^3/_4$ mm in length, smaller than the sepals (Fig. 32, *A*) which are $2^1/_2$ mm in length. The cal.-st. secrete honey as usual. Both the cal.-anth. and the cor.-anth. may be found in contact with the short, slightly outspreading styles which have very long, stigmatic papillæ which extend to their base (Fig. *E*, *F*). The Greenland specimens were found full of germinating pollen, and there can scarcely be any doubt that this is self-pollination, which I have also directly observed in Denmark; even in closed flowers I have seen (June 25th) the anthers shed a quantity of pollen on the stigmas; that self-pollination gives a good result seems to be evident from the fact that every flower appears to set fruit with hardly any exception.

♀ I have seen from Denmark, and in Fig. 32, *F* I have figured a style which differs slightly from that of the ☿, but beyond that I have nothing further to state as unfortunately I made no notes.

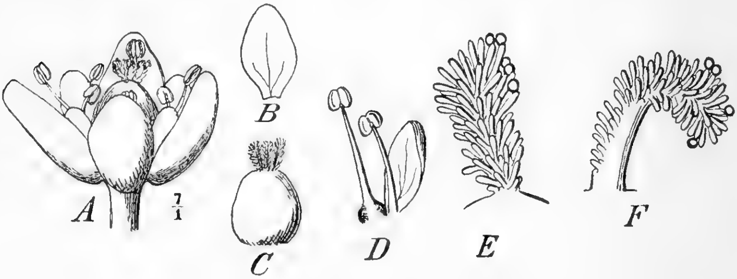

Fig. 32. *Sagina procumbens.*
A—E: ☿ from East Greenland (P. Eberlin).
F, from ♀ from Denmark (*E* and *F* $^{37}/_{1}$). (E. W.).

12. **Sagina intermedia** Fenzl.

Dovre. Pollen was found abundantly on the stigmas of styles covered to their base with long stigmatic papillæ, and appeared to have got there by self-pollination.

Fruit ripens on Spitzbergen and on the north coast of Siberia.

13. **Sagina cæspitosa** (J. Vahl) Lange.

Greenland (The district of Upernivik; 27. 7. 1888; C. Ryder). ☿: The petala are either equal to or < the sepals; homogamy: pollen may be found both in the anthers and also germinating simultaneously on the stigmas. The styles are thick, short, erect and covered with long papillæ down to their base. Self-pollination principally takes place by the erect position of the stamens, whereby the anthers approach the styles. Sets fruit which ripens.

Norway (Dovre: *S. nivalis* cæspitosa?*). Gynodioecism. ♀ have small petals, and the stamens are abortive in varying degrees, as some of the anthers contain worthless pollen, and others are quite transparent. But there are also intermediate forms with some of the stamens normal and the others abortive, for instance with one normal and the rest abortive.

14. **Arenaria ciliata** L. (Fig. 33).

Styles 3, 4, 5.

In Greenland it sets fruit which ripens on Disco.

Norway (Alten, Skjærstad). Gynomonoecism, ☿ about = ♀.

☿: Protandry with ensuing homogamy (Fig. 33, *C* and c^1); the cor.-anth. may be partially open before the stigmas are fully developed. Stigmas and anther may be found in contact. The cal.-st. are rather erect, and the cor.-st. are also bent somewhat inwards; they are almost equal in length (Fig. 33, *C* and c^1). The styles are covered with stigmatic papillæ along their upper $^2/_3$ part. They ultimately bend so decidedly outwards that they reach across the flower, but at that time the anthers are probably always empty (Sakkabani, Alten; 10. 7. 1888). ♀ were found in a tuft together with ☿ flowers, although not with perfect anthers; ♀ do not differ constantly from ☿ as regards size (see Fig. *E* and a^2) and have three outspreading styles (Fig. *G*). ☿ in the last stage are 4—5 mm in diameter. The petals of ☿ are 4—$4^1/_2$ mm in length. The stamens of ☿ are but slightly abortive; they are about half the size of the normal ones (Fig. *E*, *G* compared with *C*), and there is pollen in the anthers, but it does not appear to fall out and seems to be worthless. The styles appear to be stouter in ♀ than in ☿; they have in particular somewhat longer stigmatic papillæ (Fig. *F* and *D*), but this must be verified by further investigations, the difference, as shown by the figures, being slight.

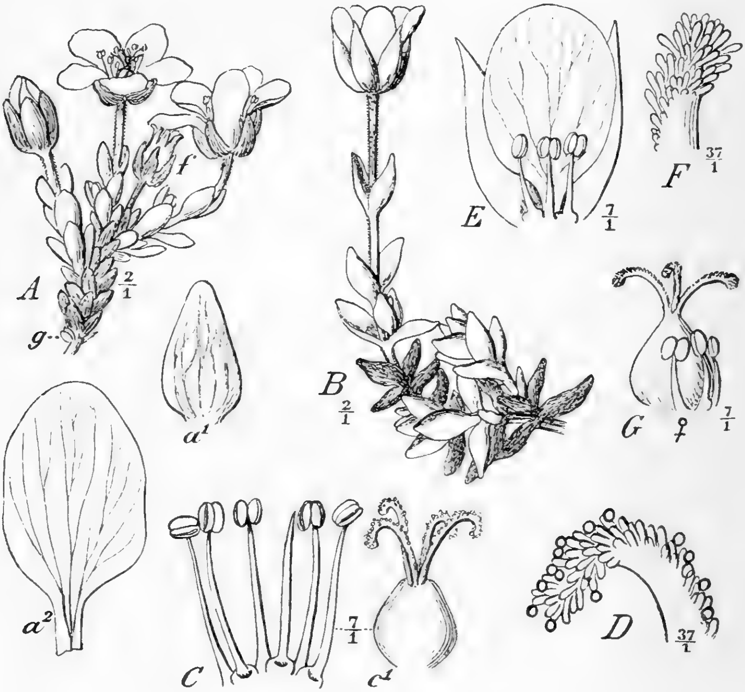

Fig. 33. *Arenaria ciliata.*

A, from Spitzbergen (Nathorst). ☿. *f*, capsule from the previous year; the darkly shaded leaves also from the previous year; *g*, a bud; a^1, sepal; a^2, petal (7/1); the latter is almost 6 mm in length.

B—*G*, from West Finmark (Sakkabani). *B*: ☿; the darkly shaded leaves are from the previous year. Flower scarcely fully expanded. *C* and *D* from ☿. *E*, *F*, *G*, from ♀. (E. W.)

Spitzbergen (17. 7. 1882; Nathorst). Fig. 33, *A*. ☿: Appear to be protandrous. Do not differ essentially from the Norwegian specimens as regards size, and appear to agree exactly with them in other respects. Malmgren records that the Spitzbergen specimens have larger flowers than those found in Russian Lapmark. ("Öfver. af K. Vet. Ak. Förh.", 1862).

15. **Moehringia lateriflora** (L.) Fenzl.

East Finmark. Appears protandrous or homogamous. Ultimately both the stamens and the styles spread out. The styles are hairy along their lower half.

16. **Minuartia groenlandica** (Retz.) Fenzl. (Fig. 34.)

Styles 3, 4.

West and East Greenland. ☿: Slight protandry, begins no doubt often with homogamy. In large buds I found the anthers of the erect stamens partially open and closely surrounding the erect, spreading styles, whose stigmas were not yet quite ripe (Fig. 34, *D*). But I have also observed the same position in expanded flowers, and then self-pollination is almost inevitable (Fig. *E*). The stamens and styles may be somewhat more outspread as shown in Fig. *F*, which is evidently connected with conditions of weather. The thin, white petals are 7—9 mm long and 5 mm wide, about twice the length of the sepals, which are 4 mm (Fig. *A*, *B*, *C*). Diameter 10—13 mm.

I found the seeds to be sometimes finely warted (Fig. *G*, from Ilua) and sometimes finely wrinkled (Fig. *H*, from Dronning Louise's Island). I am not prepared to say the reason of this difference, which is however but slight.

17. **Minuartia biflora** (L) Shinz & Thell. (Fig. 35.)

The flower is never spread out in a decidedly stellate manner because the sepals keep very erect (Fig. 35, *A*, *B*). Gynodoecism (or Gynomonoecism?); ☿ = ♀.

