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A Monograph of the Genus *Alaria*.

By

Kichisaburo YENDO, *Rigakuhakushi*,

Professor of Marine Botany, The Hokkaido Imperial University, Sapporo.

With 19 plates and 2 textfigures.

> "Bei wenigen Gattungen unter den grosseren Meerespflanzen sind die Ansichten der Autoren über die Zahl der Arten so abweichend, wie bei *Phasganon*."—RUPRECHT.

More than 32 species of *Alaria* have been described by various writers since GREVILLE established the genus in 1830. Not a few of them have been reduced to synonymous positions of the others and only about half of them are now admitted to be more or less valid. But the synonymizations by different writers frequently do not agree with one another so that the true number of valid species is not yet satisfactorily fixed. The complaint made by RUPRECHT seventy years ago may still be repeated by modern algologists.

The ambiguity of the specific limitation of *Alaria* is undoubtedly due to the following facts; first, in most species the stages of development as well as the habit of the plant are not observed by the describer himself, thus different forms of one and the same species due to the ages or conditions of the habitats may often have been mentioned in separate and independent

specific positions; secondly, collectors who know but little of the variability of the forms are inclined to choose smaller specimens in the field as more suitable for herbaria.

The present writer spent a summer on the west coast of Vancouver Island, B. C., and there he actually observed and collected various species of *Alaria* indigenous to the locality. A half-year trip along the Kurile Islands and in Kamtschatka as well as the botanizings on the coast of Hokkaido (Yesso), where he now lives, have also given him many opportunities of studying the subject among living specimens. These two localities are the most important fields for the genus, the majority of the species extant being found there. He also paid special attention to the original and the authentic specimens of the genus during his two years travel in Europe, paying visits to the important herbaria. He now considers himself justified to undertake the enterprise of preparing a monograph of this genus, a genus well defined from the others but very unclear within itself.

The present monograph, however, must not be taken as an exhaustive treatise. The species from the North Atlantic certainly require more extended observation, and some from the north-west coast of North America a careful revision with ample material. It is simply offered as a suggestion with the hope that it may induce others to complete our knowledge on the subject.

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generous enough to spare me two complete specimens of *Alaria valida* SETCH. et KJELLM. I am also indebted to Dr. W. TRANZSCHELL, in charge of the Herbarium of the Academy of Science of Petrograd, Prof. O. JUEL of the Botanical Museum of Upsala, Prof. C. A. M. LINDMAN of the Academy of Science of Stockholm, Prof. SV. MURBECK of the Botanical Museum of Lund, Prof. N. WILLE of the Botanical Museum of Christiania, and Prof. H. H. DIXON of Trinity College, Dublin, who have given me permission to freely study the original or authentic specimens kept in the herbaria of these institutions. To these gentlemen the author desires to express his sincerest thanks.

General Morphology.

The post-embryonal frond of *Alaria* is sharply differentiated into three parts, the holdfast, the stipe and the blade or lamina. It is simple for the whole life, neither branches nor stolons being found in the normal forms. It is habitually erect and no dorsiventrality is indicated in the external appearance and in the internal structure. The stipe is percurrent into the blade running in its median line and elevated equally above both surfaces. The extension of the stipe within the blade is called midrib.

The tissue elements of the frond are practically equal to those found on other Laminariaceous members. The lacunae or mucilage canals which are common in most species of *Laminaria* are entirely wanting in *Alaria*. A peculiar sort of glandular cell, which I[1] have called mucilage gland, is present in all Alarias, at least in early stages of their development.

The so-called cryptostomata are found in some species but

1) YENDO: On the Mucilage Glands of *Undaria*. 1909.

wanting in others. They are different from those found in Fucaceae, in structure and in mode of formation.

The characteristic of the genus is the formation of the sporophylls, as the generic name *Alaria* suitably expresses. The sporophylls are small leaflets, each provided with a short but more or less sharply differentiated petiole at its base. They are disposed pinnately or fasciculately on both edges of the terete or compressed stipe.

In minor points, the characters of the frond vary according to the species; or it is better to say, the specific distinctions of *Alaria* lie on the minor differences of the characters. It is therefore a most important matter to ascertain if a character is constant or variable, and consequently, reliable or unreliable for specific distinctions. The observations given below will help to solve the problem, and at the same time explain the standpoint on which the present writer has arranged the species.

Stipe.

The stipe of the embryonal frond of *Alaria* is cylindrical. Its greater part of thickness consists of septated filaments running parallel and compactly arranged. The part is enveloped with a few layers of rectangular cells containing chromoplasts. Later on, it adds to its length by stipo-frondal growth, until the frond reaches the post-embryonal stage. The upper half of the length of the stipe at this stage is more or less compressed with round edges, generally becoming cylindrical downwards. The structure is now more complicated than in the embryonal stage, and does not show much difference in its essential points from that of the other Laminariaceous members. The tissue elements may be briefly

distinguished into three kinds, the epidermal layer, the cortex and the medulla.

In the cylindrical part of the stipe, the epidermal layer and the cortex form concentric rings when observed in cross sections (Plate XVIII, fig. 12). In the center of the circular section the medulla of a compressed elliptical shape is found. Interposed between the medulla and the cortex there is a zone of distinct structure, sheathing, as it were, the former. It is clearly distinguished from the two parts by having large cells of irregular arrangement and fibrous cells compactly interposed among them. Within this is the elliptical medulla with its major axis nearly equal to the diameter of the said area. I will call the area "perimedullary tissue" for convenience' sake. This tissue is the main source of the medullary hyphae, agreeing with the similar tissue in the stipes of *Laminaria*. The cells are remarkably thick-walled. When stained in a solution of aqueous anilin blue the cell-wall gives a vivid differentiation of blue colour in sharp contrast to that of the other parts. Similar result has been obtained by WILLE[1] by treating the tissue with chloriodide of zinc (Plate XVIII, fig. 16).

The large, thick-walled cells in the perimedullary tissue must not be confused with the similar ones scattered in the medulla. In the cross sections they appear very much alike. Longitudinal sections, however, reveal the fact that the former are cylindrical cells forming continuous filaments of uniform diameter, and that the latter are the swollen parts of the trumpet hyphae. Some of the trumpet hyphae become thick-walled, as has been already observed by WILLE[2], and may assume a similar appearance, in

1) WILLE: Beiträge z. physiolog. Anatom. der Laminariaceen, p. 26, fig. 11.
2) WILLE: l. c., fig. 37.

the cross sections, to the perimedullary cells. Some other trumpet hyphae, however, remain thin-walled and may contain a hyaline, highly refracting, cartilaginous substance on both sides of the sieve plates. This substance turns yellowish in the dried specimens, and stains deep blue by aqueous anilin blue, proving in every point the callus formation observed by SYKES[1] (Plate XVIII, fig. 15, 16, 18).

The fibrous cells interposed between the large cylindrical cells of the perimedullary tissue disappear by degrees towards the periphery of the stipe, and the cylindrical cells become at the same time disposed in a more or less regular, radial direction. Hence, in the cross sections, this part appears under the microscope like a parenchymatic tissue.

From the outer part of the perimedullary tissue the cortex begins quite abruptly. It occupies a greater part of the thickness of the stipe and assumes the part of the xylem of a tree. The term cortex does not at all express the true character of the tissue but has been invariably applied to this part by former writers. It is marked by having cells of much smaller diameter than the tissue lying just inside, and by having very few fibrous cells. The inner part of the cortex has the cells generally irregularly disposed and some fibrous cells may still be found interposed between them. In the outer part, the cells become gradually regularly radiate and narrow-lumened until it passes quickly into the epidermal layer. In the longitudinal sections, the inner cortex differs from the outer by having the cells longitudinally elongated but much undulating, while in the latter they are stretched transversely (Plate XVIII, fig. 12).

1) SYKES: Anatomy and Histology of *Macrocystis pyrifera* and *Laminaria saccharina*, p. 320. Cfr. Pl. XIX, fig. 19, 21, &c.

The cylindrical cells in the perimedullary tissue and the cells of the cortex have numerous pits in their cell-walls. They are septated by thin middle-lamellae so as to hinder the free passage of cell-contents. Their abundant presence in the cell-walls gives a very irregular appearance to the forms of the cell-lumens, especially when the latter are as narrow as in the cortical part. A similar structure has been excellently illustrated by WILLE[1] for the cortical part ("mechanische Gewebe") of *Alaria esculenta*, GREV., and by MCMILLAN[2] for that of the *Pterygophora* stipe.

The cortex and the epidermal layer appear as continuous, more or less regular, radiating lines. The latter may be distinguished from the former by having cells of thinner membrane and greater diameter and by the chromoplasts. The limitation of the two parts is not sharp in the first-year fronds, but is sudden and well-marked, together with an annual ring, in the second-year fronds (Plate XVIII, fig. 12).

WILLE[3] also distinguishes four concentric zones in the structure of the stipe of *Alaria esculenta* of "wenigstens vier Jahre alten Exemplaren." His "Zone 1." corresponds to the epidermal layer, "Zone 2" to the cortex, "Zone 3" to the perimedullary tissue, and "Zone 4" to the medulla in the above description.

The mucilage lacunae, very common among *Laminaria*, are entirely wanting in the stipe of *Alaria*. Instead of them there are, at least in an embryonal stage of the frond, the mucilage glands. They are found in the epidermal layer immersed at the depth of a few cells, dispersed without any definite order along the periphery. As the meristematic layer of the cortex lies in a

1) WILLE: Beiträge z. physiolog. Anatom. der Laminariaceen, fig. 14.
2) MCMILLAN: Observations on *Pterygophora*, Pl. LXII, fig. 6–7.
3) WILLE: Beiträge z. physiolog. Anatom. der Laminariaceen, p. 17.

much deeper places than the site of the glands, they are never in double rings in the stipes of the second-year fronds. The glands are not remarkably larger than the cells of the epidermal layer and hence less conspicuous when compared with the lacunae of *Laminaria*. When the sections are stained in fuchsin and anilin blue (aqueous), however, the glands get blue-coloured, while the contents of the other cells become bright crimson red.

In the complanated part of the stipe, the arrangement of the tissue elements is greatly modified in comparison to the cylindrical part, so as to be adapted for the shape and for the future issue of sporophylls (Plate XVIII, fig. 13). The medulla is much complanated and stretched transversely, extending almost the whole width. The perimedullary tissue is here found as a very narrow area bordering around the medulla. The greater part of the thickness of the stipe is occupied by the cortex. The cells of the inner cortex are uniform in diameter and much more regular in shape than in the cylindrical part. In either marginal part, only a limited thickness of the cortex is allowed to occupy the narrow space between the epidermal layer and the perimedullary tissue. The epidermal layer shows no practical difference in both parts.

A point which requires attention in the structure of the complanated part of the stipe is that the boundary between the cortical portion and the perimedullary tissue, *i. e.* the innermost part of the inner cortex, is sharply demarcated by a layer composed of compactly arranged, narrow-lumened, cylindrical cells. These cells may be taken as a modification of the cortical cells, as they gently pass into the form of the latter. This layer is not noticeable in the cylindrical part but is much more markedly developed in the midrib (Plate XVIII, fig. 15). In this respect, the complanated

part of the stipe shows an intermediate character between the two parts just answering to its position in a frond.

In the two-year old stipe, the arrangement of tissues above spoken of remains unaltered in both the complanated and the cylindrical part of the stipe. But a new cortical ring appears between the epidermal layer and the primary cortex. In the cylindrical part it forms a continuous sheath of uniform thickness. In the complanated part, it is markedly thickened on both margins, and wing-like ridges on the edges of the stipe are accordingly formed. The midrib has no second-year cortex (Plate XVIII, fig. 12–14).

I have used above the expressions "annual ring" and "second-year cortex" for the stipe of *Alaria* plants. WILLE gives an account of the structure of *Alaria esculenta* in detail in his Beiträge zur physiologischen Anatomie der Laminariaceen, p. 17, and says: "wiefern wirklich auch das Vorkommen einer solchen Jahresring-bildung bei noch älteren Individuen von *Alaria esculenta* (L.) GREV. möglich ist, kann selbstverständlich nach Untersuchung dieses verhältnismässig jungen Materiales weder verneint noch bejaht werden." His material is said, according to his estimation, to have contained four-year old plants. I agree with him that what ARESCHOUG[1] remarked of *Alaria* "truncus ima basi 3–4 annulis ornatus" should not be taken as of the annual rings in a similar signification as for the phanerogams. ARESCHOUG's description should be taken as simply 3–4 concentric zones of tissues seen in the cross sections of the stipe. I have no doubt, however, that the growth in thickness of the stipe of a two-year old *Alaria* plant is by virtue of the secondary thickening of the pre-existing cortex. The demarca-

1) ARESCHOUG: Observations Phycologicae, V, p. 16.

tion between the old and new cortex, as alluded to above, is sharp and clear, especially when we treat the sections in a staining material. It may be well called "annual ring" in agreement with phanerogam taxonomists.

The length of the stipes varies considerably according to the species and to the condition of place where the plant grows. *Alaria Pylaii* GREV. is characterized by having the stipe several inches or even more than a foot in length. But in most species of *Alaria* it hardly exceeds a few inches before the plant begins to bear sporophylls. A typical stipe of *Alaria* is terete or cylindrical at the lowermost part just above the holdfast. It becomes gently compressed upwards, more or less broadening at the same time until it is suddenly narrowed near the transition region. The first sporophyll appears as a ligulate proliferation at a point generally above the middle point of the post-embryonal stipe. New sporophylls are given rise successively above the older ones while the stipe gains in length at the transition point by stipo-frondal growth. The lower naked part of the stipe later grows in thickness, but keeps the length of the post-embryonal stage. In a gigantic form such as *Alaria fistulosa*, several dozens of sporophylls may be already formed before the lowermost one has become soriferous. But in others, there are not so many sporophylls at one time. The oldest ones usually drop off before the plant attains its most vigorous state of growth. When the sporophylls fall away, the greater part of the length of the petioles accompany them, leaving but a small part as verruculose protuberances on the margins of the stipe. As the frond grows further and the stipe increases in length in the transition region, new sporophylls are added successively above, and the lower part of the stipe becomes cylindrical, obliterating the verruculose protuberances.

Alaria ochotensis is the only example in which the petioles of the dropped sporophylls remain permanently attached on the stipe (Plate III, fig. 1).

In an advanced stage of development, the scars of the dropped sporophylls are often hardly perceptible, except in *A. ochotensis*. Hence the lower part of the stipe becomes much longer than in the younger stage. Some writers distinguish the sporophyll-bearing portion of the stipe from the naked, by calling them rachis and and stipe respectively. To a certain extent this distinction appears to hold good in external appearance and in internal structure. But the limitation of the two parts is gradual and unfixed as may be granted from the above elucidation. In the present paper, therefore, both parts are included under the single term stipe.

The habitat of the plant undoubtedly influences the length of the stipe of *Alaria*. In one and the same species, those individuals found in water of less salinity, in a shaded place or in a deeper water have longer and slenderer stipes than those in other conditions. It is to be understood that the length of the stipe, in any sense, can not be taken as an important character for specific distinctions.

Blade.

In all species of *Alaria* the blade is simple for the whole life. But the older parts of fully grown blades are pinnately split, in the mode characteristic to the genus. The general outline of the blade is linear with attenuate, cuneate or roundish base, and a midrib running longitudinally on the median line percurrent from the stipe. The apex of the blade begins to wear away at an early embryonal stage and the process continues as the blade elongates by stipo-frondal growth.

The length of the blade varies greatly according to the species. Of *A. fistulosa*, KJELLMAN[1] reports to have measured its largest specimen in the Bering Sea at about 60 feet. MIYABE[2] states that it is said to be as long as 200–250 feet. I have measured a specimen about 85 feet long which was cast ashore on Shimuf shu Island, the northern extremity of the Kuriles. The breadth o- the blade of this species attains nearly 3 feet. This species no doubt has the largest simple blade in the vegetable kingdom. In a specimen of *A. tæniata* I found the blade to be 3.5–5.0 cm. in breadth and 3.70 meters in length—recalling a stripe of bandage. In other species, however, the length of the blade, absolute or in proportion to the breadth, is much less than those two examples. Generally, the maximum breadth of a blade is at a point about 1/5–1/3 of the whole length from the base.

In most species of *Alaria*, if not in all, the blade splits pinnately, like a *Musa* leaf, in the older parts. In certain species there seems more or less differentiation of the tissue adapted for this process. The cortical layers as well as the hyphal cells of the medullary layer of the blade run at large patently from the midrib, and the epidermal layer is composed of angulate cells disposed in less fixed direction. In *A. fistulosa*, *A. macropteria*, etc., the fine parallel wrinkles which give a marked feature to the older portions of the blade, are principally due to the peculiar arrangement of the medullary tissue (Plate II, fig. 2). The mechanical force of the waves acting upon the blade splits it in the resultant direction of the hyphal cells.

The segments of the split blade are rectangular, if the splitting is in the direction at right angles to the midrib, and more or

1) KJELLMAN: Om Beringhafvets Algflora, p. 41.
2) MIYABE: Laminaria Industry of Hokkaido, p. 52.

less rhombic, if in an oblique direction. In certain species, however, those in the upper portions of the blade are curved or even reflex, not unfrequently with subulate upper corner. *A. augusta* shows a remarkable example of this (Plate XV, fig. 2). Very likely this indicates a partial growth in the segments still going on after they have been split.

Not only in species of *Alaria*, but in most of the Laminariaceous genera, the growth of the frond at an early stage of development is displayed mainly lengthwise. The full length of the blade is attained while the frond is yet immature. How speedy this growth is may be well imagined from the fact that the enormous length of the blades alluded to above is completed within 3–4 months. In this stage, the blade is much narrower with the transition region more tapering towards the stem than in the adult form. When the growth in length has more or less retarded, the increase of breadth takes place as a secondary growth. The process is most remarkable in the transition region, hence the form of the blade undergoes a remarkable change. A blade which is to have a roundish or cordate base in a matured plant may have a cuneate or even attenuating one while in its vigorous growth in length.[1)]

Another factor which influences the shape of the blade of a Laminariaceous species is the movement of water in which it grows. In a quiet bay the blade becomes much thinner and broader than on an open coast; and on an open coast, a plant growing in a deeper region has broader blades than one near the tidal marks.

The general statement given above holds good for most species

1) Yendo: Three New Marine Algae from Japan, p. 100.
„ Development of *Costaria*, *Undaria*, and *Laminaria*, p. 702.

of *Alaria*. Describers of *Alaria* must be cautioned not to put much stress upon the shape of the blade as a specific character unless a number of matured forms from different habitats have been considered.

In *Alaria*, the wearing away of the upper portion of the blade is comparatively quicker than in other genera. In the matured form with fully developed sporophylls the upper half of the blade is in most cases already decayed. The general outline or the entire length of a blade is therefore frequently difficult to ascertain The statement on these points can be conventional and must never be regarded as of equal importance and exactness with that of other characters.

Certain species are defined as having thin and soft blades, as if the character were peculiar to the species. Not a few sterile specimens of *Alaria* which I have seen in various herbaria kept under *A. Pylaii* GREV. showed no important systematic character to justify the determination, except that the blades were thin and soft. There is no need to mention that the blade of a young individual of a Laminariaceous species has a thinner and softer substance. The inhabitants in quiet bays, especially where the salinity of the water is below the normal, may have the blade thin and soft during its whole life.

The term membranaceous, papyraceous, coriaceous, etc., are generally applied by systematists in qualifying the context of foliose fronds of various algae. In the specific distinction of *Alaria* these terms are also applied. Even in the adult forms and those of similar habitat, the apparent context of the blade in a herbarium specimen varies greatly according to the mode of preparation. The specimens mounted directly from a living specimen, whether soaked in freshwater or not, generally remain much thicker than those which have been first dried in the air and afterwards soaked in

freshwater and then mounted. *A. fistulosa*, the largest form of the genus, has the blade enormously thick and practically leather-like while in its fresh state. But when mounted for a herbarium specimen in the latter method related above, the blade turns into a thin and brittle papyraceous substance.

When a dried specimen is sectioned and dipped in water it swells up much more than to its former natural thickness. In such specimens it is rather difficult to discern the true anotomical character of the frond. A comparison of the details of construction of the blades of different species is therefore beyond my present enterprise. In the present paper the distinctive terms are still used, but very cautiously.

Midrib.

The term midrib as applied to the Laminariaceous frond is sometimes found to be used ambiguously. The thickened area which runs longitudinally in the middle of the blade of *Laminaria*, *Pterygophora* and the like, and the sharply defined longitudinal elevation on the blade of *Alaria*, have been equally called midrib by McMillan.[1] Setchell[2] previously seems to have been reluctant to adopt this usage since he chose to call the former "a sort of indefinite midrib" and for a similar thickened portion of the blade of *Pleurophycus*, "midrib" in quotation marks. In my former papers[3] the area is termed "meridional region."

Quite recently Okamura[4] published a paper treating of the relationship of *Laminaria Peterseniana* Kjellm., *Hirome undarioides*

1) McMillan: Observations on *Pterygophora*, p. 737. 1902.

2) Setchell: Distribution of Laminariaceae, p. 347. 1893; and Notes on Algae. I. p. 123. 1901.

3) Yendo: Development of *Costaria*, *Undaria* and *Laminaria*, p. 711.

4) Okamura: *Undaria* and its Species, p. 269.

YENDO and *Undaria pinnatifida* SUR. The first species has no true midrib but a thick meridional area, on which the sori limitedly develop. OKAMURA termed the area "fascia." The other two species have the true midrib which remains absolutely sterile. In spite of remarkable morphological differences, he proposes to bring them all under the single genus *Undaria*, extending its conception. I hold, however, the view that the midrib in the blades of *Alaria*, *Undaria* and *Hirome* should be taken as a special organ of distinct significance. The gradations of the soral localizations of the three species as illustrated by OKAMURA may well indicate that they are genetically related to one another, directly or indirectly, but can not have more significance than that, in the modern principle of systematic survey.

The true midrib has a well-marked structural difference from the laminal part. The most striking point is the longitudinal course of the cortical and the hyphal cells in the former, while they run at large decussately or patently from the midrib in the latter. In the meridional and the extra-meridional area of the blade of *Laminaria*, they run equally in the longitudial direction; also in *Laminaria Peterseniana* and *Pterygophora californica*. Hence it is quite natural that the fresh blade of *Laminaria* tear longitudinally, but curiously the dried ones tear transversely.

In *Agarum Gmelini* the thickened meridional area approaches in structure and in appearance to the true midrib; and more so in *Agarum Turneri*. In this respect, the midrib of *Agarum* may be taken as a link showing intermediate characters between the true midrib and the meridional area.

The typical midrib of *Alaria* is complanated with rounded edges, elevated equally above both surfaces of the blade. The cross sections, therefore, show an elongated elliptical shape with a

semiblade extending horizontally from each margin.

In young fronds, the midrib slants towards the margins, giving a biconvex shape to the cross sections. Some species keep this character unchanged. But in others, the marginal parts gradually thicken as the frond grows up, eventually to form perpendicular edges. The cross sections are now compressed rectangular.

The thickness of the midrib varies according to the species as well as to the age of the frond, often measuring 12 times as thick as the laminal part. The breadth of the midrib in a blade is nearly uniform from the base to the apex. In young post-embryonal fronds, however, the upper part is naturally narrower than the lower.

The tissue elements and their arrangement in the midrib are essentially equal to those of the complanated part of the stipe, except that there are no mucilage glands in the former. The greater part of the thickness is occupied by the cortical portion. In other words, the elevation of the midrib above the blade is mainly due to the remarkable development of the cortical tissue (Plate XVIII, fig. 14).

The structure of the cortical portion is practically the same in the midrib and in the stipe. In the former, however, the cells of the inner cortical portion are more thin-walled and greater in diameter, uniformly cylindrical, and run closely parallel in longitudinal direction. In the cross sections, these cells show angulate polygonal shape, with narrow or scanty intercellular spaces, and are disposed in compact, anticlinal rows (Plate XVIII, fig. 16). In the blade, the cortical cells are much more loosely arranged and take a decussate or patent course from the midrib as alluded to above.

The medullary layer in the sense as taken in the present monograph is a very thin layer extending nearly the whole width of the midrib. It is surrounded by the perimedullary tissue in the manner related to for the complanated part of the stipe. The term medulla used by former writers for the central tissue of the Laminariaceous midrib comprises the medulla and the perimedullary tissue together. In most species of *Alaria*, the layer is considerably thickened at a point near each margin of the midrib. For convenience' sake, I will call the point "marginal swelling of the medulla" (Plate XVIII, fig. 14, *h*).

The medullary layer in the midrib is built up of the same elements as that in the stipe and the blade, *i.e.*, trumpet hyphae and fibrous cells. The proportions of the components differ somewhat according to the species, but in most cases there are more trumpet hyphae in the midrib than in the blade. The marginal swellings of the medulla show great variation in form and tissue elements characterizing the species to a certain degree. In some species, in the cross sections of the midrib, they are narrow lanceolate in shape, in others, ovate or nearly roundish; in some species, they are composed of more trumpet hyphae and less fibrous cells; in others, a narrow middle portion is composed of fibrous cells only, a mixture of both surrounding it. Cfr. Plate XVIII, fig. 15, 16.

The part just overlying the perimedullary tissue, *i.e.*, the innermost part of the cortical tissue, is composed of cells which resemble the cortical cells in shape but are much smaller. The differentiation of this layer is indicated in the complanated part of the stipe, as has been alluded to above. The thickness of the medullary sheath, as it may be provisionally called, varies in different parts of the medulla, being, in most species, much thinner

around the marginal swellings. The relative thickness of the medulla, perimedullary tissue, and the medullary sheath, and the compactness or looseness of the cells of these tissues, show great variation according to the species.

From the outer limits of the marginal swellings of the medulla, the medullary tissue runs directly to the blade. Hence, the blade-medullae in both semiblades are practically continuous, with the midrib-medulla interposed at the middle. The cortical tissue of the midrib, however, is sharply divided from that of the blade by a special tissue intervening between them. This tissue is composed of thick-walled, small cells, and compactly fills up the spaces which lie between the outer parts of the marginal swellings of the medulla and the epidermal layers at the outer margins of the midrib. The term "spanning cortex" is applied to this tissue in the descriptive part of the species (Plate XVIII, fig. 14, *k*).

WILLE[1] gives in detail structural accounts of the midrib of *Alaria esculenta* GREV. His description agrees in essential points with the observations stated above. What he calls "Assimilations-System" corresponds to the epidermis in the present Monograph, "das mechanische System" to the cortex, and the "Leitungs-System" to the medulla and the perimedullary tissue taken together.

The midrib of *A. fistulosa*[2] displays various peculiarities in its external appearance as well as in the internal structure. Its axial part becomes intermittently hollow inside, and is elevated on both surfaces so as to answer the cavities or bores. The outer edges of the midrib are not rounded or slant but sharply angulated, already at the early stage of development of the frond, and get

1) WILLE: Beiträge zur physiol. Anatomie der Laminariaceen, p. 24.

2) For a fullar account on the midrib of *Alaria fistulosa*, see, KIBBE: Some Points in the Structure of *Alaria fistulosa*. (Puget. Sound Mar. Station Publications, Vol I, No. 8. 1915).

markedly prominent as the bores are completed. Plate I, fig. 4 will speak better than description.

The boring is practically a lysigenetic result, taking place in the axial region of the medulla at the post-embryonal stage of the frond. Disorganized hyphal cells and the residual trumpet cells, often filled with callus, are found on the inner surface of the bores. The medullary tissue is poorly developed near along the bores but markedly thickened at the marginal swellings. The perimedullary tissue is absent along the bores but well developed in the complanated regions of the midrib, and terminates at its marginal elevations. The spanning cortex is also to be seen at each marginal elevation of the midrib (Plate I, fig. 4).

The cortical portion of the midrib of *A. fistulosa* is composed of irregularly arranged parenchymatic cells. The greater part of the thickness of the bore-wall is occupied by this tissue.

The shape of the cross section of the midrib has often been used as a distinguishing character of *Alaria* species. Repeated observations on various species have taught me the danger of adopting such a view. As stated before, the midrib is much complanated with sloping edges while the blade is yet young. When the secondary growth in breadth begins to take place in the blade, its midrib gains the characters of a matured plant. By referring to the figures in the accompanying plates (Plate XI, XIII, fig. 2–3) the reader will readily understand to what degree the cross sections of the midrib of a species may vary. Certain species have of course a peculiarity in their midribs and this peculiarity may be already perceived even in an early stage of development. *A. fistulosa* can not be mistaken for others by its intermittently hollow midrib. Yet, the distinguishing of species of *Alaria* by mere cross sections of the midrib,—at least to put a great im-

portance on them,—especially in immature specimens, is not advisable. Upon this ground, the present writer mentions *A. linearis* STRÖMF. and *A. flagellaris* STRÖMF. under the "species doubtful," referring to the authors who held a similar view to STRÖMFELT.

KJELLMAN[1] seems to have put too much stress on the breadth of the midrib in describing his species from the Bering Islands. Some systematist went too far in following his view tending to value the breadth of the midrib above other characters, eventually resulting in an awkard identification.

When dried, the breadth of the midrib of *Alaria* decreases to a considerable degree. In some specimens I have observed it to lose 30–50% of breadth on drying. The midrib of a dried specimen of *A. valida* SETCH. et KJELLM. was 5 mm. in breadth. In putting a part of the midrib in freshwater I found it to expand to a breadth of 15 mm. I have not observed the species in a living state and hence am not able to state the actual contraction of the midrib by drying. Referring to the measurement given by SETCHELL (22 mm.), I think the breadth regained by soaking in freshwater not to be very far from the measurement in its fresh state. These examples show that the breadth of the midrib of *Alaria* when measured in a dried specimen will often differ greatly from that of the fresh specimen.

JÖNSSON[2] illustrates an interesting example in the difference of measurements of various parts of the frond of *A. grandifolia* J. AG. by soaking and drying. He remarks:—"These measurements of plants in wet and dry state prove that their total length is reduced 15% by the drying process, the length of the lamina 11.5%, the breadth of the lamina in one case (A) 16.6%, in

1) KJELLMAN: Om Beringhafvets Algflora.
2) JÖNSSON: Marine Algae of East Greenland, p. 22, footnote.

another case (B) 21%, and the length of the stipes 22.5%. A single measuring like this does not allow of any general conclusion as to the normal reduction by drying of the several species of *Alaria*, but as generally the descriptions do not state whether the measures refer to living, soaked, or dried material, it nevertheless shows, that it is not justifiable to let too small a difference of size (breadth or length) have worth as a character of species, variety, or even of form." JÖNSSON did not give anything about the midrib. His statement here quoted may be said to apply to the midrib, and in this case probably is of more importance.

Sporophyll.

The sporophylls of *Alaria* are small leaflets distichously arranged on both edges of the stipe. They are always perpendicular, *i.e.*, paratropic. They vary in shape according to the species, from narrow linear to moderately broad ovate, ending with a cylindrical petiole at the base. In some species the petiole is sharply defined from the roundish or cordate base of the sporophyll and in others gently passing into the cuneate base. Many species have the base of the sporophyll asymmetrical or hemiphyllous, but towards which direction the base grows broader is not fixed even in an individual. The soft but tenaceous, slender petiole is not stiff enough as to fix the direction. The number of sporophylls on a stipe is also variable. In some species they are comparatively few, in others numerous. *A. fistulosa* has the largest number and may have several dozens on each side of the stipe (Plate I, fig. 1).

In the species with a very short stipe, the first sporophyll appears at a point near the holdfast, but in those with a moderately long one, at about the middle of the length. The few early-

formed sporophylls are distantly disposed, but the later-formed, normal-sized ones are more approximate. They are alternate in some species and nearly opposite in others. But such arrangement can be discriminated only in the early-formed sporophylls, as the middle and upper ones are generally quite close together. In all species, new sporophylls appear successively above the older ones as the stipe increases in its length at the transition point. The lower older ones drop off one after the other leaving verrucose scars on the edges of the stipe. In some species, however, the growth in length of the stipe ceases before long, and the sporophylls are condensed to a limited point. A noteworthy example of such is seen in *A. angusta*. In it the sporophylls, except a few early-formed ones, grow fasciculately from a point in an upper part of the stipe, the point being much broader and more compressed than the naked portion (Plate XV, fig. 1).

The sori cover the greater parts of both surfaces of a sporophyll, leaving always a narrow border along the margin and frequently a sterile membranous portion on the upper end.

After having examined a considerable number of specimens of *Alaria*, the present writer has come to the conclusion that one is not justified in determining the species of *Alaria*, except in a few cases, unless a specimen with fully matured sporophylls is before him. The other parts of the frond serve of course to help the determination but should never be used alone. Sterile specimens of *Alaria* from the North Pacific where various species occur simultaneously at the same place, are seldom determinable with certainty.

The value of sporophylls as a specific distinction of *Alaria* lies in two points: *a*) their general shape and texture; *b*) their disposition on the stipe.

a) Shape and texture of sporophyll. In describing the shape of sporophylls of *Alaria*, the term linear, ovate, obovate, etc., and their combinations have been applied; and for the texture, coriaceous, cartilaginous, membranaceous, etc. Generally speaking, the sporophylls of *Alaria* are narrow and thick when the plant grows on a surfing rock or near the low water mark, and broad and thin, when in a quiet cove or in a deeper place. McMillan[1] observes on Vancouver Island that *Alaria nana* has much broader and more sporophylls when it is found at a higher formation on surfing reef. He attributes the abnormity of the form to its adaptation to the cumaphytic habitat. The fluctuation of the morphological characters due to the difference of the habitats, however, is quite trifling in comparison to that due to the stages of their development.

A few of the earliest-formed sporophylls are in most species different in shape and size from those formed at vigorous growth of the frond. They are generally smaller and shorter, and distantly disposed. Many examples may be given, where specimens of various species at such a stage have been erroneously identified with *Alaria Pylaii* Grev.

After a close study of the development of sporophylls in various species I can safely divide *Alaria* into two sections, Holosoria and Metasoria, on account of the changes of the appearance and texture of the sporophylls during their growth:—

I. Holosoria. Sporophylls of the species under this section are in most cases thick and coriaceous from the beginning. Their growth in length and breadth stops at a certain limit and then the entire surfaces, except the narrow borders, become soriferous. The sori begin to appear as a continuous patch on the lower half

1) McMillan: Cumaphytism of *Alaria*, p. 147.

of length of the sporophyll extending gradually towards both ends. The apex of the matured sporophyll is round and entire, and in certain species a sterile portion may be left there. The general statement given by SETCHELL[1] about the development of the sporophylls of *Alaria* holds good for the plants of this section (Plate I, fig. 1).

II. METASORIA. Sporophylls of the species under this section are thin and membranaceous or papyraceous at the beginning. If the hair-tufts or the mucilage glands are present in the blade, they are also well developed in the sporophylls. They are therefore functioning as a vegetative organ. Later on, they increase in length by basipetal growth at a limited region near the petiole. The newly formed portion is of much thicker texture, and in some species is remarkably broader or narrower than the thin upper part. The latter part wears away by degrees from the apex. The thicker part becomes soriferous. The matured sporophylls have generally certain portions of the thin and sterile foliole still remaining at their upper end, but not unfrequently are entirely free from it (Plate IX, fig. 1–3).

When there is ample material showing various stages of development of frond, the distinction above given is easily recognizable. If, however, we have only very young or fully matured sporophylls in a specimen the matter is not so apparent. Very frequently we meet with the fully matured sporophylls of the Metasoria entirely free from the non-soriferous portions. In such case one is apt to take the plant to belong to the Holosoria. With but a few exceptions, the matured sporophylls of the Holosoria have broad and rounded apices with entire margins, while

1) SETCHELL: On the Classification and Geographical Distribution of the Laminariaceae, p 347.

those of the Metasoria, more or less narrowed apices with rough margins.