West Greenland (about 69° N. lat.). ☿: Slightly protandrous, perhaps entirely homogamous. In a flower like the one figured in Fig. *C*, the cal.-anth. only were open and shed pollen directly on the stigma (Fig. c^1). A similar flower with higher cal.-st. is shown in Fig. *E*. When afterwards the cor.-st. also open they are of about the same height as

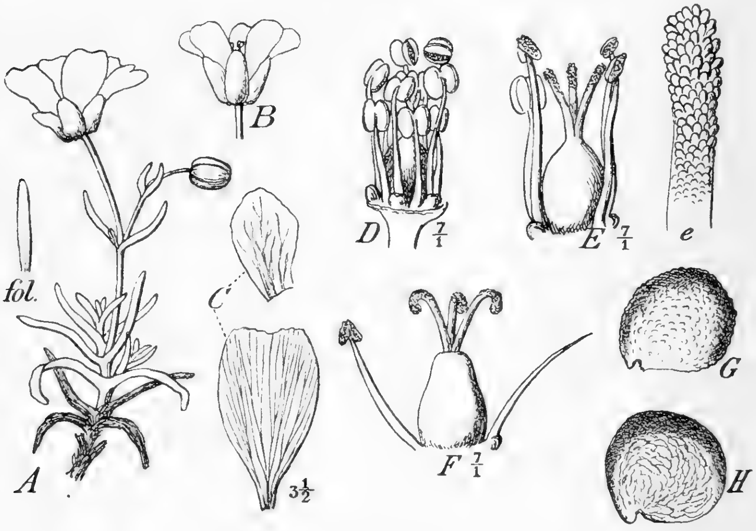

Fig. 34. *Minuartia groenlandica.*
All from Greenland. *A* (about $1^1/_2$) with a leaf (*fol*) from Umanak (Rosenvinge). *B*, from Sukkertoppen (*idem*). *C*, Sepal and petal. *D*, from a bud, two cal.-anth. have opened. *E*, *e*: All the anthers have opened with the exception of three cor.-anth. (here, as is so often the case elsewhere, a shrinking of the anther-wall takes place, on dehiscence, which must aid in the shedding of the pollen-grains). *F*, from an old flower, East Greenland (P. Eberlin). *G* and *H*: Seeds from Ilua in South Greenland (Mrs. Lundholm) and from East Greenland (P. Eberlin). — (E. W.)

the cal.-anth., and at a level with the apices of the styles. The anthers and stigmas are often in intimate contact with each other, the styles being thrust among the anthers, and self-pollination is inevitable. The filaments become ultimately more spreading. In some of the individuals the petals are narrow, almost spathulate, in others obovate (Fig. *D*, *F*); they are rounded at the apex, and frequently emarginate or slightly toothed (Fig. *D*). The sepals are 5 mm in length, and the petals 7 mm; in a flower from Finmark the sepals were only $3^1/_2$ and the petals $4^1/_2$—5 mm long.

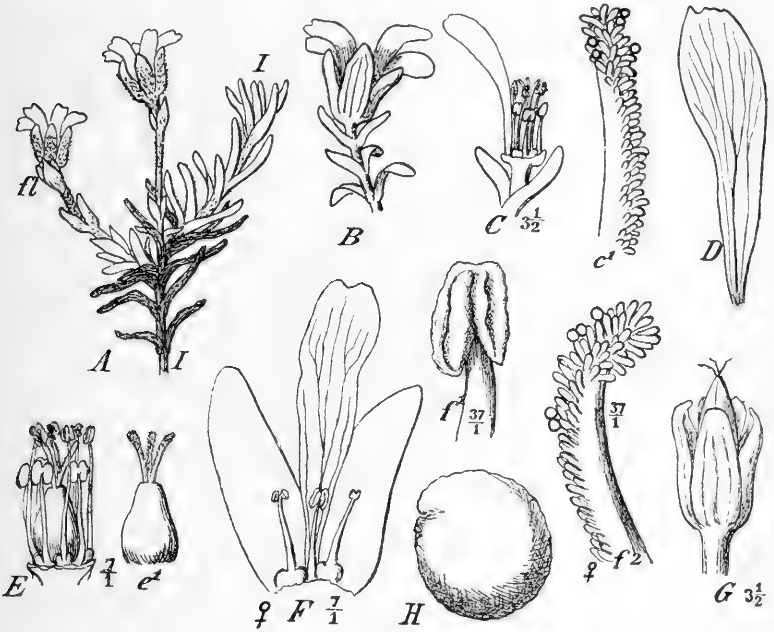

Fig. 35. *Minuartia biflora.*
From Greenland. *A—E*, Parts af ☿.
From Norway. *F* (Altenfjord), f^1 and f^2 from ♀. *G* (☿ which has finished flowering) and *H* (seed) from Dovre.

It seems that slight protogyny may occur, as the stigmatic papillæ may be fully developed even in the bud, and I have seen pollen-grains retained, but not germinating, on the stigmas of a Greenland specimen, the cal.-anth. of which were on the point of opening.

Fruit is set in Greenland, as it seems regularly and abundantly, at least as far as 70°—71° N. lat.

Norway (for instance Altenfjord, about 70° N. lat.). Gynodioecism.

☿: Slight protandry, as the cal.-st. bend inwards towards the middle of the flower and open their anthers over the still unripe styles; or homogamy and self-pollination; the anthers may be found full of pollen at the same time as there is germinating pollen upon the stigmas, and they may be found in contact with the latter. It is possible that protogyny also occurs.

♀: All the anthers abortive, but in various degree; they may be found to be shrunken; brownish, without any pollen at all, but with indications of the four pollen-sacs, as there is a transverse fold in each half (Fig. *F*, f^1). ♀ = ☿ as regards size, but the stigmatic papillæ in ♀ appear to be constantly longer than in ☿ (Fig. f^2 and c^1), and perhaps the pistil is, on the whole, somewhat larger, but this I have not measured precisely. A young fruit and a seed is shown in Fig. *G* and *H*. — Lindman finds that they correspond with those of the Alps.

Spitzbergen. Appear to agree with Greenland specimens, but the flowers appear to be smaller (sepals $3^1/_2$ and petals $4^1/_2$ mm). In the specimens from Spitzbergen the anthers were on the point of opening even in the bud, and scarcely has the flower expanded, when the anthers dehisce. — Sets ripe seeds.

18. **Minuartia stricta** (Sw.) Hiern.

Greenland. The plant evidently sets ripe fruit regularly, at least as far as 70°—71° N. lat.

Norway (Dovre). Homogamy prevails at least for a time, and as the anthers are at a level with the three highly papillose styles, and as fruit is so abundantly and regularly set, I must presume that self-fertilisation of the small flowers takes place with good result.

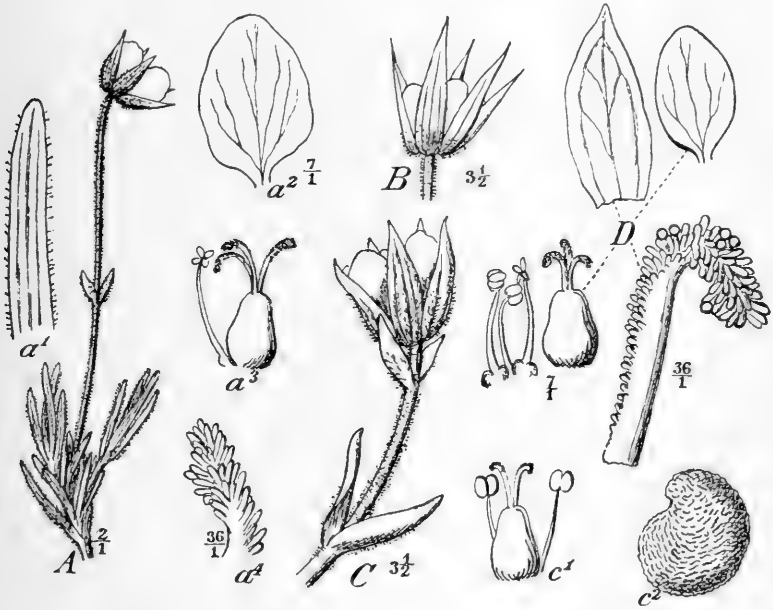

Fig. 36. *Minuartia verna* (L.), *var. hirta* (Wormskjold).

From Greenland (Disco, about 69° N. lat.). *A* with a^1 (foliage leaf $^7/_1$), a^2, a^3 and a^4.

From Norway. *B* (Altenfjord) and *C* (Dovre; 14. 7. 1887), c^1 and c^2 (seed).

From Spitzbergen (Nathorst; 1. 7. 1882). *D* (E. W.).

19. Minuartia verna (L.) Hiern. var. **hirta** (Wormskjold). (Fig. 36).

Styles 3, 4.

Greenland (about 69° N. lat.). A specimen, twice magnified, is shown in Fig. 36, *A*; the length of the petals is almost equal to that of the sepals. ☿: Self-pollination and no doubt decided homogamy. Sets fruit which ripens.

Norway (Dovre, Altenfjord, about 70° N. lat.). The petals may be still shorter than in the Greenland specimens (Fig. *C*, *D*); sepals $3^1/_2$, petals $2^1/_2$—3 mm; the entire flower may attain a diameter of 5 mm. Specimens from Alten have petals only about half as long as the sepals (Fig. *B*). — ☿: Homogamy. In younger flowers the stamens stand erect with the anthers gathered closely above the styles, and pollen is found simultaneously in the anthers and germinating on the stigma. Finally, the styles curve backwards, and can even then touch the anthers (Fig. a^3, c^1, *D*). Self-pollination may take place easily. Fruit is set abundantly. A seed is shown in Fig. c^2; it is finely wrinkled.

A specimen from Norway (Foldal) appeared to be protogynous; the styles were spread out and were quite ripe, all the anthers were closed and stood at a lower level than the ovary, perhaps this was a ♀, or a form transitional to it. — I have seen ☿ only.

Spitzbergen (Fig. *D*). The specimens preserved in alcohol which I have investigated, had their flowers closed, and were homogamous; the open anthers stood at a level with, and were probably pressed closely against, the styles which were somewhat curved backwards (Fig. *D*); there was a rather large quantity of pollen on the stigma (Fig. *D*), so self-pollination had no doubt taken place there. Ripe fruit was developed; the seeds resemble exactly those from Dovre. The capsule is only very slightly longer than the calyx.

20. **Honckeruja peploides** (L) Ehrh. (Fig. 37.)[1]

Styles 3, 4, 5 (6). 4-merous and 6-merous flowers occur (Fig. 37, *G*), for instance with 6 sepals, 6 petals, 6 + 6 stamens, 4 carpels.