Although the apical part of the sporophyll is variable in appearance, as explained above, the basal part has a constant character more or less specifically distinct. In some species the base tapers gently into the petiole, and in others is cordate or round with sharply defined petiole; in some species it is asymmetrical in a peculiar manner and in others always symmetrical. By these characters of the sporophyll, together with its general outline, we can often readily tell the species even in a specimen with the whole part of the blade withered away.

b) Disposition of sporophylls on the stipe. The various modes of disposition of sporophylls are expressed by the terms pinnate, distantly pinnate, fasciculate, etc., which shall be used and regarded with utmost care. Early European botanists to whom only *A. esculenta* has been the familiar species, were rather careless in describing the character.

Rosenvenge[1] and Jönsson[2] are of the opinion that the position of the sporophylls is not of any systematic importance. As has been already stated, the early-formed sporophylls are disposed on the stipe at much wider intervals than the later-formed ones. It is therefore apparently right to agree with these two botanists, when we compare different-aged plants of one and the same species. But when fully matured plants of the different *true* species have been laid before us we can make out in each a more or less constant character in the disposition of the sporophylls.

Alaria esculenta Grev., the type of the genus, has the sporophylls arranged regularly pinnate, with nearly constant intervals

1) Rosenvenge: Grönlands Havalger, p. 839.
2) Jönsson: Mar. Alg. East Greenland, p. 23.

between the successive two; so also in *A. prælonga* KJELLM. and *A. crassifolia* KJELLM. In *A. angusta* KJELLM., the sporophylls are condensed to a short, limited length of the stipe, and the insertions of the petioles are fused together to form a narrow wing-like portion on either margin of the stipe. *A. nana* SCHR. is unrivalled among the genus in having the sporophylls ascending. *A. Pylaii* GREV. is well known by having them at wide intervals on a long stipe. All other species may belong to one of these examples, or may have a certain peculiarity in the disposition of the sporophylls.

Holdfast.

In the early embryonal stage of the frond, the holdfast of *Alaria* is a simple scutellate body firmly attached to the substratum with its under surface. It is better to call it hapter at such stage. From all sides of the stipe just above the hapter arise rhizines in an irregular whorl, furcating repeatedly towards the periphery, each ramulet terminating in a small hapter. New rhizines come out from the stipe above the older whorl as the frond develops. The thickness and complicacy of the rhizines increase in the new ones. The primary hapter and the early-formed rhizines decay by degrees. In these respects the mode of formation of the holdfast of *Alaria* agrees with what has been hitherto observed on various other genera of Laminariaceæ.

The rhizines of the holdfast are generally cylindrical in every segment. In *A. tæniata* KJELLM. and *A. angusta* KJELLM., however, the principal segments, *i. e.*, the segments directly connected with the stipe, are stout and compressed and rhizines are very few in number and short in length (Plate XV, fig. 1). The holdfast of *A. fistulosa* is built up of innumerable, long, filiform rhizines,

compactly interwoven together. Its general outline becomes tall conical, measuring, in a full-grown specimen, 30–40 cm. in height and 15–20 cm. in diameter at the base (Plate I, fig. 1). Excepting these few cases, the holdfast of *Alaria* may be said to be as in the typical form of Laminariaceæ.

The tissue elements of the rhizines are quite simple in comparison with the stipe. Their inner part is constructed of filiform, less branching, narrow tubes, septated at various lengths. These tubes run longitudinally but undulating. In the axial part they are somewhat loosely disposed, without any definite rule, but are very compact around it. There is no apparent differentiation in size or form in them and, so far as I have observed, the trumpet hyphae are entirely wanting. The outer part agrees in important points with the epidermal layer of the stipe, but is thinner. Cfr. also, WILLE: Beiträge z. physiol. Anat. der Lamin., p. 22. In some species, abundant mucilage glands are found there, even in those species which lack them in the blades of the adult stage.

Cryptostomata.

The cryptostomata found in some members of *Alaria* are not pit-form as in the Fucaceous plants, but shallow depressions of merely one or two cells deep on the surface of frond. In *A. esculenta* GREV., *A. crassifolia* KJELLM., *A. grandifolia* J. AG., etc., they appear as a conspicuous organ scattered on the blade especially in an early post-embryonal stage of frond. In *A. prælonga* KJELLM., *A. tæniata* KJELLM., *A. marginata* P. et R., etc., they are entirely wanting. It is, however, not advisable to separate all *Alaria* into two groups, cryptostomated and non-cryptostomated, and to place too much importance upon the organ for specific distinction is

often misleading.[1] KJELLMAN[2] once identified a plant from Alaska with *A. lanceolata* KJELLM. on account of the largeness and abundance of "the tufts of long cryptostomata," though in all other characters it appears to me to be referrable to *A. dolichorhachis* KJELLM.

Various opinions regarding the nature and function of cryptostomata have been expressed by different botanists. The opinions, however, have been within the limit of the Fucaceous cryptostomata and did not take into consideration similar organs of the other families. When the tufts of hairs found in Encœliaceæ and Laminariaceæ are equally treated as cryptostomata, the nature and function of the organ become still more inexplicable. MURRAY[3] says:—"A comparison of the Fucaceous conceptacle and cryptostoma, the *Splachnidium* conceptacle with its persistent initial cell and the formation of its hairs yielding place to sporangia, the development of the *Adenocystis* cryptostoma in the heart of its sorus, the other Laminarian cryptostoma (*Saccorhiza* and *Alaria*) apart from the sorus, the cryptostoma of *Hydroclathrus* among its plurilocular sporangia, and finally the cases of the hairs in *Asperococcus* and the Cutleriaceæ and Dictyotaceæ—a comparison of these cases, and of the evidence plainly furnished by them, points very significantly to a possible origin of cryptostomata."

The development of cryptostomata is now much clearer than at the time when MURRAY's work was published. For the full knowledge on the behavior and further development of the "initial cell" in the conceptacle and cryptostomata of *Sargassum filipendula* we owe to Miss SIMONS' excellent paper.[4] Her paper largely con-

1) WILLE: Beiträge z. physiol. Anat. Lamin., p. 37.
2) SAUNDERS: Harriman Alaska Exped, Algae, p. 426.
3) MURRAY: Phycological Memoirs, X, p. 63.
4) SIMONS: Morph. Study of *S. filipendula*.

firms the observations made by BOWER, VALIANTE, OLTMANNS, etc., though there are certain points at variance with them. The mode of formation of the "cryptostomata" of *Alaria* has been fully elucidated by MURRAY.[1] The present writer[2] observed parallel cases in those of *Costaria* and *Undaria*. We are now on safe ground when we say that the tufts of hairs found in fronds of Laminariaceæ are different from the cryptostomata of Fucaceæ, genetically and morphologically. MURRAY has already recognized the difference as he expresses hesitation in applying the term cryptostomata to the tufts of hairs of *Alaria*.

MURRAY points out in the above quoted lines a morphological gradation of the cryptostomata of Encœliaceæ, Cutleriaceæ and Dictyotaceæ. His idea appears to me by far suggestive when we take into consideration all other brown algae which bear the hairs, and the development of such plants. I shall take this opportunity to elucidate briefly the embryonal stages of *Homœostroma latifolium* J. AG.

The primary stage of development of *Homœostroma latifolium* J. AG. is a discoidal monostromatic patch of parenchymatous cells (Plate XIX, fig. 5). Some of the marginal cells elongate prostrately to form the rhizoidal filaments. Meanwhile, the patch becomes polystromatic. Some of the surface cells elongate upright, and form confervoid bodies by successive transverse divisions. When there are about 20 cells in a confervoid body the basal cells grow longer than diameter and the middle and upper ones more or less compressed and broader than height. Then a longitudinal division through the median line takes place in the compressed cells. Further multiplications of cells follow next to form a linear, mono-

1) MURRAY: l. c.
2) YENDO: Development of *Costaria*, etc.

stromatic blade. A sort of segmentation, as it were, can be seen in these stages (Plate XIX, fig. 9). Each segment indicates that the cells in it are derived from the same mother cell, as an areole of the epidermal cells in an embryonal blade of Laminariaceæ.[1)]

While these processes are going on, the apical cell of the confervoid body remains single, but elongates upwards, keeping the initial diameter. As soon as the linear, monostromatic blade has been formed, the elongated apical cell begins to divide by transverse septa and the resulting filament quickly gains its length by basipetal growth (Plate XIX, fig. 8, 9). It shows all the characters of the hairs peculiar to the Phæophyceæ. Something quite similar was observed by REINKE[2)] in the sporelings of *Scytosiphon pygmæus*. From the uppermost marginal cell of each segment there starts a similar hair. Plate XIX, fig. 10 shows a marginal part of a blade of about 3 mm. in length. In it, hairs at various stages of development are found in considerable number, but not in tufts. They are thicker than the primary hair at the apex of the blade but undoubtedly are of the same nature. The tufts of hairs on the surface of the blade, mentioned in describing the species, come out in a much later stage.

A filament resembling the apical hair of the treated plant is delineated by THURET[3)] for the sporelings of *Stilophora rhizoides* J. AG. It is to be remembered that the species is characterized by having a single persistent hair at the apex of the frond.

Summing up the results hitherto obtained from the observations on the adult forms of the Phæophyceæ, we may distinguish the modes of occurrence of the hairs and their relative positions

1) YENDO: Development of *Costaria*, etc., Pl. LIV, fig. 19.
2) See ENGLER und PRANTL: Pflanzenfamilien, Algae, fig. 139, c.
3) THURET: Zoospores des Algues, Pl. 28, fig. 9.

to the sporangia in the following manner:—

1. Both hairs and sporangia isolated, dispersed on the frond without any definite order; no definite relation between their positions of occurrence.

   Striariaceæ, Dictyosiphonaceæ, Desmarestiaceæ.

2. Hairs more or less aggregated in tufts; sporangia more or less localized into sori; no definite relation between their positions of occurrence.

   Encœliaceæ (*Punctaria*, *Homœostroma*, *Phyllitis*, etc.).

3. Hairs aggregated in tufts; sporangia only around the hair-tufts.

   Encœliaceæ (*Asperococcus*).

4. Hairs isolated, or more or less aggregated; sporangia at the bases of the hairs, assuming the positions of branches.

   Chordariaceæ, Spermatochnaceæ, Cutleriaceæ, etc.

5. Hairs aggregated in tufts, in small depressions on the surface of frond; sporangia localized to form the sori in a more or less definite part of frond; no definite relation between the positions of hair-tufts and sori.

   Laminariaceæ (*Alaria*, *Undaria*, *Agarum*, etc.).

6. Hairs aggregated in tufts, in small pits on the surfce of frond; sporangia limited to the pits in a certain fixed part of the frond.

   Fucaceæ.

From a birdseye view of the various modes of occurrence of the hairs, and their relative position to the sporangia as arranged above, we may trace the apparent gradations in the localization of both organs from the isolated hairs and sporangia to the conceptacles of Fucaceæ. If the view that the ontogeny repeats the phylogeny is to be accepted, the observation on the hairs of the

embryonal frond of *Homœostroma* will illustrate the evolution of Encœliaceæ from a more primitive form such as Striariaceæ.

As for the cryptostoma of Fucaceæ, it may be explained to be a sterile conceptacle according to BOWER[1] and SIMONS[2]. Or, according to OLTMANNS'[3] view, the conceptacle may be a fructified cryptostoma. But BARTON's[4] view that "the two forms of conceptacles are of equal antiquity, and were a later development in the ancestors of the Fucaceæ than the reproductive organs," may be open to criticism. We know very little, if anything, about the ancestors of Fucaceæ. If, however, ontogeny repeats phylogeny, the tuft of hairs in the apical pit of the sporelings of *Fucus* suggests to us to prefer the view that the cryptostoma is an important vegetative organ of the Fucaceous frond and that its development is earlier than that of the conceptacle.

MURRAY[5] says:—"I am aware that the hairs of the cryptostomata are regarded by many as adapted to absorptive and other nutritive functions. This may or may not be; there is no proof of the matter, and probably more reasons to be cited against than in favour of, such an opinion." He has not treated the matter further and we are not able to know what was his opinion regarding the functions of the hair-tufts of *Alaria*. The view held by some botanists, that the hairs of the Phæophyceæ are a protecting organ against the light is undoubtedly derived from the accounts of the hairs of the Phanerogams. This can be readily denied when we consider the fact that the blades of the Phæophyceæ which are habitually decumbent have the hairs developed on

1) BOWER: On the Development of Conceptacles in the Fucaceæ, p. 37.
2) SIMONS: Morphol. Study of *Sarg. filipendula*, p. 174.
3) OLTMANNS: Beiträge zur Kenntnis der Fucaceen, p. 82.
4) BARTON: On the Genus *Turbinaria*, p. 223.
5) MURRAY: Phyc. Memoirs, X, p. 63.

both surfaces equally rich, and that in one and the same species found either in shade or in light, the hairs show no difference in their number and size.

As mentioned above, the hairs in the Phæophyceæ make their appearance at a very early stage of development of the frond. In some member they are persistent, though the cells composing them are constantly renewed by the basipetal growth; in others, they are present while the frond is not fully matured or is in an embryonal stage. In *Homœostroma*, as above observed, there are a large number of isolated hairs on the margins of the embryonal blade; they drop off as the blade grows and the tufts of hairs appear on the surface of the blade (Plate XIX, fig. 12). The renewal of the hairs and their shedding in the adult fronds are ample proof that the hairs are not directly related to the reproduction. In a dilute solution of life-staining material (for instance, 0.1% aqueous anilin blue in sea-water) the hairs absorb the colouring matter without plasmolysis taking place in the cells while the epidermal cells take in no trace of it. There may be no direct proof that the hairs of the Phæophyceæ are absorptive organ, but there is nothing against the view, so far as I am aware, in explaining them as adapted to it.[1]

Whatever it may be in other families, the hair-tufts in the Laminariaceous frond can safely be regarded as a sort of absorptive organ. The appearance of the hairs on the frond begins at an early stage of development.[2] The hairs are in a most vigorous state of growth just before the formation of the sori. When the plant has attained full maturity, the hairs are mostly broken off,

1) Reinke: Kenntniss der Tange, p. 321.
Wille: Beiträge z. physiol. Anat. der Lamin., p. 39.
2) Murray: Phycol. Memoirs, X.
Yendo: Development of *Costaria*, etc.

leaving but aggregations of the small basal cells as dark spots on the blade.

Thus, the hairs in the fronds of Laminariaceæ appear to me to be an absorptive organ as are the isolated hairs in the other Phæophyceæ. They are localized to form tufts more or less resembling in appearance the cryptostoma of Fucaceæ. The hair-tufts of Laminariaceæ, Dictyotaceæ, Encœliaceæ, etc., have been proved to be genetically different from the Fucaceous cryptostomata. Hence, it should be an improper idea to regard the latter as the most advanced form of the hair-tufts. However much they differ from the other Phæophyceous hairs in their mode of formation, they may be taken equally well as an absorptive organ. In Fucaceæ the sporangia are localized in the hair-pits of a certain part of the frond, called receptacle, the hair-pits in the vegetative parts are named cryptostomata, and those in the receptacles, conceptacles. It is quite natural to meet with "the occasional appearance of sterile representatives of sexual organs within the cryptostomata."[1]

In *Alaria*, the hair-tufts occur on the whole area of both surfaces of the blade, except the stipe, the midrib and the soriferous area of the sporophyll. The transition region of the blade is usually devoid of them, perhaps because all the cells in the area are meristematic. In most cases, certain areas of the blade along both sides of the midrib are also free from them. As the frond develops further, the scars of the withered hair-tufts are stretched in the direction of the expansion of the blade, *i.e.*, parallel to the clefts, resulting in elongated elliptical flecks. The sporophylls of the Metasoria are provided with the hair-tufts while they are functioning as vegetative organs, if the blade of the respective frond has them (cfr. p. 25).

1) Simons: Morphol. Study of *Sarg. filipendula*, p. 174.

In "non-cryptostomated" members we often find minute dark brownish spots in the upper portion of the frond. They very much resemble, in mode of occurrence as well as in anatomical characters, the scars of the withered hair-tufts. In some cases they are results of an accidental death of epidermal cells, the space being filled up by quick multiplication of the surrounding cells which continues as long as the part concerned extends as the blade develops. In others, they are remains of the mucilage glands, as stated below. While the frond is yet young, the nature of such elliptical spots may be ascertained by the presence or absence of the hair-tufts in other parts of the frond. But in a matured and old frond in which no more functionate hairs are to be found, we are often puzzled to determine whether the plant is "cryptostomated" or "non-cryptostomated." This is especially the case in the dried herbarium specimens.

From the above statements it may be readily granted that the presence or absence of the hair-tufts is often difficult to ascertain in an old fragmentary specimen; and also that the length or number of the hairs in a tuft is variable and hence of no specific importance. Yet when we are able to collect a large number of specimens of a certain species it is always advisable to make a careful observation of them. In some cases, we find a few hair-tufts in the frond of a species which is properly "non-cryptostomated" in the typical form. Cfr. description of *A. prælonga*, p. 85.

Mucilage Glands.

The presence of the peculiar glandular cells in fronds of *Laminaria Peterseniana* KJELLM. was first noted by OKAMURA[1] who took

1) OKAMURA: On Laminaria of Japan, p. 98.

them to be a kind of "excretory organ." MIYABE[1] found a similar organ in *Undaria pinnatifida* SUR., and the present writer[2] in *Hirome undarioides* YENDO. Afterwards, I described the cells in detail[3] and expressed the view that these cells are mucilage glands. SAUVAGEAU[4] noticed quite similar cells in the embryonal fronds of *A. esculenta* GREV. and was inclined to regard them as a reservoir of fucosan grains, but stated at the same time that it is a noticeable fact to find them in the lacunae-wanting members of Laminariaceæ.

I have also noticed the presence of the mucilage glands in various species of *Alaria* in the course of the present study. The glands have been carefully examined on *A. crassifolia* KJELLM., as its fresh material is most easily accessible to me. SAUVAGEAU'S observation on the glands of *A. esculenta* GREV. is by no means exhaustive. The following remarks on those of *A. crassifolia* will not be unnecessary for future investigators on the subject.