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[1] I do not think there is sufficient cause to place this species in a separate genus (*Ammodenia* Gmel., a name older than *Honkenya*

Greenland, Iceland, Spitzbergen, Nova Zembla, Norway and Denmark. I found the flower-biology to be the same everywhere, because the many variations as regards size which are found to occur in the flowers I must regard as local, I have observed these variations to occur in flowers from all countries without it having been possible for me to formulate any rule concerning this. ♂ and ♀ flowers are common everywhere, no doubt equally frequent, while ☿ flowers are rare, perhaps even very rare, and in this North America differs markedly from Europe (see Hook. et Benth. Genra pl.).

Dioecism, polyoecism (☿, ♂, ♀), monoecism; ♂ and ☿ are > ♀.

♂ (Fig. 37, *A*—*D*, *F*—*H*). At first the cal.-st. are more erect, and in this position they open their anthers; afterwards they bend backwards and become outspread; the cor.-st. perform the same movements, but I do not think they become so erect; the anthers do not turn. The cal.-st. have very large and yellow, glistening glands (Fig. *A*, d^1, h^1, etc.) which evidently secrete honey (by the river Alten I saw a *Coccinella* search for the honey). The variations in size are very considerable (compare Fig. *A*, *B*, *C* and *D*). The sepals are $5^1/_2$—7 mm in length; the diameter of the flower is as much as 12—13 mm; petals 3—5 mm long. But in addition

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Ehrh.; *Halianthus* Fr., and others), because the fleshiness of its vegetative parts and of its calyx is an adaptation-character to a saline substratum; it has no fleshy disc in "the hollows of which the stamens stand fixed," as several authors record, but simply the same glands on the cal.-st. as the other *Alsineæ* have (Fig. 37, d^1). True, there remain the large seeds, the partially many-chambered capsule, and the development of ♀ and also ♂, but as regards the kind of flower, in North America they are mostly ☿, and the capsule character varies, many small seeds may occur, and the dissepiments may disappear even during the flowering. It can at most be referred to a sub-genus under *Minuartia*.

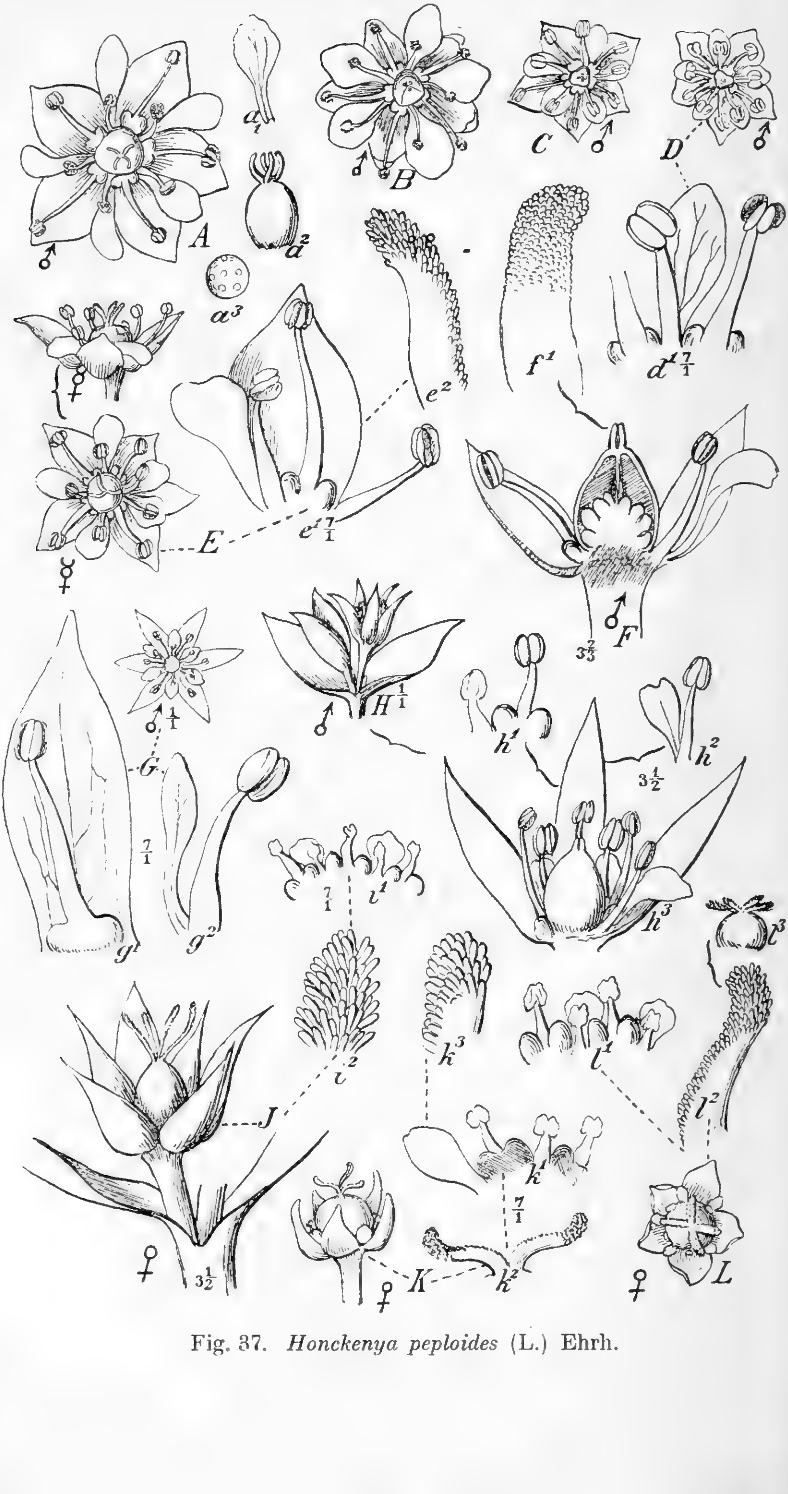

Fig. 37. *Honckenya peploides* (L.) Ehrh.

(The magnification the same, viz. about $2^{1}/_{2}$ for *A*, *B*, *C*, *D*, *E*, *K*, *L*, and $^{7}/_{1}$ for the majority of the isolated stamens, etc.).

♂: *A*, from Greenland (about 60° N. lat.). All the stamens are open and full of pollen. Detached petal (a^1), pistil (a^2) and pollen-grain (a^3). *B*, from Denmark. *C*: ♀ from Reykjavik (about 7 mm in diam.). *D*: from Spitzbergen (Nathorst; 9. 8. 1882); about 6 mm in diam.; cal.-anth. open, cor.-anth. closed; see d^1.

☿: *E*, from Spitzbergen (Nathorst; 9. 8. 1882), taken from a branch on which was a large fruit. Sepals 5 mm, petals $2^{3}/_{4}$ mm. There was germinatiag pollen upon the stigmas; to this belong e^1 and e^2.

♂: *F*, from Tromsö, with style (f^1). *G*, nat. size, with g^1 and g^2; from Altenfjord. *H*, from Kola (Dr. Brotherus), nat. size; to this belong h^1 (one cor.-st. abortive), h^2 and h^3.

♀: *J*, from Kola (Dr. Brotherus) with i^1 and i^2; these flowers from Kola are remarkable on account of their long and pointed sepals. *K*: ♀, from Spitzbergen (Nathorst; 9. 8. 1882). Pollen rather abundant on the stigma and some of it germinating. The anthers (k^1) were quite transparent. *L*: ♀ from Tromsö; to this belong l^1, l^2, l^3. (E. W.)

the relative length of the calyx and the corolla varies, as shown in Fig. 37 (cal. $>$ cor. in Fig. *A*, *C*, *D*; cal. $=$ cor. in Fig. *B*); the petals may be as long as the sepals or much shorter, for instance, half as long, and examples of both kinds of flowers may be found on the same shore.

Flowers are also recorded in which the petals are entirely absent (f. *apetala*) or in which the petals have partially disappeared. The diameter of the flower varies greatly according to the degree to which the sepals have expanded, and increases during the flowering period; it varies between 7—14 mm.

The petals vary also in form, and the narrower they are, the more reduced is the venation (compare Fig. a^1, d^1 and g^2). I have not found the form in which the corolla is entirely wanting (*apetala* Rostr.). The length of the stamens varies also, relatively to the corolla and the calyx. The pistil is remarkably large, usually 3—4 mm in length and appears to be normal, but the styles are very short ($^{1}/_{2}$—$1^{1}/_{2}$ mm), almost conical, erect and minutely papillose, and they always remain so (see Fig. a^2; *F*, f^1; h^3).

The figures show also that they vary in length (the styles of a^2 are for instance much longer than those of F and h^3).

The ovary characters also appear to be fairly normal; the ovules are large, perfectly formed (Fig. 37, F) and curved, the integuments are formed, even the long hairs which serve to guide the pollen-tubes are there, but the nucellus appears to be more or less shrunken, and on closer inspection the whole conveys the impression of being abnormal. The ovules are not everywhere abortive to the same extent, even in the same ovary they may be found to vary in size, and in some cases I must even assume that the ovules had been quite normal, but fruit-setting was nevertheless impossible, because the stigmatic papillæ were so undeveloped (f^1). All these flowers die also without setting fruit, and in such withered and closed flowers the size and position of the ovary and the styles is found to be unaltered.