The smallest specimen of *A. crassifolia* with the mucilage gland, as far as I have observed, was 2.2 mm. in total height. The frond was lanceolate with a cylindrical stipe of moderate length, and the blade measured 0.61 mm. at its broadest part. The upper part as well as the marginal area of the blade remained still in the monostromatic state. The mucilage glands were mostly found at the boundary between the monostromatic and the polystromatic area, in a few but irregular rows. Surface views of the glands were mostly circular, but some in the upper part of the blade more or less longitudinally stretched. The apartures of the small circular glands were little more than the size of single

1) YENDO: Three New Mar. Algae. from Japan, p. 102.
2) YENDO: l. c.
3) YENDO: On the Mucilage Glands of *Undaria*.
4) SAUVAGEAU: Sur les "Glandes a Mucilage" de certaines Laminaires, p. 12.

epidermal cell, but those of the stretched ones nearly as large as two or three epidermal cells taken together. A number of the glands have also been found on the surface of the stipe.

As the embryonal blade elongates further by stipo-frondal growth, the monostromatic part is eroded away by degrees. This generally takes place when a frond has attained 6–7 cm. in total length. At this stage, the mucilage glands are much denser than in the preceding stage, and much larger in size and greatly elongated. Very frequently, two, three or more of the elongated glands are found continuous together, forming a simple or ramified passage. See Plate XVIII, figs. 9–11. The small circular ones may be seen near the transition region only and along the very margins of the blade. The content of the gland is granular and colourless. The glands in the stipe undergo no marked change in their shape and size.

When the frond has grown to measure more than 12 cm. in total length, the contents of the older mucilage glands turn into a dark brownish colour even in the living material. In general, the glands in the region up to 20–30 mm. from the transition region are colourless and granular; but those in the upper parts of the blade, except the newly formed young ones, are all brownish (Plate XVIII, figs. 8–10).

The longitudinal stretching of the glands while yet young, appears to follow the longitudinal elongation and the multiplication of the epidermal cells. This can be concluded from the fact that the disposition of the epidermal cells is not at all disturbed upon or around the glands. But in the later stages, generally after the content has turned into a dark brownish mass, the glands gain in width and the epidermal cells around the opening become radiately disposed (Plate XVIII, fig. 9, *a*). In *Undaria pinnatifida*, the

glands gain their size by expanding in all directions, hence the epidermal cells have to be arranged radially at an early stage of development of the glands.[1] This difference may be easily explained from the modes of growth in the two plants. In *Undaria*, the pinnae extend in area by the growths in length and width, but in *Alaria*, the embryonal blade grows much quicker in length than in width.

I[2] have already mentioned the difference in number of the glands in the marginal and the middle part of the frond of *Undaria*. In the former part there are always more numerous glands than in the latter. In *Alaria crassifolia*, the glands are practically limited to the margins of the blade (Plate XVIII, fig. 8).

When the fronds of *A. crassifolia* have attained the length of 50–60 cm. and the sporophylls make their appearance as small ligules, there are very few glands, if any, to be found in the transition region or in any other part of the blade. But in the membranous sterile part of the sporophylls, which are to be found in a further advanced stage of frond, the mucilage glands are very well developed.

In *A. fistulosa*, the largest form among the genus, the glands may be seen all over the blade, except the midrib, even after the numerous sporophylls have appeared.[3] The glands of this species are not stretched longitudinally as in *A. crassifolia*; those in the transition region are nearly as round as those of *Undaria*, and those in the part about a meter or so above the transition point

1) YENDO: On Mucilage Glands of *Undaria*, Plate XLVIII, fig. 7.

2) Ditto, p. 614.

3) Miss KIBBE observes a peculiar sort of cells in the frond of *Alaria fistulosa* and regards them as a fungus. I am inclined to doubt her observation; she may have mistaken the glandular cells as a parasite. (Puget Sound Marine Station Publication, Vol. I, No. 20 1916). In her previous paper (the same Publication, Vol. I, No. 8. 1915) specially treating on the structure of *Alaria fistulosa* she gives no account on the remarkable glands.

—the part near the base of the blade in proportion to the whole length, which measures 10–20 meters when the sporophylls begin to appear—are *transversely* stretched. Remember that the young and sterile frond of this species may have the blade 10–20 meters in length and 20–30 cm. in breath, and when nearly matured the blade is fully one meter broad. This shows that the blade, after it has completed or nearly completed its growth in length, must extend its breadth with an astonishing speed. More stretching in the transverse direction than in the longitudinal, is naturally to be expected. This is indicated by the disposition of the epidermal cells and by the transverse stretching of the glands.

SETCHELL and GARDNER stated in their joint work, Algae of the North-western America, p. 276, that the stipe of *A. fistulosa* "seems to be free from mucilage ducts, but the blade in both forms (f. *stenophylla* SETCH. and f. *platyphylla* SETCH.) possesses abundant structure of this kind, just under the outer layer of cells, as GUIGNARD has indicated." But so far as I have examined Japanese material I could not find true mucilage ducts in the frond of *A. fistulosa*.

I will take this opportunity to say a few words on GUIGNARD's observation directly concerning this subject. He disproves the presence of the "cavité mucifére" in the frond of *Undaria pinnatifida* SUR. (= *Ulopterix pinnatifida* KJELLM. = *Alaria pinnatifida* HARV.). It will clearly be understood that the brownish spots frosted all over the blade of this plant did not attract his attention. He mentions two species of *Alaria*, *A. esculenta* GREV. and *A. grandifolia* J. AG., as lacking the mucilage canals. He did not examine the embryonal fronds of these species. Lastly, he points out the presense of "canaux muciféres trés gros et trés nombreux

dans toutes les parties de la lame" of *A. fistulosa*.[1] The remark by SETCHELL and GARDNER refers to these lines.

GUIGNARD's observation on the mentioned species have all been done on herbarium specimens. It is rather excusable that he has mistaken the mucilage glands of *A. fistulosa* as the mucilage lacunae, and overlooked the similar but smaller cells in the fronds of *Undaria pinnatifida*. His statement disproving the conclusion by KJELLMAN[2] that *Alaria* plants have no mucilage canals is therefore to be re-disproved.

In a fully matured frond of *A. ochotensis* YENDO the transition region is so rich in the roundish glands as to turn the part of the blade, when dried, into a dark reddish-brown colour. In the upper part of the blade as well as in the membranous sterile part of the sporophylls, the glands are much elongated, furcated and armed with short lateral processes, and a few of them are often fused together (Plate XIX, figs. 2–3). The mucilage lacunae of *Laminaria* occur in some species, for example, *Laminaria angustata* KJELLM., in detached groups of incomplete network.[3] The mucilage glands of *A. ochotensis* approach in general aspect, though of course genetically differing from, the mucilage lacunae of *L. angustata*. It is too complicated for a fucosan reservoir.

The mucilage glands of the other species of *Alaria* have more or less fixed character in each. The three examples described above illustrate extreme cases of the primitive and well-developed state of the glands. Under the descriptive part some accounts of the gland of each species will be given, referring to the above remarks.

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1) GUIGNARD: Observations sur Appareil Mucilère des Laminariacèes, p. 43.
2) KJELLMAN: Handbok i Skandinaviens Hafsalgflora, p. 19.
3) MIYABE: Laminaria Industry of Hokkaido, Plate 29, fig. 5.

Monstrosities of the frond.

I. Duplication of blade. In one of the specimens of *A. tæniata* KJELLM. in the Herbarium of the Hokkaido Imperial University, Sapporo, one side of the blade is totally doubled, that is to say, two semi-blades are present on one side of the midrib. They are equal in shape and size and are symmetrical with the opposite, single semi-blade. A transverse section near the transition point shows the sheering of the medullary portion into equal parts at its marginal swelling. The semi-blade is duplicated from the ordinary crucial point between the midrib and the blade, with a narrow but roundish sinus in the section. The spanning cortex is found in the normal position but not newly formed for the inner side of the semi-blade (Plate XVI, fig. 4). The two semi-blades run parallel in the usual direction. They have the same thickness as the single semi-blade and all elements of the tissue are represented in due manner and proportion.

I can not find any evidence explaining the cause of this abnormity. In the transition region there is no symptom of deformation, there simply being two ridges instead of one to indicate the future development into two semi-blades. The terminal portion of the frond is eroded so that nothing can be induced therefrom.

KUCKUCK[1] has observed the duplicate blades in *Laminaria saccharina*. KILLIAN[2] also notes "Flügelbildung" of a blade in *Laminaria digitata*.

II. Ramification of Stipe. In *A. prælonga* KJELLM. and *A. lanceolata* KJELLM., we meet very often with a bifurcated stipe. The bifurcation always takes place, as far as our material shows,

1) KUCKUCK: Bemerk. zur Mar. Algenveg. von Helgoland, p. 248, fig. 18.
2) KILLIAN: Beitr. zur Kenntn. der Laminarien, p. 472, fig. 26.

at a point in the sporophyll-bearing region of the stipe, and is by the median plane. Judging from a very young frond which has a clearly divided stipe, the abnormity appears to have been caused by a certain influence at a point just below the transition point. The frond develops further adding a length to the stipe and thus shifting the affected point further below the transition point. In all specimens with such abnormity the two arms are nearly parallel with very narrow sinus and have equal values. The sporophylls may be found on the outer edges only of the two arms or on both edges as well, and also below the furcation (Plate IV, figs. 4, 5). Similar cases have also been reported by SETCHELL[1] on *A. esculenta* GREV., collected by COLLINS on the coast of New England. In some examples the sporophylls are not particularly different in number and size from the normal form, but in many cases, only a few of them, very irregular in size, are to be found.

The blades on the two arms are not especially smaller than the normal ones. In one case, however, one of the two blades was destitute of its inner half, in spite of the midrib being as broad as that of the complete blade.

III. Other monstrosities. Besides the two kinds of monstrosities mentioned above there are various examples of deformation, but of less importance. One of the common cases is the spiral twisting of the sporophylls. This is undoubtedly caused by a checking of growth in one side of a sporophyll while the other side develops at normal speed. It may be due to an internal cause in the tissue of the sporophyll or by an animal feeding on the plant. In the Holosoria the spiral turning is mostly found at the terminal portions of the sporophylls.

Bifurcation of a sporophyll is also not rarely met with. An

1) SETCHELL: Regeneration among Kelps, p. 149.

upper portion of a sporophyll divides into two segments with broad and round sinus. The resultant segments are sometimes of equal value, but sometimes one of them appears as if ramified from the other.

Species which have in normal condition smooth blades, may sometimes be found with transverse corrugation along both sides of the midrib. Examining closely we find generally in such case numerous parasitic crustacea, mostly of species belonging to Gammaridæ, living in the midrib. The little creature digs a labyrinthic tunnel through the medullary and subcortical tissue of the midrib. This causes the retarding of the growth in length of the midrib. As the blade is in no way infected by the parasite, the unequal speed of growth in length of the two parts results only in the corrugation.

Development and Life History of *Alaria*.

The recent investigations on the embryonal stages of *A. esculenta* GREV. and some species of *Laminaria* by DREW,[1] KILLIAN,[2] SAUVAGEAU,[3] etc., have greatly changed the view hitherto held by modern botanists on the life history of the Laminariaceous plants. We are now aware that the zoospores liberated from the unilocular sporangia of the sori of the Laminariaceæ do not directly develop into the well known, large forms of fronds, but germinate into microscopic protonema-like bodies. The latter are sexual and dioeceous, *i. e.*, either male or female gametophytes. From the oogonium an embryonal frond starts which may develop into the large form commonly known as a Laminariaceous plant. Thus in

1) DREW: Reproduction and Early Development of *Lam. digitata*.
2) KILLIAN: Beiträge zur Kenntn. der Laminarien.
3) SAUVAGEAU: Sur les plantules de quelque Laminaires.

the species investigated, very probably in all members of the Laminariaceæ, there is an alternation of generation with the conspicuous asexual form and the microscopic sexual.

When I[1] described *Hirome undarioides* as a new species, I expressed the view that the plant stands as an intermediate form between *Undaria pinnatifida* SUR. and *Laminaria radicosa* KJELLM., in its habit, texture and propagating organs; and that an explanation of the genetic relationships between them may be facilitated if hybrids of Laminariaceous species have been proved possible. In the specific determination of other members of Laminariaceæ the same is to be observed. The late discovery is from this point of view highly interesting and important.

The early embryonal stages of the fronds of the Laminariaceous plants have also been carefully studied by DREW,[2] and by KILLIAN[3] on *Laminaria digitata*, by SAUVAGEAU[4] on *Laminaria saccharina*, and by myself[5] on *Costaria Turneri* and *Undaria pinnatifida*. Of the later stages, there are works by BARBER,[6] SETCHELL,[7] REINKE,[8] MCMILLAN,[9] GRIGGS,[10] KYLIN,[11] etc., on various species. By these studies our knowledge on the development of the frond of Laminariaceæ has been much amplified than in before. There remain, however, some points for further study on the life history of various species, if not of the majority. The question

1) YENDO: Three New Mar. Algae from Japan, p. 102.
2) DREW: Reproduction and Early Development of *L. saccharina* and *L. digitata*.
3) KILLIAN: Beiträge zur Kenntn. der Laminarien.
4) SAUVAGEAU: Sur les Plantules de quelq. Lam.
5) YENDO: Development of *Costaria*, etc.
6) BARBER: On the Structure and Development of the Bulb in *L. bulbosa*.
7) SETCHELL: On the Life History of *Saccorhiza*.
8) REINKE: Studien z. vergleich. Entwicklungsgeschichte der Laminarien.
9) MCMILLAN: Observation on *Pterygophora*.
10) GRIGGS: Juvenile Kelps and the Recapitulation Theory.
11) KYLIN: Über den Generationswechsel bei *Laminaria digitata*.

whether *Alaria* sheds its blade periodically, for instance, appears to me to be yet unsettled.

The gametophyte stages of *A. crassifolia* I have also studied from living material collected in the field. Owing to a considerable number of strangers always associated with the sporelings of the plant, it was not easy matter to trace the stages of development in a satisfactory manner. The sterile fronds of *Microsphar*(?), *Myrionema* and *Ectocarpus*, which are found growing with the sporelings, have been especially embarassing. Unfortunately I could not find any sporophyte directly starting from a gametophyte.

The earliest stage of development of the sporophyte which I observed was two-celled (Plate XVIII, fig. 4). The lower cell was cylindrical, measuring 8μ in diameter about 26μ in length with the basal end slightly crooked. It had no special content except fine granules and colourless plasma. The upper cell was similarly cylindrical with roundish apex, and measured 9μ in diameter, 26μ in length. Disc-shaped chromoplasts compactly lined the inner surface of the wall, and a few highly refracting grains were present. In both cells the nuclei were not visible before staining. As far as the blade is composed of a single layer of cells, the frond in a more advanced stage is essentially similar to that of the corresponding stage I have observed in *Costaria Turneri*.

In elucidating the development of *Costaria Turneri* and other Laminariaceous plants, I[1] have pointed out that:—the growth of the early embryonal, monostromatic fronds is mainly due to the activity of the subapical cells, and that of the later polystromatic fronds, to the activity of the transitional region. Killian's[2] observation on the development of *Laminaria digitata* agrees with mine

1) Yendo: Development of *Costaria*, etc., p. 713.
2) Killian: Beiträge zur Kenntn. der Laminarien, p. 447.

in the important points in this respect. He distinguishes a marginal meristematic tissue at the transition region of the post-embryonal frond, by virtue of which the blade increases in breath.

SAUGAVEAU[1] discredits the presence of any special tissue which functions for the increase of breadth of the frond and says:— "Le cloisonnement intercalaire dispersé est donc général; il entraîne l'accroissement en longueur et en largeur de la lame et il ne peut être question de méristème marginal." As far as I have observed in the development of various species of Laminariaceæ, the growth in length as well as in breadth of the post-embryonal fronds is due to the activity of the transition region. The region acts for the addition to the length of frond while in its younger stages, and then to the breadth. There is no specialization of tissue for either. The same region acts for both, but more or less separately in time. At the same time, however, it must not be overlooked that the whole part of the blade widens and thickens in itself by cell-multiplication. The areolar arrangements of the epidermal cells, and the changes of shapes of the mucilage glands according to the part of frond, give positive evidence of this fact. Certain differences in the rate of cell-multiplication may be found according to the parts. The undulation or crispation of the margins of the frond which is quite plane or less waving while young, is due to the greater rate of growth along the margins after the length of frond has been completed by the stipo-frondal growth. The transverse wrinkles along the midrib of *Alaria* and *Undaria*, the undulations in the fronds of *Costaria* and certain *Laminaria* may be explained in a similar way. The subulate and reflexed tips of the split segments of *A. angusta* (Plate XV, fig. 2) can hardly be interpreted unless a partial extension of the segments after the

1) SAUVAGEAU: Plantules de quelque Laminaires, p. 19.

splitting is admitted to have taken place (cfr. p. 11). Yet there is no doubt that the principal growth of the fronds, in length and in breadth, of the Laminariaceous algae results from the activity of the transition region, where the meristematic tissues are located.

Soon after the precortical layers make their appearance in the transition region, the embryonal fronds of *Alaria* begin to reveal some of the generic peculiarities in a primitive state, *i. e.*; 1), the mucilage glands frosted about the boundary between the monostromatic and the polystromatic area: 2), formation of the midrib. These two peculiarities can be perceived when a frond has attained the total length of 6-7 mm. In this respect the embryonal fronds of *Alaria* resemble those of *Undaria* most. Both are, however, distinguishable by the difference of germinating seasons, formation of the pinnules at the transition point and by the localities of the species. The embryonal fronds of *Undaria* appear early in January in northern Japan, and earlier in middle and southern, while those of *Alaria* are found in March–May. In *Undaria* the formation of the pinnules takes place at the transition region soon after the blade has grown to the length of 2 cm. or so. Species of *Alaria* are limited to the eastern coasts of northern Japan while *Undaria* is limited to the west coast of the Hokkaido and to both sides of the Main Island. But in the vicinity about the Tsugaru Strait, where *Undaria pinnatifida* and *A. crassifolia* occur living together, separation of the plants by the last mentioned point is of course unreliable.