Near Altenfjord (Norway) I gathered unusually large ♂ flowers (Fig. 37, G): in one 6-merous flower the diameter of the calyx was about 16 mm, and the length of the petals 5 mm. As regards other features see Fig. g^1, g^2. I have gathered unusually small ♂ flowers, for instance on Sjælland: diameter only 6 mm, petals 3—$3^1/_2$ mm, cal.-st. 5 and cor.-st. 4 mm. In the latter locality the small-flowered plant was growing about 15 degrees south of the large-flowered one.

♀: ♂ flowers with a few rudimentary stamens occur, but they seem to be rare. Purely ♀ flowers are common. Here also the flowers vary considerably in size and in the relative length of their different parts, but on the whole the ♀ are $<$♂ (compare Fig. h^3 with J; as also K and L with ♂ uppermost in the plate: A—D). The diameter of the calyx is for instance 7—9 mm and that of the corolla about 5 mm, and the petals in particular are always very small, usually only 1 to 2 mm long (see Fig. i^1, k^1, l^1). The same figures show their length relatively to the stamens. The stamens usually have very short filaments and transparent anthers, but the size of the glands is about as in ♂. The styles are 2—3 mm in length, and finally they are straight, laterally outspread and highly papillose (compare Fig. i^2, k^2 and f^1).

All the ♀ described above set fruit abundantly, at any rate in Denmark, where, consequently, insects must be present which pollinate them. Fruit is also set in West Greenland and in Iceland. I have seen very small ♀ from Spitzbergen (Fig. *K*) and Tromsö (Fig. *L*). The sepals were only 3$^1/_2$ mm. There was germinating pollen on the stigma of the flowers from Spitzbergen, so there, also, pollinating insects must be present, and a female plant had fruit on it (9. 8. 1882, Nathorst).

☿ seem to be very rare; I have seen specimens only from Spitzbergen and northernmost Norway; according to my pocket-book notes they are not rare in Greenland; but as regards Greenland a confusion with ♂ is possible, and my statement in "Bestøvningsmaaden af nogle grønlandske Blomster", p. 130, needs to be revised (see however North America; note on p. 231). A specimen from Spitzbergen is shown in Fig. *E*. They are of medium size and resemble more closely ♂, but the styles are longer, outspread and more highly papillose; most likely the papillæ would have grown longer than those in Fig. e^2 as the flower is hardly yet in its last stage. As it is they stand midway between ♂ and ♀.

Monoecism. Near Molde on the coast of Norway I saw fruit on a plant on which there were also withered ♂ flowers.

The case mentioned by me in 1878 in "Bot. Tidsskrift", vol. 10, of vegetative shoots growing out after flowering and developing vigorously above the uppermost flowers, I have often observed since, for instance also in West Finmark; I have now even seen these shoots begin themselves to flower.

21. Viscaria alpina (L.) G. Don. (Fig. 38).

Styles 4—5.

West and East Greenland. Fragrant flowers (the perfume recalls slightly that of vanilla). Gynodioecism. ☿ > ♀.

☿: Protandry with the ordinary movements of the stamens and styles, in three sets, finally homogamy. Self-pollination will be able to take place. Scarcely does the flower begin to open, then the cal.-anthers are seen at the throat. The stigmatic papillæ occur only on the upper half in a continuous row, but farther down small ones occur at intervals. During the flowering period the stamens are thrust far out and are exposed, so that they are quite bared to the effects of rain and dew (Fig. 38, *A*). The pollen-grains are greenish and ordinary in structure (numerous pores; Fig. a^1).

Protogyny occurs; at first the styles spread out and then curve backwards; their papillæ are bigger than those in the protandrous flower. Then the cal.-st. spread out, and finally the cor.-st. But this is very probably a form transitional to ♀. In the same inflorescence I found both quite sterile flowers and also protogynous ones with stamens partially abortive.

♀: Seem to be much rarer than ☿. Even before the flower is fully expanded the apices of the styles project beyond the throat (Fig. *G*).

The following figures show the relation between the ☿ and the ♀: —

☿ Petals $9^1/_2$—11 mm in length.
♀ — $6^1/_2$— 8 — —
☿ Corolla about 10—12 mm in diameter.
♀ — — 7—8 — —
☿ Corolla-tube (up to the scales at the throat) 4—5 mm.
— - (— — — $3^1/_2$ mm.

In ♀ the anthers of the stamens may be quite transparent, thin and devoid of fibrous cells, but may however attain a length of 2—3 mm (Fig. *E*, *F*); or they may be fairly normal, have fibrous cells, and well-developed, but useless pollen-grains, as in the intermediate forms (Fig. c^1).

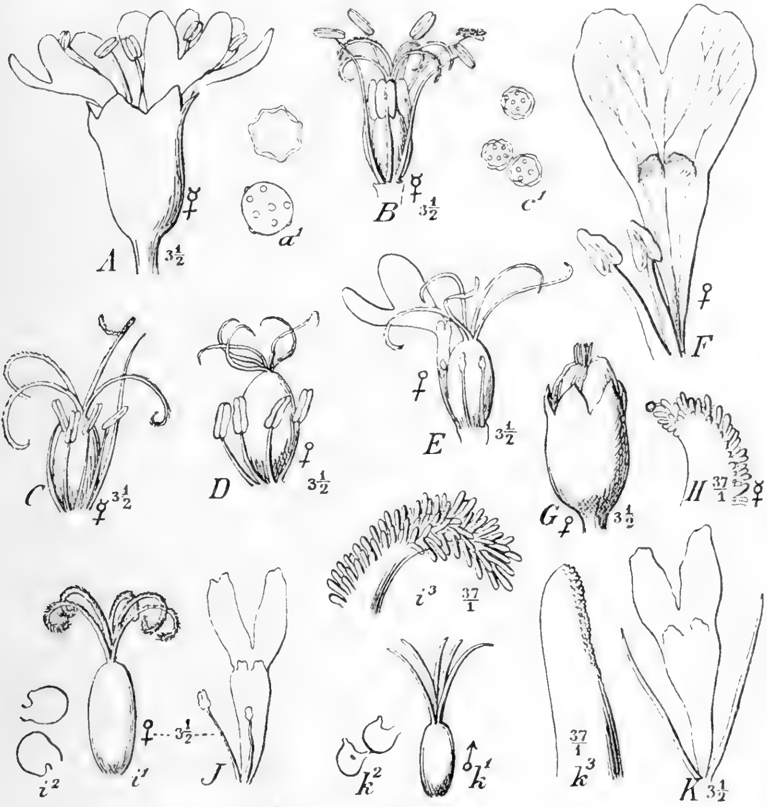

Fig. 38. *Viscaria alpina.*

A—*H*, from Greenland; *J*—*K*, from Norway (Altenfjord; about 70° N. lat.). — *A*, ☿ in its second stage; a^1 normal pollen-grains. *B*, ☿ with protogyny; cal.-st. have become outspread, but only one anther has opened. *C*, ☿, with only one normal anther; in all the others the pollen-grains are small and abnormal (c^1). *D*, ♀, with fairly normal anthers, but the pollen is worthless. The styles are withered; the ovary is evidently swollen. *E* and *F*, ♀ with transparent anthers. *G*, ♀ in a bud; the styles are already protruding. *H*, Stigmatic papillæ of ☿. *J*, i^1, i^2 (ovules) and i^3 from ♀. *K*, k^1, k^2 (ovules) and k^3 from ♂. (E.W.)

The pistil is perhaps somewhat larger than in the ☿, and the styles reach right across the petals, twisting to the left. The stigmatic papillæ are larger than in the ☿ (see Fig. i^3 and *H*).

Transitional forms from ☿ to ♀ occur, the anthers being only more or less abortive in some of the stamens, and normal in the others. Among the abortive stamens there often occur some with pollen and fibrous cells, but the pollen-grains are smaller than ordinary, thicker-walled, and of irregular outline; the pores are also more distinct (Fig. c^1). The barren stamens do not become elongated (Fig. *C*).

In a flower (Greenland, about 67° N. lat.; 13. 7. 1884) one of the cal.-anth. was seen to be open while all the others were closed, and the styles were already entirely outspread; if this was not an imperfect ☿, then there must have been protogyny (Fig. *B*).

♂. In "K. Danske Vid. Selsk. Overs.", 1886, p. 129, I recorded the occurrence of ♂ in Greenland, but I am now rather doubtful as regards this point.

Ripe fruit is commonly set in Greenland.

Norway (Dovre and Alten); Sweden (Fig. 38, *J. K*). Gynodioecism and Gynomonoecism, Andromonoecism; slightly fragrant in the evening. ☿, protandrous, corolla-tube $4^1/_2$—5 mm; diameter 10—11 mm, exactly as in Greenland.

A 4-merous flower was found together with 5-merous ones, viz. 4 seps., 4 pets., 4 + 4 st. and 3 carp. The number of the styles are 3—4—5.

♀: Diameter 7—9 mm, corolla-tube 5—$5^1/_2$. In specimens from Alten the ovaries were smaller in ♀ than in ☿, viz. $3^1/_2$ mm as compared with 4—$4^1/_2$ mm; the styles, on the other hand, were slightly longer. The petals 10 mm in length in ☿ and $6^1/_2$ in ♀. Near Alten female plants were found (15. 7. 1885) which had set numerous fruit the year before.