The appearance of the sporophylls takes place in most species n June–July, varying according to the germinating time of the sporophyte frond. The first few sporophylls remain less developed in size when compared with the successive upper ones (Plate IX, fig. 1). New sporophylls come out continuously upwards on both edges of the stipe till the later part of spring. Those sporophylls

which appear early may be soriferous late in summer or early in autumn, but the liberation of the zoospores begins, on an average, in autumn between October and November. They then drop off from the petioles, leaving verrucose scars on the stipe. During winter, the upper sporophylls develop only a little. In early spring they begin to develop quickly and the sori on them ripen continuously until the entire frond is uprooted in the middle of summer. The sporophylls which are formed at a later period in the life of the frond remain undeveloped and must follow the fate of the frond, becoming useless before they can exercise their proper function (Plates IX and X).

How, then, does the blade pass through the winter? Does *Alaria* shed its blade periodically?

A. esculenta GREV. has been the subject of this discussion among the European algologists as the species is easiest accessible to them for observation. BÖRGESEN[1] wrote a paper specially devoted to the question and enumerates the views of many former writers. Beside those mentioned by him, DAWSON TURNER[2] remarks that *Fucus esculentus* is perennial, though he does not touch the subject in question directly. RUPRECHT[3] repeated the words "einjährige Exemplare" in describing the North Pacific *Alaria*. It may be taken as evidence that he believed the *Alaria* plant to live more than one year. SETCHELL and GARDNER[4] in their joint work report the presence of the "rings of growth" in the stipe of *A. valida*. ROSENVENGE[5] does not actually say that *Alaria* is perennial, but he illustrates the shedding of the old blades in his specimens.

1) BÖRGESEN: Note on the Question whether *A. esculenta* sheds its Lamina, &c.
2) TURNER: Historia Fucorum, Tab. 117.
3) RUPRECHT: Tange des och. Meeres, p. 355.
4) SETCHELL and GARDNER: Alg. N.-W. Amer., p. 278.
5) ROSENVENGE: On the Marine Algae from Northeast Greenland, p. 113, fig. 5.

Börgesen[1] discredits the annual shedding of the blade and sticks to the opinion that the blade of *A. esculenta* elongates continuously by stipo-frondal growth, its upper part wearing by degrees and so keeping nearly the same length. Phillips[2] and Oltmanns[3] are not very far from this view.

Summing up the statements of the previous writers, I understand them to be classifiable briefly as follows:—

(1). *Alaria* plant is perennial.

Turner: Historia Fucorum. (on *A. esculenta*). 1809.

Ruprecht: Tange des och. Meeres. (on *A. fistulosa* and *A.* sp.). 1850.

?Setchell and Gardner: Algae of N.-W. America. (on *A. valida*). 1903.

(2). *Alaria esculenta* is perennial and sheds its blade annually.

Harvey: Phyc. Brit., I. (sporophylls also). 1846.

Johnstone and Croall: Brit. Seaweeds, III. (Sporopylls also). 1859.

Areschoug: Observ. Phyc., V. 1884.

Kjellman: Handbok i Skandinav. Hafsalgflora, I. 1890.

Wille: Beitr. z. Physiol. Anat. der Laminariaceen. 1897.

Reinke: Stud. z. vergl. Entwicklungsgesch. der Laminarien. 1903.

Rosenvenge: On Mar. Algae from N.-E. Greenland. (on *A. grandifolia* J. Ag.). 1910.

(3). *Alaria esculenta* does not shed its blade periodically.

Phillips: Notes on *Sacc. bulbosa* and *A. esculenta*. 1896.

Börgesen: The Mar. Algae of Faeröes. 1904.

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1) Börgesen: Note on the Question whether *A. esculenta* sheds its Lamina, &c.

2) Phillips: Notes on *Sacch. bulbosa* and *A. esculenta*.

3) Oltmanns: Morph. und Physiol. der Algen.

BÖRGESEN: Note on the question whether *A. esculenta* sheds its Lamina periodically or not. 1904.

OLTMANNS: Morph. und Physiol. der Algen. 1904.

In various herbaria in Europe which I have visited, there was no specimen of *Alaria* to give any evidence in support of the view that the plant is perennial and sheds the blade periodically. I have seen a single specimen with a constriction in the blade in the Herbarium of Trinity College, Dublin. The specimen was collected by NOLT and sent from SONDER under *Laminaria Noltii* AG. At the constricted point the blade becomes quite narrow, measuring but a few millimeters on both sides of the midrib. From this point the blade expands to its normal breadth, more or less abruptly upwards and comparatively gradually downwards. The substance of the blade in the two parts has no marked difference, therefore not justifying the view regarding the upper part as having grown at quite a different season from the lower. The midrib is in substance, thickness and breadth uniform throughout the whole length. The statement made by HARVEY in Phyc. Brit., Plate 79, about the regular change of the blade of *A. esculenta*, however, seems not to have been derived from this specimen.

ROSENVENGE[1] gives photographs of two specimens of *Alaria* from Greenland, each with a remnant of the old blade at the top of the new. They may be taken as full proofs of the renewal of the blade of *Alaria* but not of the perennial existence of the plant.

On the coasts of Japan, most *Alaria* attain their full maturity in summer. The species which inhabit the comparatively warmer waters, such as *A. crassifolia* and *A. prælonga*, discharge the spores during July–August with the utmost vigor; and the fronds are entirely washed away from the substrata before the end of

1) ROSENVENGE: On the Mar. Alg. from N.-E. Greenland, p. 113, fig. 5.

September. How the zoospores behave after they are freed from the sporophylls is not satisfactorily known to me.

The question whether the zoospores of the Laminariaceous plants rest for a certain period after liberation, or germinate soon and pass a considerable time in the state of a protonema-like body, is not yet satisfactorily solved. The young sporelings of *A. crassifolia* are met with between March and May. Late in March, on the coasts about the Tsugaru Strait, bunches of embryonal fronds of this species may be found on rocks, barnacles, mussels, other larger algae or on the sheaths of *Potamilla myriopus* in the sublittoral region. Taking one of these bunches we find some fronds already as large as 30–50 cm. in length while some are microscopic, and even protonema-like gametophytes are still associated with them (Plate XVIII, figs. 1–3). This lack of uniformity in the time of outsprouting may perhaps be due to the fact that the spores are discharged during a considerable range of time, as the sporophylls attain their maturity successively from the lowermost upwards, and eventually the spores from the basal sporophylls develop earlier than those from the upper ones. At least in *A. crassifolia*, the maturing of the sporophylls takes place twice in the life of the plant. I will treat of this further below. The other species found in colder waters, *i.e.*, in the northern part of the Kurile Islands or in Sakhalin, are very likely similar in this respect. Their fully matured fronds are found during August–September, and the sporelings are mostly met with in April–June. According to KJELLMAN,[1] the blade of *A. grandifolia* is shed at Spitzbergen in winter. ROSENVENGE[2] observed the same in north-eastern Greenland.

1) KJELLMAN: Spitzbergens Thallophyter, II, p. 11.
2) ROSENVENGE: On the Mar. Alg. from N.-E. Greenland, p. 114.

The first-year fronds of *Alaria* found in summer have generally much narrower and thinner blades when compared with the second-year ones. Some of them may have small sporophylls which become soriferous and discharge the spores late in autumn.[1] The thin and narrow blade is worn away for the greater part of its length.

In the following year, during March and April in the warmer parts and gradually later in the colder north, the blade begins its sudden growth, and sporophylls of normal size make their appearance above the smaller ones of the preceding year, quickly increasing in number successively upwards. The sporophylls of the preceding year drop off one by one from below, leaving verrucose scars on the stipe (Plate X). The blade now built up is thicker in substance and darker in colour than that of the preceding year. The sporophylls attain their full maturity in the latter part of spring and then the life of the plant terminates within a few months. Thus it exists for two whole years, but not longer.

The life history alluded to above holds good, as far as I could find, for all species found within our boundaries. Even such a gigantic form as *A. fistulosa* shows only a slight modification if any. The marvelous size of the blade of this species is therefore nothing but the result of the speedy growth during 5–6 months.

As far as I could refer to, full evidence for the perennial life of the *Alaria* plants has never been positively given by any algologist, although there have been many who describe them to be perennial. WILLE[2] relates:—"Dass im Stipes ein sekundäres Längenwachstum vor sich geht, jedenfalls oben und bis unterhalb der ältesten Sporophyllen, konnte mit Sicherheit an Exemplaren nach-

1) WILLE: Beiträge z. physiol. Anatom. der Laminarinceen, p. 16.
2) WILLE: l. c.

geweisen werden, welche drei Reihen von Sporophyllen hatten und somit wenigstens vier Jahre alt gewesen sein mussten, da man wohl voraussetzen darf, dass Individuen von *Alaria esculenta* (L.) GREV. keine Sporophyllen erzeugen, bevor sie wenigstens ein Jahr alt sind." There is no doubt that the stipe of *Alaria* elongates by the secondary growth. But how the "drei Reihen von Sporophyllen" could be distinguished in a matured form of *A. esculenta* GREV. and how they could be applied for the estimation of the age of an *Alaria* plant, I have no idea.

BÖRGESEN[1] denies the periodical sheddings of the blade of *A. esculenta*. He states that "the leaf keeps on growing at its base during the greater part of the year, while the apex is continuously so to speak worn away by the waves." He seems to have omitted to mention the life-length of the plant. But it may be understood from what he states that he thinks the plant perennial. In The Algae-vegetation of the Färöese coasts he seems also to have said nothing about the stages of development of *A. esculenta* GREV. in different seasons, though he repeatedly touches on it in describing its habit. In explaining Plate XIX of the work, he writes:— among the *Himanthalia* are young *Alaria esculenta*, and ...." I should like to know how young they were, whether sporophyll-bearing or not. I agree of course with BÖRGESEN in denying the periodical shedding of the blades of *Alaria*, if he means by periodical more than once in the whole life of a plant at certain fixed intervals. It is a fact with our species of *Alaria* that the first-year blade is for the greater part worn away during the winter and only a certain portion remains to be shed in the next early spring. The second-year blade generally begins its growth with less breadth than the base of the first-year blade and so the

1) BÖRGESEN: Note on the Question whether *A. esculenta* sheds its Lamina &c., p. 200.

demarcation between the two parts is never difficult to recognize. The illustrations of the Greenland specimens given by ROSENVENGE referred to above, point to this stage. As the remnant of the first-year blade is worn away as soon as the new blade has started, at least on our coasts, a favorable opportunity must be caught to observe the actual alternation of the blades. ROSENVENGE observed on the coast of Greenland that the lower part of the old blade of *A. grandifolia* J. AG. remained still unworn in summer.

BÖRGESEN[1] has discredited the observation by WILLE[2] who writes, "dieses Endblatt fällt jeden Herbst ab und wächst von neuem heraus im Lauf des Winters." He confesses that he has "only seen specimens from April to August and from October to December:" and he fills up this gap with observation on the plant by Mr. R. RASMUSSEN, Director of the Faeröese High School. It is very much to be regretted that he had no winter specimens, indispensable forms for making a conclusive remark on the problem.

Granting the view of BÖRGESEN as established from his observations on the Faeröese Islands and strengthened by RASMUSSEN's note, and as true for *Alaria* plants in the North Atlantic, the difference between his view and that of the others may be condensed to the question whether the renewal of the blades of *Alaria* is gradual or sudden. It will be wisest to answer the question thus:—"the renewal of the blades of *Alaria* may be gradual or sudden according to the conditions of the place where the plant grows." Still it is true that there is more evidence of sudden growth of the blade at a certain time of the year, than of the uniform speed of growth throughout the whole year.

I will here take this opportunity to relate briefly the life

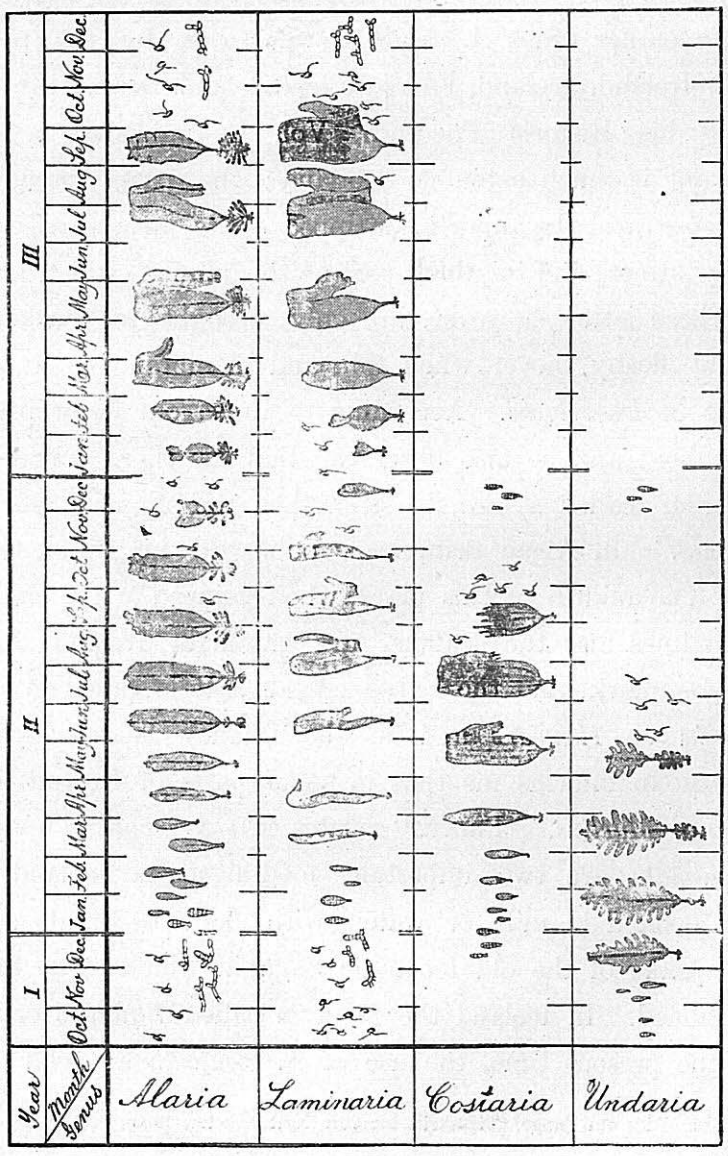
1) BÖRGESEN: Mar. Algae of the Faeröes, p. 450.
2) WILLE: Beitr. zur Physiol. Anat. der Laminariaceen, p. 7.

history of Japanese species of *Laminaria* compared with that of *Alaria*. European botanists unanimously describe the annual sheddings of the blades of *Laminaria digitata*, *L. hyperborea*, *L. saccharina*, etc., some believing and some assuming the plants as perennial. As far as I could understand from the accounts of these three species, there seems to me no actual proof to warrant the assumption that their life-length is more than three whole years. It may live over two winters, but not three.

About 16 species of *Laminaria* are found on the coasts of Japan. Some of them are of great value for domestic use and export, and their life history and various other points have been closely studied. According to my own observations on *Laminaria japonica* ARESCH., *L. angustata* KJELLM., *L. ochotensis* MIYABE and *L. longissima* MIYABE, the discharge of spores from matured sori takes place, as a rule, between August–November. The sporelings, undoubtedly germinated from these spores, make their appearance during January–February of the next year. The first-year blade at its full length in July–September is known to the fishermen as "mizu-kombu" (water laminaria) on account of its soft and thin substance. It may or may not be soriferous at the end of the same autumn. Before the winter, the greater part of the blade is worn away and the entire frond practically ceases to develop further. In the early months of next year, the transition region is very active to form the second-year blade which is abruptly and considerably broader when compared with the first-year blade. The latter does not remain long upon the new blade, being only occasionally found by collectors. The second-year blade now increases in length with enormous speed, so quick in *L. longissima* as to elongate 70 feet or more in less than 5 months. In July–August the blade becomes soriferous and before the end of October

the whole frond is washed away from the substratum. There is, therefore, very little difference in the life histories of *Laminaria* and *Alaria* on our coast.

The figure shown below is a diagram to indicate the life histories of *Alaria*, *Laminaria*, *Costaria* and *Undaria*, as found on



our coasts. It may give some help to understand what has been alluded to above.

Economic Use of *Alaria*.

The economic value of *Alaria* plants can not be spoken of as great. In earlier times *A. esculenta* was eaten by the people of Scotland, Ireland, Iceland, Faeröese Islands and Denmark. TURNER writes in his Historia Fucorum, Vol. II, published in 1809:—"This plant is much eaten in Scotland; the parts employed for that purpose are the midrib, stripped of its membrane, which is extremely sweet, and the thick part of the pinnae, which are called *Keys*. These latter, however, are only brought to market when thick and fleshy, never when thin and membranous. It goes by the name of *Daberlocks*. According to LIGHTFOOT its proper season is September; and he also observes, that it is recommended in the disorder called a *pica*, to strengthen the stomach and restore an appetite." In Algae Britanicae, published in 1830, GREVILLE says:—"The midrib of this plant, when stripped of the membrane, and sometimes also the leaflets, are eaten in Ireland, Scotland, Iceland, Denmark, and the Faroe Islands. It is called in Scotland *Badderlocks* or *Henware* and in the Orkney Islands *Honeyware*. Dr. DRUMMOND informs me that in some parts of Ireland it bears the name of *Murlins*." PRINTZ[1] relates that *A. esculenta* and *Rhodymenia palmata* are two important food-algae in Iceland, where they are cooked in milk or water with flour or groats added to it. He speaks of the old Icelandic Saga in which these seaweeds are mentioned. In Iceland the plant is called *Bladtare* or *Butare*.

At the present time, the use of *A. esculenta* as food appears

1) PRINTZ: Lidt om Tange, (Tidsskrift for vore Nyttevækster, 1908).

to have been abandoned in Europe, except in small localities. The Alaskan aborigins still appreciate, as I have been told from a Siwash chief, the matured sporophylls of *A. marginata* and other larger forms as a delicacy. I have seen the natives of Kamtschatka eat the midribs of *A. fistulosa*. This has been already noted by RUPRECHT in Tange des ochotischen Meeres, p. 355 (1848). He says:—"Nach WOSNESSENSKI ist sie (*A. fistulosa*) den Kamtschadalen (bei Javina), welche die Blattrippe essen, als « Kdusschisch » bekannt, *Ph. alatum* in derselben Gegend und in Petropawlowsk als « Kauam » oder « Kauan » : letztere wird gekocht ganz und mit verschiedenen Beigaben verspeist, die Blattrippe aber roh."

In Japan, where numerous species of seaweeds are used for food and other purposes, a considerable amount of *Alaria* is left unused. This is principally due to the fact that other brown algae, such as *Laminaria* and *Undaria*, much better in taste, consistency, etc., are found in association with it. The Ainu in the southern Kuriles frequently use the matured sporophylls as food.

As a source of kali or iodine, the *Alaria* plants are not entirely useless. The following table gives some of the analyses by TURRENTINE[1] and by MIYAMA and KAKIHARA.[2]

Species	Location	Potash (K_2O)	Iodine (I)	Pot. Chlor. (KCl)
A. valida	San Juan County	9.2	0.08	14.5
lanceolata ?	Symonds Bay	3.0	0.12	4.7
lanceolata	Sitka	3.4	trace	5.4
fistulosa	Kuriles	11.53	0.010	—
sp.	Sakhalin	4.97	0.024	—
prælonga	Akkeshi	7.78	0.125	—
prælonga	Hamanaka	8.26	0.070	—

1) TURRENTINE: The composition of Kelps, p. 220.
2) MIYAMA and KAKIHARA: Reports on the Kali Resources, p. 18.

Compared with other species of Laminariaceæ, the valuable contents, iodine and kali, are comparatively poor in *Alaria*. The kelp-burning of *Alaria* might pay fairly well only in such an extraordinary time as during this great war, when the market price of kalium chloride has become more than ten times as high as in ordinary days. The value of *Alaria* as a resource of kelp is much discounted by the fact that wherever *Alaria* plants grow, there are also found other Laminariaceous members which are richer in iodine and kali.

In short, *Alaria* plants have very little value as human food or for kelp-ash. For manure they may be used equally well as other brown seaweeds, such as *Sargassum*, *Fucus*, etc.

Distribution and Habitat.

All species of *Alaria* are inhabitants of the northern colder seas. The greatest number of species are found within a range from about 42° N up to the arctic circle. On the Pacific coasts, its southern limit is at Kinkwasan Island (38° 17′ N) on the west side (*A. crassifolia*) and about the middle part of California (37° N) on the east (*A. marginata*). On the west side of the Atlantic, no record of *Alaria* is known south of Cape Cod (about 41° 30′ N) where *A. Pylaii* Grev. occurs; and on the east, *A. esculenta* Grev. finds its southern limit on the coast of France (about 45° N). In the Baltic Sea, *Alaria* is entirely wanting within the Kattegat.

In Japan, *Alaria* is found on the Pacific as well as on the Ochotsk coast. No species occurs in the Japan Sea. It may intrude into the Sea a short distance only through the two entrances, the Tsugaru Strait from the Pacific Ocean, and the Soya Strait from the Ochotsk Sea.

The absence of *Alaria* in the Baltic Sea and in the Japan Sea is not to be explained as parallel examples due to similar physical conditions. Within the Kattegat the salinity and temperature lower quickly towards the Baltic Sea. In the Japan Sea, on the contrary, both show higher figures than on the Pacific coast, as can be seen in the following tables.

I. Mean annual temperatures of sea-water at various parts of Hokkaido.

	Pacific coast			Tsugaru Strait		Japan Sea coast			
	Nosappu	Akkeshi	Erimo	Esan	Fukuyama	Inao	Suttsu	Kamui	Takashima
1911	6.6	5.9	5.6	10.3	13.8	12.9	11.8	11.1	11.6
1912	5.1	5.1	5.0	9.0	13.5	11.8	11.3	11.1	10.9
1913	4.4	4.6	6.4	8.1	12.4	10.7	10.5	9.5	10.2
1914	5.9	7.1	7.9	10.0	14.4	12.6	12.1	10.7	12.2
1915	5.4	6.0	7.1	9.8	13.9	12.2	11.3	10.2	11.8
1916	6.6	6.8	8.1	10.6	14.3	12.8	12.1	11.2	11.9

II. Mean annual density of sea-water at various parts of Hokkaido.

	Pacific coast			Tsugaru Strait		Japan Sea coast			
	Nosappu	Akkeshi	Erimo	Esan	Fukuyama	Inao	Suttsu	Kamui	Takashima
1911	1.0239	1.0236	1.0235	1.0244	1.0255	1.0251	—	1.0255	1.0251
1912	241	237	235	242	256	253	—	252	250
1913	241	238	239	243	256	251	—	248	246
1914	244	242	242	248	256	254	—	247	246
1915	244	243	234	245	255	252	—	245	247
1916	243	241	237	248	257	255	1.0249	249	252

In the above cited tables the localities are arranged from the eastern end of Hokkaido (Yesso Island) towards the west along the southern coast, then passing the Tsugaru Strait, towards the

north. Several species of *Alaria* are found about Nosappu, a few about Akkeshi and Erimo, and one about Esan. At Fukuyama, which stands at the western end of the strait or at the entrance of the Japan Sea, usually no *Alaria* is found. At the above mentioned places on the Japan Sea *Alaria* has never been collected.

Thus on the coast of Hokkaido where *Alaria* exists, the water temperature is never above 11° C, and where it is entirely absent the temperature is higher than that except in an unusually cold year. The salinity of water is generally less on the *Alaria*-existing coast than on the other. That the lesser density of the water is not an important factor for the existence of *Alaria* may be observed from the fact that Nosappu, where more *Alaria* in species and in number are found, has stronger salinity than the other two places. This view may be more emphatically expressed when we compare the Baltic and the North Sea.

The minimum temperature of seawater is much lower on the Pacific coast of Hokkaido than on the Japan Sea side. At Esan no record of water temperature below 0° C is known. At Erimo in December–February it goes below this point very frequently, and floating ice carried from the north-east is not infrequent there. On Feb. 26, 1915, −3.8° C has been recorded. On the coast farther north-east of Erimo the temperature is still lower in winter time and the shore is usually blockaded with a thick ice sheet during December–February. At Nosappu, on March 7, 1914, the water temperature near the surface went down as low as −11.0° C.

In the Baltic Sea the freezing of the seawater along the coast is general during winter.[1] It may take place on the Swedish coast of the Kattegat. The Danish coasts and the open coasts of southern Norway which are washed by the Bank Water and the

1) Kylin: Studien über die Algenflora der Schwed. Westküste, p. 207.

North Sea Water[1] respectively, are free from ice. From the data above stated we perceive that the physical conditions of the regions mentioned of the North Atlantic and of the North Pacific are just opposite in relation to the existence and non-existense of *Alaria*. This apparent contradiction, however, may be easily explained when we consider the origins of the waters of the Baltic Sea and the Japan Sea.

The Baltic Sea may be compared with, or regarded as, an extensive lake communicating with the Atlantic Ocean through the Skagerak and Kattegat. The Sea is supplied with freshwater from innumerable rivers. The ocean water known as the Jutland Current intrudes into the Sea along the Danish side of the straits. The mass of the intruding water is by no means large enough to have an influence upon the physical characters of the Sea. The water of the Sea is practically supplied by freshwater streams, the greater number of which originate in the colder regions. *Alaria*, which is an open-sea inhabitant, can never intrude into, or exist in, such a freshwater lake. Especially the Swedish side of the strait is washed by this *Alaria*-lacking water.

The Japan Sea has two main currents. The more influential one, known as the Tsushima Current, is a branch of the Japan Current and runs into the Sea through the Tsushima Strait, travelling towards the north-east along the west coast of Japan. Through the Tsugaru Strait a minor branch goes out into the Pacific Ocean close along the southern shore. The remaining part continues to proceed northward as far as the Soya Strait where it ramifies again into two parts, the major one bending eastwards through the strait and the minor one keeping the original course intruding into the Strait of Tartary.

1) Hjort and Gran: Hydrographic-Biological Investigations.

The other current, known as the Tartar Current, is less influential in comparison with the Tsushima Current. It has its origin at the Strait of Tartary and runs south-westwards along the continental shore. This stream has a lesser salinity and a colder temperature as may be easily understood from the fact that Vladivostock harbour is closed up by thick ice during winter while Otaru Harbour on the same latitude has never suffered from that trouble.

A certain amount of the water of the Pacific and of the Ochotsk Sea flows into the Sea along the northern sides of the Tsugaru Strait and the Soya Strait respectively. But these inflowings have little influence on the physical conditions of the Sea, compared with the influence of the Jutland Current along the Danish coast upon the Baltic Sea.

The Tsushima Current which supplies, as it were, the principal part of the water of the Japan Sea is a branch of the Japan Current. The latter has its origin in the north equatorial current and is tropical in its nature. As it travels north-eastward it deposits the spores of the tropical algae on the coasts of southern Japan and also carries the spores of the inhabitants of the latter further northwards. *Alaria* is neither a tropical nor a subtropical plant. The Japan Current and its branch carry, therefore, *Alaria*-lacking water into the Japan Sea.

The non-existence of *Alaria* in the Baltic Sea and the Japan Sea may now be easily explained. The two seas have no source from which *Alaria* may be carried in, and they are not birth-places of the plant.

Alaria Pylaii Grev. which is an inhabitant of the north-eastern coast of North America has been recorded, though with some doubt, from Spitzbergen. Thus the species may be taken

as a representative of the colder waters of the North Atlantic. Its occurrence in Puget Sound and the Alaskan coasts,[1] detached and isolated localities for the distribution of the species, requires a careful revision. If it could be proved positively, the species would be the only one common to both the Atlantic and the Pacific Ocean.

Excepting the doubtful species above mentioned, each species has a more or less fixed area of distribution. Out of 15 species ennumerated in this Monograph, 3 species are from the North Atlantic coasts and 12 from the Pacific. The Arctic Sea can by no means be said to have been thoroughly explored. Yet it is known that *A. grandifolia* J. AG. flourishes luxuriantly about Spitzbergen and *A. Pylaii* GREV. may very likely extend there. In the Siberian Sea, *A. dolichorhachis* KJELLM. is found, and this species is known to extend into the North Pacific through Bering Strait. From the Arctic coast of Alaska only one record of *Alaria* has been known. The record is based upon one of RATHROCK's sketches of algae determined by HARVEY as *A. esculenta*. In HARVEY's time the specific limitation of *A. esculenta* was much broader than at present, so the accuracy of the sketch is rather to be doubted. Yet it gives an evidence that certain species of *Alaria* exists on the Arctic coast of Alaska.

It is a noteworthy fact that many of the species of the North Pacific have very limited areas of distribution, while the North Atlantic species, though few in number, have much wider distribution. In the Pacific, *A. fistulosa* has the widest range of distribution, extending from the South Kuriles towards the north-west up to Dall Island. Several others are quite local in occurrence. A comparison of the distribution in the Atlantic and the Pacific is especi-

1) Reported by SAUNDERS under *A. fragilis*.

ally interesting when we refer to the debate of Börgesen *v. s. v.* Porsild and Simmons concerning the characters of the marine flora of the Faeröes. But there seems no need to reopen this discussion.

The following table is prepared after consulting the former records to show the distribution of the 15 species. The reader has to be cautioned that in the species of *Alaria* there are yet uncertain points regarding their exact limitations.

	North Atlantic			Arctic		E. coast of Asia.		W. coast of N. Amer.	
	North Atlantic Islands	W. coast of Europe	E. coast of North America	Spitzbergen	Siberian Sea	Ochotsk Sea and Sakhalin	E. coast of Kamtschatka, Kuriles and N. Japan	Alaska to Vancouver Island	Vancouver Island to California
A. esculenta	+	+	+	....	....	....	....	....	....
Pylaii	+	....	+	+?	....	....	....	+	....
grandifolia	+?	....	....	+	....	....	....	....	....
tæniata	....	....	....	....	....	....	+	....	....
lanceolata	....	....	....	....	....	....	+	....	....
ochotensis	....	....	....	....	....	+	....	....	....
prælonga	....	....	....	....	....	....	+	+	....
macroptera	....	....	....	....	....	+	+	....	....
crassifolia	....	....	....	....	....	....	+	....	....
fistulosa	....	....	....	....	....	+	+	+	....
nana	....	....	....	....	....	....	....	+	....
valida	....	....	....	....	....	....	....	+	....
marginata	....	....	....	....	....	....	....	+	+
angusta	....	....	....	....	....	....	+	....	....
dolichorhachis	....	....	....	....	+	....	+	+	....

The observations on the nature of the Baltic Sea and the Japan Sea relating to *Alaria* lead us to think about the center of distribution of the genus. From the above table showing the distribution of the species, considered together with the nature of the currents which wash the localities, we are able to safely state that the localities are directly or indirectly washed by the Arctic waters.

We know very little of the algal floras of the Siberian Sea and the American Arctic Sea. How many species of *Alaria* may be found in the regions and in what state of growth they may flourish, is not satisfactorily reported. There are reasons, however, to assume that we may not expect many species from there. Yet the supposition that the north circumpolar regions might have been or may be the center of distribution of *Alaria* has some probability.

Starting from the above assumption I venture to say :—*Alaria* had its origin in the North Circumpolar Sea and migrated southwards into the Pacific and the Atlantic Oceans as far as where the Arctic currents terminate; the initial form gradually diverged into the various present species which flourish in a most vigorous state about the southern limits of the Arctic currents.

In general, the formation in which *Alaria* plants are habitually found is the sublittoral. They prefer the exposed coasts of steep rocks. Very frequently they form a narrow belt fringing the low water mark or within a few feet below it. Usually, however, they are associated with other algae, almost invariably with other Laminariaceous members, and may thrive to a depth of 4–5 fathoms below the low water mark.

The sporelings of *Alaria* germinate, except in the extreme north, in early spring. They are found in great abundance on rocks, mussels, larger algae, etc., immediately below the low water mark. A few months later, during the spring tide just following the vernal equinox, the water ebbs so as to expose these sporelings and young shoots to the strong heat of the sun. The majority are destroyed on this occasion, though many other plants adapted to such conditions may survive well. This is undoubtedly the cause why *Alaria* plants are found at a certain depth below the ordinary

low water level, the depth varying according to the tidal range of the locality.

Up in the north, the germinating season is undoubtedly later than in the south. The influence of the sun's heat upon the algae at low tide is not sufficiently intense to harm them. Here the plants may be found still flourishing, but not so well as in deeper water, just above the water level during the lowest spring tides. On the west coast of Vancouver Island, where the tidal range is as great as 25 feet at spring tides, the *Alaria* plants, as well as other Laminariaceous members, are exposed to the air at ebb-tide hours. This region is well known for the rich moisture in the air during summer, so that mist and fog prevail for several hours almost every day. The luxuriant growth of *Alaria*, which is properly a sublittoral inhabitant, between the tidal marks in this region is very likely due to this climatic circumstance. In the southern parts of Kamtschatka and in the North Kuriles, parallel examples might be met with.

Börgesen observes at the Faeröese Islands that *A. esculenta* is found as high as several feet above the lowest water mark at several places, as the dashing waves can irrigate the place. This is also the case with other places in the world and with some other species of algae. It is one of the ecological characters common to those algae which are inhabitants of the lowest littoral region and adapted to confront the surfs.

It is well known to the field algologists that *Alaria* plants are rarely found in quiet bays or in tide pools. An observation on the tide pool flora made by Miss Skinner[1] on the west coast of Vancouver Island is highly suggestive and may contribute a positive record for this fact. She studied eight tide pools of various

1) Skinner: Observ. on the Tide-pool Veget. of Port Renfrew, p. 153.

sizes and various heights above the low water mark, on a ridge of rocks which jutted into the sea sixty feet and was about thirty feet across its widest point. Pool No. I at the highest level was about 15 feet above the low water mark; and No. VIII at the lowest was nearly at the low water mark. No specimen of *Alaria* was found in the pools higher above the mark, and a few plants (species undetermined) were found "on the bottom in exposed position" of pool No. VIII. From the result obtained by her, and after consulting the floral features of the region, it is ascertained that *Alaria* plants can not properly exist in quiet places, however well it may be supplied with new water by constant irrigation. HARVEY[1] remarked on *A. esculenta* :—"The roughest water seems to be most favourable to its existence." This is true for *Alaria* in general.

A few exceptional examples to the general statement above given, however, may also be mentioned. BÖRGESEN[2] observes on the Faeröese Islands that *A. Pylaii* seems to prefer somewhat sheltered coasts, and KJELLMAN[3] also reports its occurrence in tide pools of the littoral formation in the Norwegian polar sea.

Describing the habitat of *A. grandifolia* J. AG., KJELLMAN[4] says:—"The species is sublittoral, living generally at a depth of 2–15 fathoms. It is met with in the interior of deep bays as well as on exposed coasts, in the latter case near the shore, sometimes, when the bottom is favourable, several miles off. It is on rocky bottoms that it attains its greatest size. Living sometimes alone in rather great numbers, sometimes in accompany with other *Laminariaceæ*, it constitutes an essential element of the formation of *Laminariaceæ* on the coasts of Spitzbergen and the west coast

1) HARVEY: Phyc. Brit., Plate 79.
2) BÖRGESEN: Algae Vegetation of the Faeröese Islands, p. 754.
3) KJELLMAN: Algae of Arctic Sea, p. 215.
4) Ditto, p. 217.

of Novaya Zemlya." This description may be almost word for word applied to the habitat of *A. fistulosa* in the North Pacific. The fronds of enormous breadth and length reach the surface of the sea and then bend horizontally; the hollow midrib serves as a buoy and the blade hangs down along it like a gigantic *Musa* leaf. A large number of the plant are usually found aggregated at some distance from the sea shore, choosing a suitable depth and substratum for growth. In the South Kuriles the favourable site is in waters of 5–7 fathoms depth and in the North Kuriles, a little shallower. It is told by seal hunters that the dense aggregation of the floating blades is a resting place for the sea-otters. According to SETCHELL and GARDNER,[1] its habitat on the coasts of north-western Alaska seems to be about the same. KJELLMAN[2] simply remarks that it is gregarious in the lower part of the sublittoral region of the Bering Islands.