Andromonoecism occurs on Dovre. In a dense inflorescence the lowermost flowers were purely ♂, while the uppermost ones were more or less distinctly ☿. ♂ > ♀ (see Fig. *K* and *J*). In ♂ the petals were $9^1/_2$ mm and in ♀ 8 mm in length. In ♂ the pistil is smaller, the ovules are smaller and compressed, but appear otherwise to be fairly normal, only the stigmas are undeveloped (Fig. k^1, k^2, k^3, compared with i^1, i^2, i^3).

[Note. Lindman and Axell: Gynodoecism, ♀ common on Dovre; slight protandry.]

22. Melandrium[1] apetalum. (L.) Fenzl. (Figs. 39 and 40).

Greenland. Sets ripe fruit, at least as far as 70°—71° N. lat.

Norway (Kongsvold, Alten). ☿ and ♀.

According to Lindman dimorphous ☿, protogynous-homogamous. He has described more closely the variations which occur in the structure of the flowers: (**a**) some flowers are larger than the others, but are more inconspicuous and have shorter stamens, the petals do not reach to the throat of the calyx; they are dull dark-red (Fig. 39, *A*, A^1, a^1). The flowers are protogynous, and the styles twisted; (**b**) others are smaller, have protruding petals and longer stamens (see Fig. *D*, *C*); he regards them as approaching to ♂. The calyx is thinner and lighter coloured. The anthers stand at a higher level than the stigmas.

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[1] The characters on which the genus *Wahlbergella* is founded are very insignificant, and the genus ought not to be retained; also the characters are not correct; as for instance the record in Hartmann's Flora that the claws of the petals of *Wahlbergella* are wingless, but those af *Melandrium* are winged, or that the seeds have a membranous edging; for *M. triflorum*, which evidently stands very near to the two *Wahlbergella*'s, has wingless seeds (see Fig. 41, *H*).

♀ flowers are also mentioned by **LINDMAN**, they belong to form a.

I have found the same forms, not only the different ☿ flowers, but also the ♀. As regards the former, reference should be made to **LINDMAN**'s figures; I shall only remark that according to specimens which I have seen cultivated

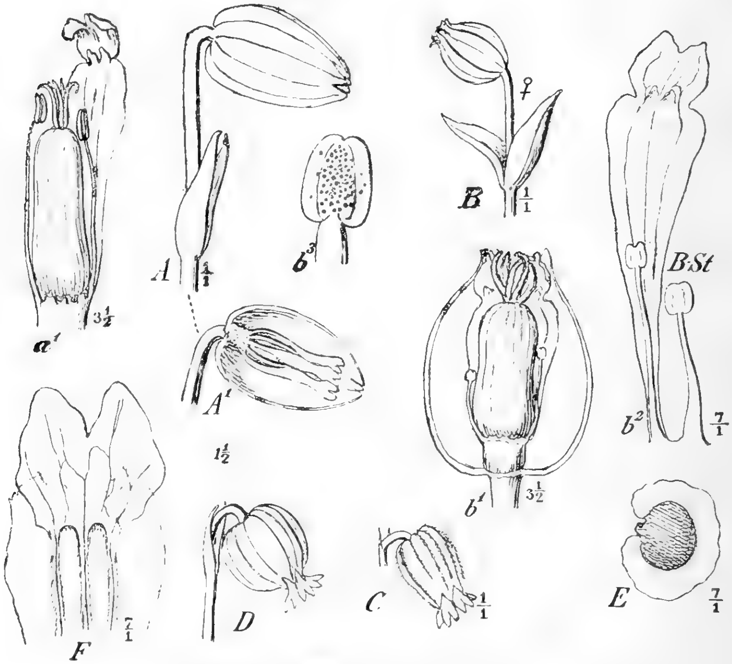

Fig. 39. *Melandrium apetalum.*
A, *A*¹, *a*¹: ☿ with short petals (f. *brevipetala*); Dovre, 14. 7. 1887 (calyx 18 mm long, petals 13 mm; cal.-st. 8—9 mm. The stigmas are covered with pollen). *B*, *b*¹, *b*², *b*³: ♀ from Altenfjord (about 70° N. lat.), 18. 7. 1885. The petals and the styles are just at the throat of the calyx (*b*¹); *b*³: anther with crystals of calcium-oxalate. *C*, *D*: Flowers from a cultivated plant (seeds from Petrograd); the petals are protruding; in *D* the calyx is greatly swollen. *E*, Seed (Dovre). *F*, Dorsal view of petal. (E. W.)

(seeds from Petrograd), there occurs a form with much more inflated calyx, becoming almost globular, even during the flowering period; it has protruding petals (Fig. *C* and *D*). In this form the flowers do not become erect after flowering, but remain nodding. Self-pollination appears inevitable, as the anthers no doubt lie for a long time quite close to the stigma, or else the pollen falls from them down upon it; anthers may also be found which are in direct contact with the stigmas. I give a few figures of ♀ which show that the anthers may be fairly normal in form, but they are transparent, devoid of pollen and with crystals of calcium oxalate (Fig. b^1, b^2, b^3). It is smaller than ☿ (Fig. *B* and *A*); the total length about 12 mm against 17 mm; petals about 9 mm, cal.-st. scarcely 5 mm and cor.-st. 3 mm, styles 2 mm, thicker than usual (Fig. b^1). The ovary also appears larger, about 6 mm long.

Th. Fries has established a variety *arctica* ("Tillägg. til Spitzbergens Fanerogamflora" in Öfvers. of K. Vet. Ak. Förhandl., 1869, p. 133); it has protruding petals, consequently, it seems to come near to the above-mentioned form which Lindman describes as being more staminate, and is perhaps identical with it. In the flowers of this form from Spitzbergen, which I have investigated, the limbs of the petals were protruding and the anthers were standing just at the throat, at a level with the uppermost tips of the styles. They appeared to be protogynous. As an indication of self-pollination may be mentioned that pollen was found only on the upper end of the style, just where the cal.-anth. could touch it, as long as the cor.-anth. which were standing at a lower level, had not dehisced. On the other hand, in a flower in which the cor.-anth. also had dehisced, without the cor.-st. having as yet become outspread, there was also pollen on the middle of the style, separated off from that of the upper part, and its situation corresponding to the level of the lower anthers; it had not yet germinated, which, on the other hand, the pollen situated higher up had. Thus, there was both as regards the position of this pollen and the degree to which it had germinated, every reason to believe that it came from the anthers of the same flower. For the rest, an immense quantity of pollen may be found deposited on the styles. Petals total length 15 mm, cal.-st. 10 mm long, cor.-st. 8 mm, pistil 8—$8^1/_2$ mm, of which the styles about 3 mm.

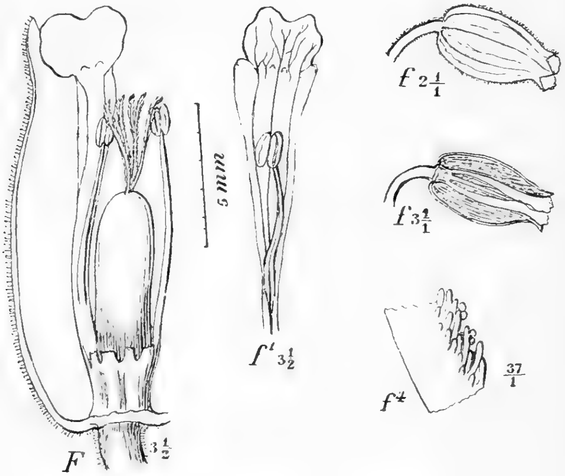

Fig. 40. *Melandrium apetalum.*
From Nova Zembla, gathered by Th. Holm. *F*, Anthers open; many pollen-grains in them, some of which are germinating. (E. W.)

I have seen flowers from Nova Zembla (Fig. 40) which in a way stand intermediate between the two forms described by LINDMAN. The petals are just visible at the throat of the calyx (Fig. *F*), consequently, they are longer than in the one of his forms, but shorter than in the other; the anthers are at the level of the stigmas; much as in one of his forms, open, and quite evidently able to carry out self-pollination. In addition, the pollen was germinating in abundance not only in the anthers, but also on the stigmas. In Nova Zembla fruit is set which ripens.

23. Melandrium triflorum (R. Br.) J. Vahl (Fig. 41).

Greenland. I have described it in "Overs. over d. K. danske Vid. Selsk. Forhandl.", 1886. Slight perfume.

☿: Slightly protogynous; self-pollinating. Both the cal.-anth. and the cor.-anth. lie finally close to the styles and are in contact with them. The styles, surrounded by

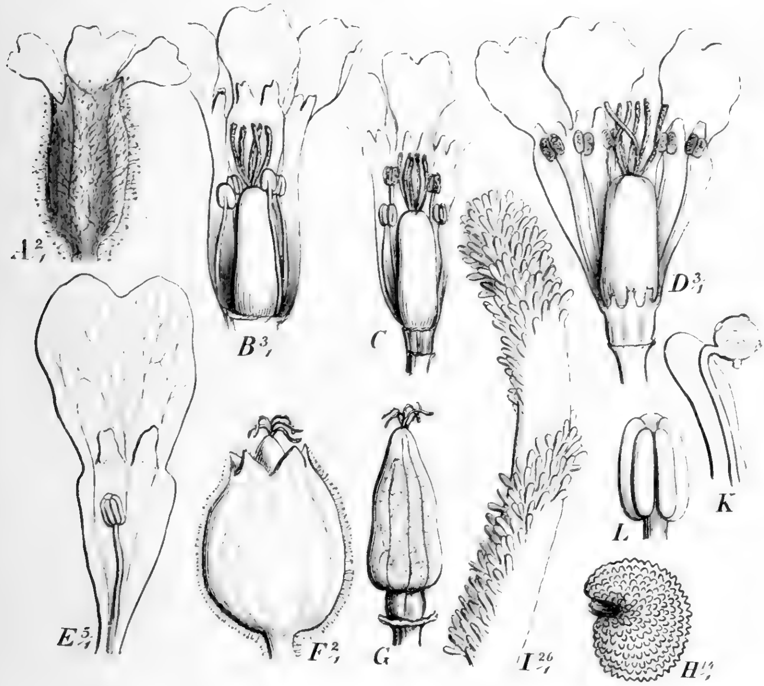

Fig. 41. *Melandrium triflorum* (R. Br.) J. Vahl.
A, The limbs of the petals are more or less outspread. The appendages of the throat (see *E*) are hollow. *B*, On the slightly club-shaped styles the stigmatic papillæ are fully developed (see *I*), but the anthers are closed and stand at a lower level than the styles. In *C* the cal.-st. have straightened, and the anthers have opened at the level of the middle of the styles, almost at the throat of the flower. In *D* the cor.-st. have also straightened and opened their anthers (the parts of the flower are spread out artificially). As the stigmas are still ripe, self-pollination will certainly be inevitable. In flowers at this stage of development I always found a great quantity of pollen on the stigmas, partially germinating (*K*). *F* and *G* almost ripe fruit. *H*, a seed. Some of the hairs have been omitted. From Kristianshaab, W. Greenland. (E. W.)

the anthers, are situated just at the narrow throat. A large quantity of pollen-grains may be found on the stigmas, some of them germinating. Six styles may occur. Petals 12—$12^1/_2$ mm. Throat-scales hollow. Dehisced cal.-st. $8^1/_2$ mm, pistil $7^1/_2$ mm to the tip of the styles. Diameter of corolla 12 mm finally. Fruit appears to be set very regularly. (See expanation of Fig. 41).

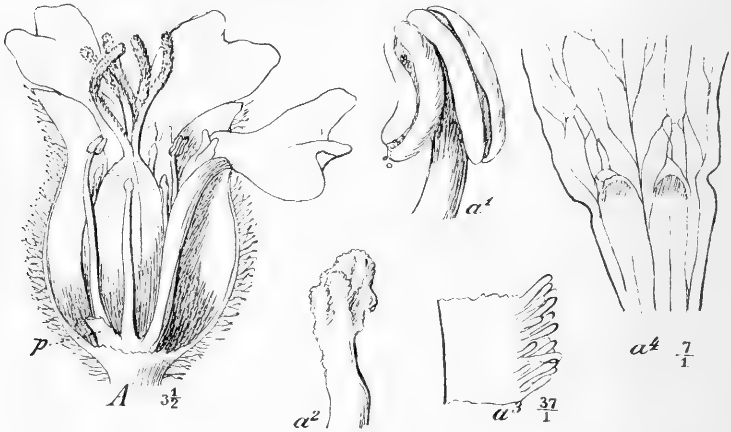

Fig. 42. *Melandrium triflorum.*
From Greenland (about 73° N. lat.; C. Ryder, 5. 7. 1887). Parts of ♀; a^1 and a^2, anthers showing different degrees of reduction. a^4, Dorsal view of petal.

I have received ♀ flowers of this species also, gathered by Lieut. C. Ryder at about 73° N. lat. in West Greenland; one of them is illustrated in Fig. 42. Four of its cor.-st. contain a little pollen, but it is not normal; in another flower only one or two of the cor.-st. contained a little pollen. All the cal.-st. are smaller than the cor.-st. and more reduced. Petals 13 mm, cal.-st. 6 mm, cor.-st. $8^1/_2$ mm, styles 5 mm, diameter of corolla 8—10 mm.

Transitional forms from ☿ to ♀ occur with a few or several anthers developed, for instance, all the cal.-st. sterile, and all the cor.-st. normal and longer than the cal.-st.

In Greenland fruit is set which ripens even as far north as 76° N. lat., and fruit-setting appears to begin very early.

24. Melandrium affine J. Vahl.

(See Warming in "Oversigt over D. Kgl. Danske Vidensk. Selsk. Forhandl." 1886, p. 129).

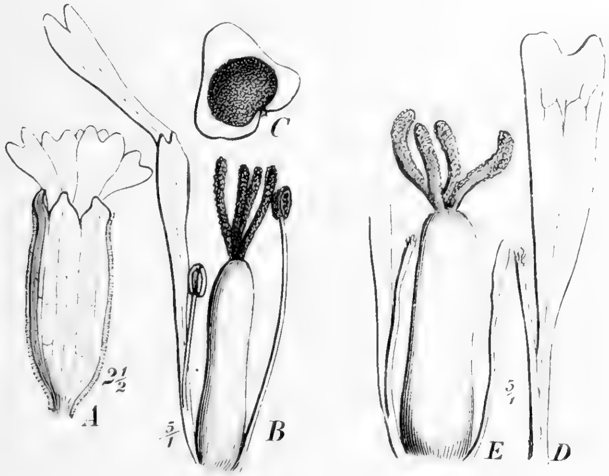

Fig. 43. *Melandrium affine* J. Vahl.
A, *B*, Hermaphrodite flowers. *C*, a seed. *D* and *E* from male flowers; the filaments are developed, but not the anthers, and the petals differ in form from those of ☿. From Altenfjord, northern Norway. (E. W.)

Greenland. ☿: Slight protogyny. Self-pollination. Calyx 12 mm, corolla-tube about 10—11 mm, cal.-st. $9^1/_2$ mm, cor.-st. $8^1/_2$—9 mm. The calyx-anthers reach to the tip of the styles. The anthers shed masses of pollen upon the stigmas, with which they are in direct contact. Petals white. Sets ripe fruit in West Greenland, regularly it appears, for instance at 70°—71° N. lat., and even as far as Grinnell Land (Discovery Bay, according to a specimen from the

Herb. Upsala, which was forwarded as *L. apetala* L. var., but according to Th. Fries is a true *Mel. affine*).

Norway (Altenfjord, about 70° N. lat.). ☿, ♀. Protogyny.

☿: The anthers of the cal.-st. in my Fig. 43, *B* are open and pressed against the styles to which they adhere by means of the pollen tubes. The styles (4—5—6) are slenderer than in ♀; the cor.-anth. have not yet dehisced.

In another ☿ all the anthers were of equal height and at a level with the upper one-third of the styles, consequently they were all like the cal.-anth. in my Fig. 43, *B*. The stigmatic papillæ extend down to the base.

♀ (Fig. 43, *D*, *E*): The petals are narrow, smaller and less notched at the apex, and the scales at the throat are absent, the stamens sterile, either with anthers (pale, transparent) or even entirely without anthers, but terminating in long hairs. Styles 4, thick, twisted. The stigmatic papillæ are short, and fairly equal in length from base to apex. The ovary is considerably larger (both longer and thicker) in ♀ than in ☿ (Fig. *E* and *B*).

Spitzbergen (15. 7. 1882; Nathorst). ☿: Protogyny. In a well-developed bud the styles were spread out and the stigmas almost ripe, and the anthers had so far developed that the pollen-grains were lying isolated. In older flowers the stigmas were found covered with germinating pollen before the cor.-st. had elongated and opened their anthers; this pollen comes evidently from the cal.-anthers. Fruit ripens in September; also in Nova Zembla.

25. **Silene inflata** (Salisb.) Sm.

Flower scentless; moth-pollinated. The petals are not involute[1]).

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[1]) Vaucher has a great many good biological observations on the *Sileneæ* which have not been noticed in the newer literature, for

Denmark. Trioecism and gynomonoecism; protandry. The scales at the throat consist of two low protuberances with corresponding shallow depressions on the dorsal side. Zygomorphy is often distinctly seen, the stamens and styles being bent downwards in the lower part of the flower; the flower is what Delpino calls zygomorphic of the 1st degree.

☿: Highly protandrous, the stamens appear gradually not exactly in two sets. The stamens project far out.

♂ are almost equal to ☿ in size; they are hardly common.

♀ < ☿. Diameter of corolla 13—14 mm, in ☿ 15—18 mm (the corolla grows during the flowering period), but otherwise the difference is but slight. In both flowers the calyx is 12—13 mm in length, the corolla-tube in ♀ 9—$10^1/_2$ mm, in ☿ 11 mm; petals in ♀ 13—14—16 mm, in ☿ 14—$16^1/_2$ mm, the limb in ♀ 4—5 mm, in ☿ $5^1/_2$ mm. The ovary is $3^1/_2$—5 mm in length in both; and the thickness and the length of the style are the same in both. Nor can I see any difference as regards the ovules; there are about 12 in each row, both in ☿ and in ♀. The calyx-stamens in ♀ are often remarkably long, viz. $4^1/_2$—5—$6^1/_2$ mm in length, so that they project far above the ovary, and they have distinctly marked-off, dorsified anthers; the length may diminish to 2—$2^1/_2$ mm. The cor.-st. are as usual somewhat smaller. The anthers are

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instance with regard to the involution of the petals (those that become involute in the evening he calls "meteoric corollas"); and with regard to protandry, direct or indirect pollination (e. g. self-pollination and crossing); and about movements before, under and after flowering, etc. In one place he writes as follows: — "Du reste, on peut croire qu'en observant les divers *Silene* sous ce point de vue, on y découvrirait d'autres arrangements qu'on ne soupçonne point encore, et qui donneraient une idée bien plus grande de la richesse et de la variété que le créateur à mises dans ses ouvrages, que ne peuvent le faire les differences de feuilles ou d'inflorescences".

transparent, thin and without the least indication of pollen. The styles protrude 8—10 mm and are on the whole 15—16 mm long.