The two examples mentioned above tell us the fact that the spores of these species germinate in a much deeper place than the others. This does not mean, however, that they choose a calm place for their existence. They are found, at least *A. fistulosa* as I have actually observed, in those places where the currents are unusually swift. Their anchorage in deeper water may be more probably an adaptation for their enormous length of frond, in analogy to *Nereocystis* or *Macrocystis*.

Systematic Position of the Genus *Alaria*.

The genus *Alaria* in the sense taken by modern algologists was established by GREVILLE in 1830 for *Fucus esculentus* L. Prior to this, the plant was mentioned, though not very precisely, under

1) SETCHELL and GARDNER: Algae of N. W. North Amer., p. 276.
2) KJELLMAN: Om Beringhafvets Algflora, p. 41.

Ceramium by STACKHOUSE in 1801, under *Musæfolia* by the same author in 1809, under *Laminaria* by LAMOUROUX in 1813, under *Orgyia* by STACKHOUSE in 1816 and under *Phasganon* by GRAY in 1821. RUPRECHT has given a lengthy discussion on the priority of the generic name for the plant in his Tange des ochotischen Meeres, p. 365, and he preferred the name *Phasganon* to others. GOBI in Die Algenflora des Weissen Meeres, p. 77, revived the *Orgyia* instead of *Alaria* and *Phasganon*.

Whatever the historical records of the plant may be, the name *Alaria* as a genus under Laminariaceæ is at present so widely adopted that any alteration would result but in confusion.

Which species of *Alaria* was first known to science, is also a much debated question. In current references *Fucus esculentus* in LINNÉ's Mantissa published in 1767 is mentioned to have been the first. RUPRECHT published the view that *Fucus alatus* described by CARGILL in 1720 is undoubtedly the plant that LINNÉ meant by *Fucus esculentus*, and should stand in place of it. He also points out that *Fucus pinnatus* GUNNER (1766) and *Fucus teres* GOOD. et WOODW. (1797) are to be synonymized under it. In his Tange des ochotischen Meeres, therefore, the name *Phasganon alatum* is adopted in stead of *Alaria esculenta*. GOBI mentioned *Orgyia pinnata* as a more legal name than these two. Researches of old literature and strict hold of the rule of priority might lead to the view of RUPRECHT or GOBI. The specific, as well as the generic names adopted by these two writers, however, are pre-Linnean and simply historical.

The thorough classification of Laminariaceæ we owe to SETCHELL's work published some twenty five years ago. He arranged the then known 19 genera of the family into tribes and subtribes according to the probable affinities, mainly based upon

the morphological characters. Since that time there have been added numerous species and genera to the family, counting today 29 genera including a few questionable or critical ones. Extended observations on the anatomy and the development of the frond have thrown much light on the family. SETCHELL's classification requires, therefore, additions and amendments on various points. REINKE's Studien zur vergleichenden Entwicklungsgeschichte der Laminariaceen, though a highly interesting and instructive paper, does not add much in this line to SETCHELL's view. According to SETCHELL, and adopted by REINKE, *Alaria* is most closely related to *Pterygophora* so that he has established for these two the subtribe Alarieæ under the tribe Alariideæ. Both are indeed sharply distinguished from all other co-families by having the sori on the leaflets situated upon the stipe alone.

Under the same tribe SETCHELL included *Undaria*, *Ecklonia* and *Eisenia* group, under the subtribe Eckloniæ. This classification is undoubtedly derived from his incomplete acquaintance of *Undaria* at that time, as he complained of the difficulty of getting its material for study. He also put too much stress on the marginal outgrowths from the blade of *Eisenia*.[1] Recent observations on *Undaria* by OKAMURA and by the present writer give ample evidence that it has less affinity with *Ecklonia* or *Eisenia*, while on the contrary, the genus has a very close relationship with *Alaria*.

The sori of *Undaria* develop on the wing-like outgrowths on both edges of the stipe and nowhere else. These outgrowths are practically enormous extensions of the edges. The ruffle-like undulations of the external margins result from the excessive growth in length in the marginal parts. These undulated sporophylls, as they are called, are at some distance below the transition region in

1) SETCHELL: Post-Embryonal Stages of Laminariaceæ, p. 129.

f. *distans* MIY. et OKAM., quite approximate in f. *typica* YENDO and confluent with in f. *narutensis* YENDO. Whatever the gradations may be in the separation of the sporophylls from the sterile blade, the essential difference between the sporophylls of *Alaria* and *Undaria* is in the degree of their differentiation. In the former they are separated into a number of petiolated leaflets[1] while in the latter they are continuous and directly confluent with the stipe edges. *Hirome undarioides* YENDO shows a step more primitive in this respect than *Undaria*.

Alaria, *Undaria* and *Hirome* have the true midrib. There are costated members among the family Laminariaceæ, such as *Agarum*, which, however, must by no means be regarded as standing near to them. *Pterygophora*, which is acknowledged to have the closest relationship with *Alaria*, is not provided with the true midrib. Yet its presence in the three named genera must never be passed over as merely incidental.

The mucilage glands, again, as far as has hitherto been observed, are limited to *Alaria*, *Undaria*, *Hirome*, and *Laminaria Peterseniana* KJELLM. The last mentioned species has neither midrib nor sporophylls. On the other hand, it has various peculiarities to be counted under the genus *Laminaria*. OKAMURA's idea to comprise it in *Undaria* together with *Hirome* is hardly acceptible before we have extended the limitations of the other genera of Laminariaceæ.

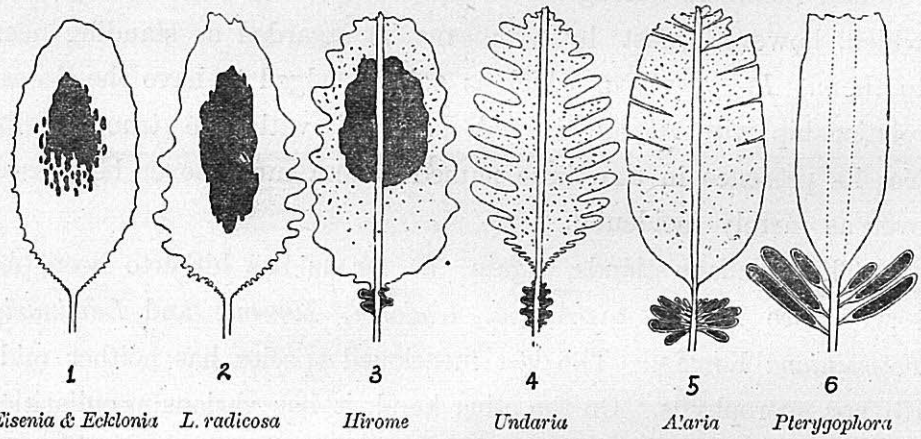
Leaving *L. Peterseniana* KJELLM. aside for the present, the three genera, *Alaria*, *Undaria* and *Hirome*, form a continuous series, and the genus *Pterygophora* stands near *Alaria* in another direction.

SETCHELL[2] holds the view that "the nature of the outgrowths

1) There are various degrees in separation of the leaflets; compare *A. Pylaii* (Pl. VII, fig. 1) with *A. macroptera* (Pl. II, fig. 1), and *A. angusta* (Pl. XV, fig. 1).

2) SETCHELL: Post-Embryonal Stages of Laminariaceæ, p. 126.

from the blade of *Eisenia* are certainly most important" in generic consideration of the Laminariaceæ. Upon this ground *Eisenia*, *Ecklonia* and *Undaria* are associated in the subtribe Eckloniæ under the tribe Alariideæ. If so, the marginal outgrowths of *Eisenia* and *Ecklonia* must be first compared with those of *Laminaria radicosa* KJELLM. The latter species shows in several points a certain affinity with *Hirome* and *Undaria*, and more indirectly with *L. Peterseniana* KJELLM. The relationship between *Eisenia* and *Alaria*, if any, should be considered as most indirect, placing *Laminaria radicosa*, *Hirome*, and *Undaria* between them.



A series of diagramatic figures to show the varieties of localization of sori in various genera of Laminariaceæ.

Synoptical Key to the Species.

1. Matured sporophylls entirely soriferous ..... I. Holosoria.
   A. Midrib interruptedly hollow.....*A. fistulosa* P. et R.
   B. Midrib thoroughly solid.
      a Blade finely corrugated in the upper part.
      Sporophylls dropped with petioles..*A. macroptera* (RUPR.)

Sporophylls dropped leaving petioles
on the stipe ..... *A. ochotensis.*

β. Blade smooth in the upper part.
Sporophylls linear ..... *A. prælonga* KJELLM.
Sporophylls cuneate ..... *A. dolichorhachis* KJELLM.

γ. Blade finely striated in the upper part ..... *A. marginata* P. et R.

2. Matured sporophylls bearing foliose sterile portions at the apices ..... II. Metasoria.

A. Sporophylls pinnate.

α. Sporophylls disposed at great intervals ..... *A. Pylaii* GREV.

β. Sporophylls disposed at regular intervals, except the lower ones.
Sporophylls very thick, almost terete ..... *A. crassifolia* KJELLM.
Sporophylls coriaceous with cuneate bases ..... *A. esculenta* GREV.
Sporoyhylls coriaceous, large, with obtuse bases ..... *A. valida* SETCH. et KJELLM.

γ. Sporophylls very much approximate.
Sporophylls obliquely ascending .... *A. nana* SCHRADER.
Sporophylls patent ..... *A. grandifolia* J. AG.

B. Sporophylls fasciculate.

α. Rhizines cylindrical ..... *A. lanceolata* KJELLM.

β. Rhizines complanated and thick.
Sporophylls cuneate, soriferous part broader than the sterile crown .. *A. tæniata* KJELLM.
Sporophylls long cuneate ..... *A. angusta* KJELLM.

SPECIES.

Alaria fistulosa P. et R.

(Plate I, figs. 1-4.)

Illustr. Alg., p. 11, Tab. XVI.—J. Ag.: Spec., I, p. 144.—Kütz.: Spec. Alg., p. 579.—Kjellman: Om Beringhafv., p. 49.—Saunders: Harr. Alaska Exped., Algae, p. 426, Pl. LVII.—Setch. et Gardn.: Algae N. W. N. Amer., p. 276.—Collins, Holden and Setch.: Phyc. Bor.-Amer., Fasc. B. No. XLII.—Kibbe: in Puget Sound Mar. Station Publ., Vol. I, p. 43, fig. 1-33.

=*Phasganon fistulosum* Rupr.: Tange des och. Meeres, p. 355 *et f.*

?=*Alaria marginata* β *musæformis* P. et R.: Illustr. Alg. p. 11.

?=*Alaria* sp? Kjellman: Om Beringhafv., p. 42.

Definition of the species. Root, at an early stage of development, holdfast of dendritic ramification, soon issuing numerous, branching, filiform rhizines successively above, the new rhizines growing over and interweaving with the older ones, resulting in general outline to a high conical mass. Blade linear, 10–25 meters in length, 30–90 cm. in breadth, membranaceous and brittle, densely glandulated, cryptostomata wanting, coarsely transversely corrugated along the midrib, margin entire, undulating, splitting transversely to the midrib in the older part; base of blade gradually tapering, tip of blade .... Stipe 20–50 cm. in length, terete and verruculose below, 8–12 mm. in diameter, gradually complanated and slightly broadened above, measuring 10–20 mm. in width, narrowed at the transition point; lower half of the length naked, upper half to the narrowed region bearing the sporophylls. Midrib 2–3 cm. broad, elevated above the blade on both surfaces with sharp edges, the middle one-third of the breadth longitudinally inflated, showing an elliptical cross section, but septated at irregular intervals, canaliculated along both sides of the inflation; these peculiarities disappearing before reaching to the transition point

where the midrib continues to the stipe below. Sporophylls holosoric, numerous, compactly disposed on both sides of the stipe, adding new ones successively above, oblong-obovate, or elliptical, 12–20 cm. in length, 2–4 cm. in breadth, cartilaginous, with well-defined cylindrical petioles; base of sporophyll obtuse or round, generally asymmetrical, tip round. Sorus on both surfaces of each sporophyll, in a continuous patch, occupying the whole surface leaving but a narrow border along the margin sterile.

Remarks on the species. This is a very distinct and well marked species. The much interwoven, tall conical or mitriform holdfast and the hollow but septated midrib are unrivalled characters among the allies. The sporophylls are ovate-spatulate, considerable in number, and densely beset in a limited portion of the stipe. At the beginning of appearance, they are membranaceous and obovate, very densely disposed on the margins of the stipe, *i. e.*, in a manner quite different from other species. The blade may often attain more than 50 feet in length, 3 feet in breadth, decussately cleft like a *Musa* leaf. It is the largest form of *Alaria*.

The plant grows gregariously at a depth of 5–10 fathoms below the low water mark. The upper parts of the blades, when the tide is low, float on the surface of the water and afford a resting buoy for sea-otters and other marine fur-animals.

SETCHELL and GARDNER distinguished two formæ, f. *platyphylla* and f. *stenophylla*, from the Unalaskan forms. But judging from the descriptions and considering the Kurile specimens, the formæ proposed seem merely due to the state of growth, as has been already observed by KIBBE.[1)]

The specimen kept in the herbarium of the Botanical Museum

1) KIBBE: Puget Sound Mar. Station Publ., Vol. I, p. 43.

of Upsala under *Alaria* sp ?, undoubtedly the plant mentioned in Beringhafv., p. 42, appears to me to be a fragment of an abnormal blade of *A. fistulosa*, although the characteristic hollow midrib could not be ascertained in the specimen.

In Illustr. Alg., p. 11, POSTELS and RUPRECHT mention *A. marginata β musæformis*. The brief description of this forma does not give any concrete idea of a distinct form of the plant. The original, kept in the herbarium of the Academy of Science of Petrograd, is a poor specimen without sporophylls. SETCHELL[1] notes that he recognized in the midrib an "evident symptom of having been characteristically and interruptedly fistulose."

KJELLMAN[2] remarks on the present species: "Arten synes mig vera närmost beslägtad med *A. tæniata*. Kostans grundform är densamma." I am rather astonished to read this statement. In the herbarium of the Botanical Museum of Upsala there is a young specimen of *A. crassifolia* KJELLM. determined by KJELLMAN as *A. fistulosa*. The above statement together with this identification make me doubt the specific conception of *A. fistulosa* held by KJELLMAN.

In the remark appendiced to the note on *Orgyia pinnata*, GOBI mentions a specimen with hollow and septated midrib in the Herbarium of the Botanical Museum of the University of Petrograd. The specimen, according to him, is from POSTELS and has been collected in a northern sea without exact locality. I have not seen the specimen in the Herbarium. But it appears to me very likely that it might have been collected in the North Pacific and should be identified with *A. fistulosa*. GOBI was tempted to neglect the peculiarity of the midrib, saying:—"Ich führe dieses Beispiel

1) SETCHELL: Critical Notes on Laminariaceæ, p. 11.
2) KJELLMAN: Beringhafv. Algflora, p. 42.

an nur um zu zeigen, dass die Aufblähung der Rippe oder Stiel—was eigentlich dasselbe ist—keinen irgend welchen specifischen Werth erhalten kann." It is to be regretted that he has not seen the specimens of the North Pacific *Alaria* in the Herbarium of the Academy of Science of Petrograd.

Locality. Augustine Bay, Dall Island (FRYE); Wrangell Narrows (SAUNDERS, SETCHELL and GARDNER); Douglas (JEUNE, SETCHELL); Juneau (SAUNDERS); Glacier Bay (SAUNDERS); Yakutat Bay (SAUNDERS); Prince William Sound (SAUNDERS); Cook's Inlet (SAUNDERS, RIGG): Kukak Bay (SAUNDERS); Kadiak Island (POSTELS and RUPRECHT, SAUNDERS, SETCHELL); Bay of Unalaska (POSTELS and RUPRECHT, SETCHELL); Kyska Island (TOWNSEND and SETCHELL); Bering Island (KJELLMAN); Kurile Islands(!); Kushiro, Yesso (MIYABE)(!); Kitami Prov., Yesso (MIYABE); Sakhalin (Herb. A.C.S.*).

Alaria macroptera (RUPR.) *nov. nom.*

(Plate II, figs. 1–5.)

=*Phasganon macropterum* RUPR.: Tange des och. Meeres, p. 353.
=*Alaria macrophylla* MIYABE: Lam. of Hokkaido, p. 56, Pl. 25.
=*Alaria corrugata* MIYABE: Lam. of Hokkaido, p. 55, Pl. 24.
=*Alaria esculenta latifolia* P. et R.: Ill. Alg. p. 11. Pl. XVII.
=*Alaria esculenta pinnatifida* P. et R.: Ill. Alg. p. 11. *p.p.*
=*Alaria marginata* P. et R.? in Herb Acad. Petropol.
?=*Alaria laticosta* SAUNDERS (non KJELLM.): Harr. Alaska Exped. Algae, p. 425, Pl. LV.
=*Phasganon alatum* var. *latifolium* RUPR.: in Herb. Acad. Petropol. *p.p.*
=*Phasganon longipes* RUPR.: Tange des och. Meeres, p. 353.

Definition of the species. Root, holdfast of dendritic ramification; blade linear lanceolate, 3.0–4.5 meters in length, 25–30 cm.

* Agricultural College, Hokkaido Imperial University, Sapporo.

in width at the broadest part, membranaceous, richly transversely corrugated, cryptostomata wanting, margin finely crispated, splitting in the older parts transversely to the midrib; base of blade gently tapering or acute when young, roundish or even cordate when old, tip of blade narrowed above, pinnately split and usually worn away. Stipe 5–12 cm. in length, cylindrical below in well developed and matured specimens, 4–6 mm. in diameter, terete and more or less broadened above, narrowed below the transition point, lower half of the length naked, upper terete part bearing the sporophylls, but in the younger individuals subcompressed or ancipitous till almost to the base, and bearing sporophylls from near the base. Midrib complanated, 6–10 mm. broad, elevated above the blade equally on both surfaces with round edges, continuous with the stipe below. Sporophylls holosoric, 30–40 in number, pinnately arranged on both margins of the terete part of the stipe, a few lowermost ones more or less apart, but the middle and upper ones close together, with the bases of the petioles fused into a continuous narrow wing on each margin of the stipe, lanceolate or linear-cuneate, 20–30 cm. long, 3.0–4.5 cm. wide in the broadest part; base of sporophyll acute, often obtuse, very frequently oblique, ending in a cylindrical petiole; tip obtuse with rounded apex, or often round. Sorus in a continuous patch on both surfaces of each sporophyll, occupying generally the entire area of the surface except a narrow border along the margin, but frequently leaving an upper part sterile and membranaceous.