Lange indicates the female plant as f. *micropetala*.

Gynomonoecism: A few ♀ together with ☿.

Norway, Sweden: Gynodioecism. I found ♀ in Østerdalen and on Dovre, as also in the neighbourhood of Stockholm; it may have very rudimentary stamens, and the diameter of the corolla may be 17—18 mm, consequently much larger than recorded above. ☿ protandrous. Both zygomorphic. Trioecism with ☿ and ♀ > ♂ according to Axell.

26. Silene maritima With.

Norway (Altenfjord). ☿: Rather markedly protandrous with the usual development in three sets, but the cor.-st. may spread out singly and almost simultaneously with the cal.-st. Calyx 15—16 mm in length; diameter of corolla 13—15 mm, corolla-tube about 13 mm, stamens 14 mm in length, protruding beyond the throat. As the styles ultimately come into contact with the anthers, and the latter may still contain pollen, self-pollination may take place. The scales at the throat consist of such low protuberances as to be almost wanting. At night the flower stood fully expanded, white and fragrant. After rain there was much water in the base of the flowers, even among the basal portions of the stamens.

Iceland (Reykjavik; 4. 8. 1886, A. Feddersen). Relative size of parts about as those given above, but the diameter of the corolla 18 mm. Decided protandry. Ultimately the styles protrude 6—7 mm. Various flies and plant-lice were found between the calyx and the corolla.

27. Silene rupestris L.

Norway (Romsdalen, Dovre). ☿: Protandrous in three sets, rather markedly. Calyx about 4—5 mm, petals $4^1/_2$ mm, corolla 6 mm in diameter, corolla-tube 3—4 mm, the throat is about $1^{1}/_{2}$ mm wide, so that entrance is easy for insects with short proboscises.

Switzerland. The corollas are not "meteoric". ☿: Protandry, but styles and stigma develop while the cor.-anth. are shedding their pollen. Possibility of self-pollination (Vaucher; H. M.).

28. Silene acaulis L. (Fig. 44).

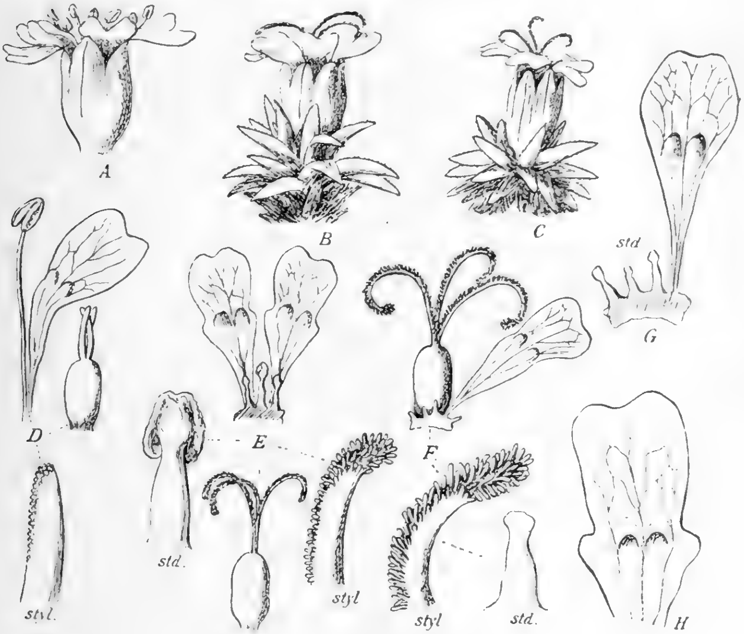

Fig. 44. *Silene acaulis* L.

A—F, from Greenland; *G*, from Norway. — *A*, ♂ (about 69° N. lat.); all the anthers open; the parts shown in *D* belong to this. *B*, ♀; *E* belongs to the same form. *C*, ♀ (about 67° N. lat.); *F* belongs to the same form. *D*, from ♂ from Greenland; petal with stamen and pistil $3^{1}/_{2}$; *styl*, apex of style. *E*, from ♀ (Upernivik; C. Ryder); the petals and pistils $3^{1}/_{2}$, the staminodes (*std.*) $^{37}/_{1}$. *F*, from ♀ from East Greenland (11. 8. 1888; P. Eberlin); the pistil with the corolla $3^{1}/_{2}$; *styl*, style; *std.* sterile stamen. *G*, from ♀ from Tromsö. *H*, Dorsal view of petal, showing the openings into the cavities in the scales at the throat and that petals with lateral projections may occur (compare *G*).

Wherever I saw it, I found the colour to vary; white specimens occurred here and there. Slight perfume in Greenland. In the Greenland specimens I found flowers formed the year previous to that in which they were to open. In specimens gathered on May 10th, 1887, by Lieut. Ryder, near Upernivik, young flowers, about $^1/_2$ mm in diameter, were found far down among the leaves. (See p. 282, Fig. 24).

Greenland. Trioecism: ☿, ♂ and ♀; as ♀ sets fruit, we have here evidence of insect-pollination. I have not seen ☿ flowers, but Lange mentions them in "Conspectus Floræ Groenlandiæ" on the authority of Vahl.

♂ are > ♀ (Fig. 44, *A*, *B*, *C*), which is especially seen in the length of the petals and in the diameter of the corolla. In ♂ the petals are 8—10 mm, in ♀ $5^1/_2$—$6^1/_2$, of which the claws are about 4 mm long and the limb scarcely 2 mm (see Fig. *D*, *E*, *F*). The calyx tube is generally larger in ♂ (5—7 mm) than in ♀ (4—5 mm). The corolla-tube in ♂ is 6—$6^1/_2$ mm, in ♀ 4—$5^1/_2$ mm, the diameter of the corolla in ♂ is 7—11 mm, in ♀ 6—8 mm (see Fig. *A*, *B*, *C*). ♂ has always a small pistil with styles $1^1/_2$—2 mm in length, which I have not seen grow and separate (Fig. *D*), as they do in the Alps according to H. Müller. There are shrunken ovules, the integuments of which are however formed. The cal.-st. are the first to develop, then the cor.-st. The styles have at the top some very short stigmatic papillæ, which never grow longer than those shown in Fig. *D*.

♀ flowers have always rudiments of stamens, but in various degrees of development; in some cases they are as much as 2 mm long, and have distinctly marked-off anthers (Fig. *E*, *std*), which are however shrunken, transparent and devoid of pollen; in other cases they have still shorter stamens, and the anthers are hardly indicated (Fig. *F*). Correspondingly with this there appears to be a different degree of development of the size of the flowers, the size of the petals, and the degree of development of the stigmatic papillæ, so that the flowers which have the larger stamen-rudiments are larger and have shorter stigmatic papillæ, while the flowers which have smaller rudiments are smaller and have longer stigmatic papillæ (compare Fig. *B* and *E* with *C* and *F*); the former are nearer to the hermaphrodite condition, while the latter are more decidedly female. About $^3/_4$ of the style is covered with papillæ. The pistil is 4—6 mm long, the styles about 3 mm, and the ovary $2—3^1/_2$ mm; consequently, there is no great difference between the size of the ovary in the ♂ flower and ♀, as Fig. *D*, *E*, *F* also shows.

Ripe fruit is set in Greenland; in the capsules investigated I have however found many aborted ovules besides the ripe seeds, of which there were often only 2—4 in each capsule. This is indicative of defective pollination.

Spitzbergen. Dioecism. The ♂ flowers agree with those from Greenland. Petals 10 mm and cal.-st. 8 mm. Aurivillus is of opinion that the passage to the honey is shorter in Spitzbergen flowers than in those from southern countries; this I regard however as doubtful.

Iceland (North coast; St. Stefánsson). Monoecism, dioecism, andromonoecism. ☿ protandrous; the corolla-tube short, 3—4 mm; ♀: the tips of the styles protrude before the flower opens. Petals as much as 7 mm, corolla-tube 5 mm. Sterile stamens as much as $4^1/_2$ mm, pistil 8 mm, of which the styles occupy 3—4 mm; consequently, unusually large female flowers. Stefánsson has gathered flowers from the same place, which are ♀, but approach closely to ☿: the anthers are transparent and without fibrous cells; the cal.-stamens are altogether 8 mm long; the pistil is 5 mm, and the styles are somewhat shorter than in ♀.

Norway, Sweden. (I have examined specimens from Finmark, Nordland, Dovre, Tronfjæld, Åreskutan and Jemteland). Trioecism, but ♂ and ♀ have been found on the same individual (trioecism and monoecism: Axell). ☿: the stigmatic papillæ were larger than in ♂. According to LINDMAN the high degree of protandry makes self-pollination impossible. ♀: There are two sizes of ♀ flowers (corolla 5—11 mm in diameter) according to LINDMAN. From Tromsö I have seen specimens with corolla-tube 5 mm, staminodes 1 mm, ovary 3 mm in length and corolla 7—9 mm in diameter. From Dovre with diameter $5^1/_2$—7, corolla-tube 5—6 mm, petals 9 mm, calyx-tube 5 mm; the pistil altogether $8^1/_2$—9 mm; the rudiments of the stamens $2^1/_2$ mm. Even before the flower has opened the styles protrude. ♂: like those from Greenland. Ovules rudimentary. Corolla 8—9 mm in diameter, on Dovre even 12 mm, indeed a few as much as 15 mm, calyx-tube $6^1/_2$—8 mm. The pistil-rudiment may attain a length of $3^1/_2$ mm, petals 14 mm, and the corolla-tube 7 mm. Near Hammersfest and Tromsö I saw many ripe fruits in the female plants; on the Skaadavara mountain in Altenfjord, on the other hand, they had remained barren.

The Alps (Vaucher, Koch and H. M.). Trioecism, monoecism. The ☿ flower is as a rule larger than the ♂, which is larger than the ♀. Marked protandry, self-pollination is possible in the case of the ☿ flower (H. M.). Butterfly pollination. ☿ is found only singly, here and there, but appears nevertheless to be of far more common occurrence than in the North.

29. Dianthus superbus L.

This large-flowered species with fragrant, finely divided petals seems to occur with ☿, ♀ and ♂ flowers. According to VAUCHER the flowers open in the evening and close irregularly during the warm hours of the day.

Denmark. ☿: Protandry. ♀ (?): the form *micropetalus* Lge. is probably a female plant.

Kola (specimens from Dr. Brotherus). At the transition-point between the limb and the claw there are long unicellular hairs with undulating walls and filled with sap. The corolla-tube is about 2 cm in length. ☿ and ♀ occur, or at any rate forms which approach much to ♀; their stamens reach only to the upper part of the ovary; the anthers are about $1^1/_2$—2 mm long and well-developed, but the pollen contained in them is evidently useless, shrunken, etc. A fly was found in one flower.

Germany. Sprengel figures it; gynodioecism; self-pollination impossible. ☿ > ♀. — The Alps. Gynodioecism, androdioecism (?; Vaucher); butterfly-pollination with large flowers in plains and small ones on mountains. ☿: corolla 50—60 mm in diameter, tube 20—25 mm. Marked protandry with movements of stamens. Self-pollination impossible (Vaucher; H. M.).

♀: It does not appear to be a constant feature for the ♀ flowers to be smaller than the ☿; H. Müller, however, records the diameter as 36—45 mm; they are many times rarer than ♀. Rudiments of stamens occur; useless pollen may be present. ♂: Vaucher writes that "les stigmates souvent avortent".

General remarks concerning the Biology of the Flower.

The Form and Venation of the Petals. A single vein enters the petal at its base, and immediately divides into three branches (cf. the foliage-leaves), which may themselves branch, becoming reticulate in large petals (*Sileneæ*); (Figs. 13, 21, 23).

The Appendages of the throat (ligules). In the *Sileneæ* they are in some cases solid, and in others hollow as in the *Borragineæ*.

The Growth of the Petals. The petals often grow during the expansion of the flowers, — this is at all events frequently the case in the *Alsineæ*, — therefore, conclusions with regard to the occurrence of large-flowered or small-flowered types, should be formed with great caution.

Secretion of Honey. Honey is secreted in all the Caryophyllaceae; in the *Alsineæ* it is from the gland-like, swollen, yellowish base of the calyx-stamens; it accumulates in the sometimes hollow base of the sepals (*Spergularia* and the *Paronychieæ* deviate from this rule). In the *Sileneæ* honey is secreted by the inside of the ring which unites the bases of the stamens and the petals, perhaps also at the base of the ovary. In the female flowers, also, the size of the nectaries is essentially unaltered, even when the anthers are considerably reduced.

The Anthers in the *Alsineæ* are often twisted in such a way that the pollen-covered surface is turned upwards or even outwards, in correlation with the fact that the honey occurs between the petals and the stamens (see H. Müller and A. Schultz). In self-pollinating individuals this feature will hardly be found.

The Styles are, for a longer or shorter distance, covered with stigmatic papillæ, varying in length, being longest in the large-flowered *Sileneæ.* I have, however, never found germinating pollen far down, near the base of the style; but whether this is because the papillæ occurring there, are not functional, I do not know. In *Cerastium trigynum* the styles are very broad towards the apex, even sometimes bi-lobed. In older flowers they are twisted spirally. either to the right or the left, most markedly in the *Sileneæ.* Vaucher has already explained this as being suitable to the purpose: "afin de recevoir plus ·facilement le pollen des fleurs mâles."

The Development of the Flowers after Expansion. Protandry is very common in the Arctic Caryophyllaceæ, and the movements of the stamens are the same as elsewhere: first the calyx-stamens stretch out, and bend inwards towards the middle of the flower, then the corolla-stamens perform the same movements, and lastly the styles ripen and spread out; sooner or later however homogamy ensues in almost all the species, and the flower may be entirely homogamous from the beginning. Protogyny is very rare (*Melandrium apetalum*, *M. triflorum* and *M. affine*, *Cerastium trigynum*, and according to LINDMAN *Stellaria Frieseana* var. *alpestris*).

Abortion. When the stamens are aborted in a protandrous flower, the corolla-stamens are the first to be reduced, and they are also always even smaller and younger than the calyx-stamens. In protogynous flowers the order of development is reversed.

Everywhere did I find confirmation of the rule established by H. MÜLLER, viz., that protandry or, on the whole, the degree of dichogamy, is correlated with the size of the flower. The larger the flower is, the more pronounced is the protandry, provided the conditions are otherwise similar. In the foregoing I have arranged the species belonging to each genus in the order of the decreasing size of the flower, beginning with the largest-flowered. An examination of some of the genera will prove the correctness of MÜLLER's rule — of course with exceptions, for there should be laid stress on the fact that the external conditions must be similar.

Some species are homogamous almost from the beginning; these are either Arctic or Alpine, or else autumn and winter flowers, or they are very small-flowered. In the *Paronychieæ* pure homogamy seems to be frequent. These facts appear to me to be connected with the fact that the Arctic-Alpine and the small flowers are probably not so quickly developed as in southern countries, or as are the large flowers. It is above all in the physical conditions that we must look for the explanation of these differences in the development.

Self-pollination is by no means rare; it appears to be least common in some of the large-flowered *Sileneæ*, for instance *Dianthus superbus*; the vigorous development of the corolla is there followed by a quicker development of the stamens. But in many homogamous or slightly dichogamous and small-flowered species, self-pollination is a process which regularly takes place, and which produces an excellent result. It is seen here, as in the Greenland *Cruciferæ*, *Saxifragæ*, etc., that fruit-setting follows immediately after flowering, and that there is a gradual succession of the sizes of the fruits, according to the age of the flowers.

Polygamy (Pleogamy). Many of the High Arctic, and even small-flowered and homogamous species have polygamy, especially gynodiœcism (for instance *Cerastium alpinum*, *C. trigynum*, *Stellaria longipes*, *S. borealis*, *Minuartia biflora*, and others, even Arctic species of *Melandrium*). Polygamy must be regarded as an unfavourable feature where the country is as poor in insects as are the Arctic countries.

From the preceding detailed descriptions it is evident that few species have hermaphrodite flowers only, and continued investigations will probably result in the reduction of even their number; also probably many more combinations of ☿, ♀ and ♂, than are now known, will be found.

A peculiarity common to the gynodiœcious species is the varying degree of reduction of the stamens in the female flowers; many examples of this have been mentioned and figured above. There is every possible degree of reduction of the anthers, according as the development which has once begun, stops earlier or later; I have seen no female flower which was entirely without rudiments of stamens. To this must be added those hermaphrodite flowers in which a few or several stamens are abortive. Several successive stages of more or less decided abortion may thus be demonstrated, and that often in one and the same species.

Another peculiarity which accompanies the one mentioned above, is that the corolla is diminished in size more or less in all the female flowers. There are extremely few

Caryophyllaceæ of which the female flowers are similar to the hermaphrodite flowers in size, as they are in *Minuartia biflora.*

The alterations in the structure of the flowers in individuals of the same species, of which so many examples have been given in the foregoing, will be understood, to a certain extent, if the ontogeny of the flower is known. Those organs which have developed first, or at an early stage, grow most quickly and vigorously in the flower (especially the calyx and pistil and the calyx-stamens), and will have the best chance of becoming developed, should any check occur; while the last-developed or slow-growing organs may become dwarfed, or are even completely suppressed — all according to the point of time when the check occurred. In the protandrous flowers it is the corolla-stamens which are suppressed whenever the androecium is reduced, which is in perfect harmony with the ontogeny. In the protogynous flowers the pistils hasten as usual, and attain full maturity before the stamens, and so, if the check occurs very early, a purely female flower may be produced.

The size of the flowers evidently has also a certain connection with the longevity of the individual: annual species generally have smaller flowers than perennials; this is also confirmed with regard to the Caryophyllaceæ as a whole. Further, the numbers in the flowers are dependent on the size of the flowers. But the causal conditions are still problematic in many respects, viz., with regard to the dependency of the form of the flower on the prevailing conditions, especially those relating to nutrition. Dichogamy or pleogamy in the Caryophyllaceæ must, as a whole, be regarded rather as a sign of weakened constitution, or of unfavourable conditions of life, than as an advantage.

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