Remarks on the limit of variation. The present species attracts the attention of the collector by its finely corrugated and very long blade. This character, however, is often not remarkable in some individuals, especially in the lower half of the length. In a herbarium specimen, when the upper portion has been cut off,

this important peculiarity is not recognizable. The shape of the base of the blade is also variable as in many others, according to the age of frond. In the young forms it is cuneate or acute, but in the fully matured forms, rounded or even cordate, with the transition point acute for a short length. The close arrangement of the sporophylls also varies somewhat, being sometimes, especially in the younger forms, more or less separated. The plant, therefore, seems to have a tendency to approach *A. prælonga* KJELLM.

The type specimen in the Herbarium of the Academy of Science of Petrograd has the sporophylls only partly soriferous. The upper sterile portion of each is thin and membranaceous, broader than the soriferous portion. This character suggests the placing of the species under the Metasoria. But after consulting the numerous specimens from our coast, which can not but be identified with the present species, I am strongly inclined to dispose the species under the Holosoria. In some specimens, the sporophylls are oblong linear, with both ends obtuse or rounded, and in others very long linear, often measuring more than a foot in length and only a few centimeters in breadth.

Remarks on the synonyms. The present species is easily recognized and distinguished from the others by having a finely plicated blade and large sporophylls. RUPRECHT has already observed the former character as he states "Querfalten am Blatte ausgezeichnet, selbst am Rande der Fiedern."[1] The plication of the margins of sporophylls, however, is due to unequal contraction of the soriferous and sterile areas in drying. In the fresh specimens they are simply undulating. The broad base of the blade is counted by RUPRECHT as one of the specific characters. This has been regarded as of specific importance by MIYABE, SAUNDERS,

1) RUPRECHT: Tange des ochot. Meeres, p. 354.

KJELLMAN, etc., in describing their species listed above. The shape of the base of the blade, however, is of secondary importance. RUPRECHT himself relates on *Phasganon longipes* RUPR.:—"Ein Rasen mit 5 Exemplaren von der S. W. Küste von Kamtschatka bei Javina im September gesammelt, erhielt Blätter mit mehr oder weniger deutlich eiförmiger Basis und ein Blatt, dessen unteres Ende in den Stamm ausgezeichnet keilförmig und lang gezogen war: hier konnten nicht zwei Arten gemischt sein, denn all übrigen Character war dieselben." We have in our herbarium many specimens showing such variations as RUPRECHT had noticed.

Having examined and carefully studied the original specimens of *Phasganon macropterum* RUPR. and *Phas. longipes* RUPR. in the herbarium of the Academy of Sciences of Petrograd, I have not the least doubt of the propriety of combining them into one species. RUPRECHT seems to have laid too much stress on the length of the stipe, which is never a matter of specific importance but one generally due to the habitat. A glance at the original specimen of *Phas. macropterum* gave me the conviction that *A. corrugata* MIYABE, which is quite familiar to me, is another form which should be amalgamated with that species.

SAUNDERS identified a specimen from Kukak Bay with *A. laticosta* KJELLM. in spite of what KJELLMAN has said of the specimen: "the form, color and consistency of the blade, and the form, width and rigidity of the sporophyll differ somewhat from this species." These characters which KJELLMAN mentioned are all important specific ones, and yet SAUNDERS did identify his plant with KJELLMAN'S species. It might have been because of the broadness of the midrib of his specimen. As may be understood from what is stated on p. 20 of the present paper, the breadth of the midrib is variable and hardly of systematic value. The illustration of

SAUNDERS' specimen delineated by himself (l. c., Pl. LV) may be referred to either the present or *A. ochotensis.* His description for his plant is so brief that I am unable at present to reach a concrete decision. But the fine corrugation of the blade, so excellently delineated by him, justifies the referring of the plant to this species. The fact that in his plant the scars of the dropped sporophylls are found on both sides of the stipe till near the holdfast, point at the same time to the next species.

In Grönland Lam. och Fuc., J. AGARDH doubts *Phas. longipes* RUPR. to be equivalent with his *A. grandifolia.* On examining the original of the latter at Lund, I can not agree with J. AGARDH's view about the identity of these two species.

J. AGARDH seems to have regarded *Phas. macropterum* RUPR. as comparable with *Laminaria Pylaii* DE LA PYL. Cfr. Spetzbergens Alger, p. 30. However RUPRECHT's species may cover more than one form of plant, no specimen referrable to *A. Pylaii* is to be found among the originals of *Phas. macropterum* in the herbarium of the Academy of Science of Petrograd.

The name *Phas. alatum* RUPR. var. *latifolium* RUPR. has practically the same limitation as *A. esculenta latifolium* P. et R. After careful study of the original specimens in Petrograd, the plants under this name are quite inseparable from those under *Phas. alatum macropterum* RUPR. and comprise *A. Pylaii* GREV., *A. prælonga* KJELLM. and *A. macroptera* in the sense taken in the present paper.

A specimen from Petropaulowsk, Kamtschatka, bearing in RUPRECHT's own handwriting the note: "*Alaria marginata* P. R.? est potius *A. esculenta* var. *latifolia* Ill. Alg." is in the herbarium of the Academy of Sciences of Petrograd. This is to be referred to the present species.

Locality. Kurile Islands (Herb. S. A. C.); Port Ochotsk

(Rpurecht); Ajan Bay (Ruprecht); Petropaulowsk, Kamtschatka (Lütke, Postels and Ruprecht); ?Kukak Bay (Saunders, under *A. laticosta*); Tonnaicha, Sakhalin(!).

Alaria ochotensis *sp. nov.*

(Plate III, figs. 1–5; Plate XIX, figs. 1–3.)

Definition of the species. Root, holdfast of dendritic ramification, with filiform rhizines. Blade linear-lanceolate, more than 2.5 meters in length, 25–30 cm. in width at the broadest part, membranaceous, extremely thin when dried, finely transversely corrugated in the matured forms, frosted with numerous cryptostomata; margin entire, undulated or crispated, splitting in the older parts transversely to the midrib; base of blade acute from an early stage of development, tip of blade narrowed above, pinnately split and usually worn away. In the cortical layer of the blade, peculiar, ramified glandular cells present, the content of which turns brownish on drying, giving the blade a characteristic brown colour. Stipe short, 3–4 cm. in length, terete or cylindrical below, gradually broadened and complanated above, narrowed again at the transition point, naked for a short length near the base, bearing sporophylls on the margins of the complanated part. Midrib complanated, with slanting edges, 0.7–1.3 cm. broad, elevated above the blade equally on both surfaces, continuous with the stipe below. Sporophylls, holosoric, 30–40 in number, pinnately arranged on both margins of the complanated part of the stipe, a few lowermost ones more or less independent, but middle and upper ones starting from a narrow continuous wing on each margin of the stipe, adding new ones successively upwards, lanceolate or linear-cuneate, 10–15 cm. long, 2.0–2.5 cm. wide in the broadest part; base of sporophylls acute, often obtuse, very often oblique, ending in a

cylindrical petiole which is persistent on the stipe after the sporophyll has dropped; tip obtuse or rounded. Sorus in a continuous patch on both surfaces of each sporophyll, occupying generally the entire area of the surface, except a very narrow border along the margin, but frequently leaving the upper part sterile and membranaceous.

Remarks on the affinity of the species. The present plant has some resemblance to *A. dolichorhachis* KJELLM. and *A. lanceolata* KJELLM. But it may be readily separated from them by having extremely thin, membranaceous, corrugated blade as well as a peculiar kind of glandular cells. In general appearance of frond, it stands most closely to *A. macroptera*, so that I was rather uncertain if it would not be better mentioned under its varietal rank. From that species, however, it may be distinguished by rich cryptostomata and glandular cells in the blade, by non-approximate sporophylls, and by the petioles of the dropped sporophylls remaining attached to the stipe.

The form conception of *A. esculenta pinnatifida* P. et R. taken by the authors is rather difficult to understand. The definition given in Ill. Alg., p. 11 is well applicable to this species. But as far as I could understand from the original in the herbarium of the Academy of Science of Petrograd, as determined and arranged by RUPRECHT, there appear more than two distinct forms under the formic name. One of them, collected in Kamtschatka, has certain resemblance to *A. Pylaii.* The others approach to either *A. macroptera* or the present.

As remarked under the preceeding species, the plant which SAUNDERS has identified with *A. laticosta* KJELLM. seems to have certain points comparable with this species.

Locality. Southern part of Sakhalin (K. MIYABE, Herb. S. A. C.); Aniwa Bay, Sakhalin (S. MURATA) (!).

Alaria prælonga Kjellm.

(Plate IV, figs. 1–5.)

Om Beringhafv. Algfl., p. 38, Tab. 4, fig. 1–4. — De Toni: Syll. Alg. III, p. 330.

=*Phasganon alatum* Rupr.: Tange och. Meer., p. 355, 359. *p.p.*

=*Phasganon alatum* var. *latifolium* Rupr.: Ditto, p. 355, *p.p.*

=*Alaria esculenta* P. et R.: Ill. Alg., p. 11, *p.p.*

=*Alaria yessoensis* Miyabe: Lamin. of Hokkaido, p. 54, Pl. 23.

?=*Alaria lanceolata* Coll., Holden et Setch.: Phyc. Bor.-Amer. Fasc. B. No. XLIV.

Definition of the species. Root, holdfast of dendritic ramification. Blade linear, 1–7 meters, generally 2–3 meters in length, 10–13 cm. in breadth, coriaceous, cryptostomata wanting, margin entire, splitting obliquely to the midrib in the older parts; base of blade gently tapering; tip narrowed above, pinnately cleft and generally roughly worn away. Stipe 3–12 cm. in length, subcylindrical below, 2.5–3.0 mm. in diameter, gradually compressed above, measuring 3–5 mm. in width, but quickly narrowed at the transition point; lower half of the length naked, upper and compressed part, except the narrowed region, bearing sporophylls. Midrib smooth, complanated, 5–13 mm. broad, elevated above the blade on both surfaces with roundish edges, continuous with the stipe below. Sporophylls, holosoric, 12–40 or often more in number, pinnately arranged on both margins of the complanated part of the stipe, a few lowermost ones at wide intervals, but middle and upper ones approximate and regularly disposed, adding new ones successively upwards, linear-oblong or linear, 6–20–30 cm. in length, 1.5–2.5 cm. in breadth, with well defined cylindrical petioles; base of sporophyll obtuse, very frequently asymmetrical; tip roundish or obtuse. Sorus on both surfaces of each sporophyll,

generally occupying the entire surface except a narrow border along the margin.

Remarks on the limit of variation. Although the shape of the base of the blade of most members of the Laminariaceæ varies according to the stage of development of the plant, the gradual attenuation, *e.g.*, narrow cuneate shape in the present species is quite constant and remarkable. The substance of the blade is coriaceous, resembling a thick parchment paper on drying. A remarkable character of the present species is that the blade is entirely wanting in cryptostomata as far as I could determine.

Some specimens may have numerous small holes in the upper and older part of the blade, often so numerous that the part gains the appearance of a cribrous lamina. These perforations become smaller in size and less in number as we trace them downwards and finally they may be reduced into mere brownish spots, very sparingly distributed on the blade. Under the microscope, these brownish spots show shallow depressions of the cortical part on either surface with a much distorted arrangement of the cortical cells. I was not able to find any reason for calling the depression a cryptostoma or hair-pit. The specimens from Hidaka Province, however, have had sparing cryptostomata showing with other specific characters an intermediate form between the typical forms of both *A. prælonga* and *A. crassifolia*.

A typical form of the present species has the sporophylls arranged at regular intervals as in *A. esculenta* and *A. crassifolia*. The shape of the sporophyll is linear, with a round or obtuse apex and an obtuse, very frequently asymmetrical, base. As already mentioned before, we sometime meet with an intermediate form in the characters of sporophylls between the present and *A. crassifolia*. In such case, the presence or absence of cryptostomata

and the shape of the base of the blade may be taken as the discriminating characters.

Remarks on the synonyms. Among the specimens under *Phas. alatum* var. *latifolium* RUPR., preserved in the Academy of Science of Petrograd, there are some from Javina, Kamtschatka. These differ greatly from the rest by having leather-like blades and much aggregated sporophylls. Judging from RUPRECHT's handwriting on the specimen sheet, he seems to have had ample doubt on the determination and to have at first supposed them to be a young stage of *Phas. marginatum* RUPR. But I am inclined to consider them to be referrable to the present species. The Petropaulowsk specimen of *A. esculenta* P. et R. as treated in Illustr. Alg., p. 11, also seems to be joined here.

The plant distributed as Phyc. Bor.-Amer., Fasc. B., No. XLIV, was at first hesitatingly identified with *A. lanceolata* by SETCHELL. He[1] referred it later to *A. marginata* P. et R. The specimen in the copy I have seen was provided with comparatively few sporophylls set apart at regular intervals in the main part, some younger ones being aggregated at the upper. The shape and substance of the sporophylls, as well as the arrangement on the stipe, recalled more of *A. prælonga* KJELLM. than any other species. It is to be questioned how SETCHELL comprehended *A. prælonga* KJELLM. The informations concerning this species in Algae of the Pribilof Island, p. 529 and in Algae of the North-western Coast of North America, p. 274, are therefore not referred to here.

Locality. Javina, Kamtschatka (RUPRECHT); Petropaulowsk, Kamtschatka (POSTELS and RUPRECHT); Bering Islands (KJELLMAN); South-eastern coast of Hokkaido, Japan (Herb. S. A. C.).

1) SETCHELL: Critical Notes on Laminariaceæ, p. 11.

Alaria dolichorhachis KJELLM.

(Plate V.)

Algae of Arct. Sea, p. 217, Pl. 20–21, 25, fig. 11–18.—Id.: Beringhafv. Algfl., p. 35.—DE TONI: Syll. Alg. III, p. 328.—SETCH. et GARD.: Alg. N. W. Amer. p. 272.

= *Alaria elliptica* KJELLM.: Alg. Arct. Sea, p. 221, Pl. 23, Pl. 25, fig. 25, 26.—DE TONI: Syll. Alg. III, p. 329.

= *Alaria crispa* KJELLM.: Beringhafv. Algfl., p. 37, Tab. 3, fig. 5–7.—DE TONI: Syll. Alg. III, p. 330.

= *Alaria muscæfolia* J. AG. in litt. Herb. J. AGARDH. (tantum specimen Spitzbergensis).

= *Alaria Pylaii* J. AG.: Bidrag till Kännedom Spetzberg. Alger, p. 30 (non alior).

?= *Alaria esculenta* HARV.: Flora West Esk., p. 49 (sec. KJELLMAN).

?= *Alaria esculenta* var. *latifolia* f. *singularis* RUPR. (Herb. Acad. Petropol.).

Definition of the species. Root, holdfast of dendritic ramification. Blade ovate-lanceolate, 1 meter or less in length, up to 40 cm. in width at the broadest part, thin, membranaceous, cryptostomata wanting; base of blade cuneate for a short length, abruptly expanding upwards into a broad roundish shape. Stipe up to 20 cm. in length, cylindrical below, 3–4 mm. in diameter, terete and broadened above, narrowed below the transition point. Midrib smooth, 4–7 mm. broad, prominent with roundish edges. Sporophylls, holosoric?, numerous, pinnately arranged on both margins of the terete part of the stipe, a few lowermost ones at wide intervals but the middle and upper ones approximate and distinct, long cuneate, attaining 20 cm. in length, tapering towards the base into slender petiole, 2.0–3.5 cm. broad near the rounded apex, papyraceous, with plicate margins.

Remarks on the affinity with other species. KJELLMAN mentioned

the close affinity of this species with *A. esculenta* f. *typica*[1] as well as with *A. Pylaii*, *A. membranacea* and *A. grandifolia* J. Ag. The resemblance of this species to *A. esculenta* Grev. is merely superficial. Both are readily distinguished by the disposition of sporophylls and by other characters. With *A. Pylaii* Grev. and *A. membranacea* J. Ag., as far as I understand these species, *A. dolichorhachis* Kjellm. has nothing to do.

A fully matured specimen of this species is not known to us It can not, therefore, be ascertained whether the species belongs to the Holosoria or to the Metasoria. The type specimen of *A. dolichorhachis* is provided with sporophylls yet faintly soriferous So also *A. crispa* Kjellm. The sori appear to develop first in the lower halves of the sporophylls and then spread gradually upwards. In the specimen (No. 2101) under *A. musæfolia* J. Ag. in the Agardhian Herbarium, the sori begin to appear as an elliptical patch at a point a little below the middle of the length of each sporophyll. In both cases there is no sudden change of breadth in the soriferous and non-soriferous part. These examples lead me to assume, after considering the other species, that the present species belongs to the Holosoria.

Remarks on the synonyms. Unfortunately I failed to study the type of *A. elliptica* in Kjellman's collection at Upsala. Its co-type, collected at Pitlekay in July, 1849, was found in the Agardhian Herbarium at Lund (specimen No. 2082). Its stipe measures about 6 cm. in length, with numerous, long, cuneate sporophylls closely pinnately disposed. The midrib is about 3 mm. wide, much narrowed at the transition region. The blade is undulately plicated, acute at the base but abruptly broadened upwards.

1) Kjellman: Alg. Arct. Sea, p. 218. No reference whatever for this form-name is mentioned by the author. He might have meant by it simply the typical form of *A. esculenta* Grev.

The specimen No. 2101, alluded to above, in the Agardhian Herbarium, was collected at Spitzbergen during the Torell Expedition and was compared by J. AGARDH with *Laminaria musæfolia* DE LA PYL. In Bidrag till Kännedomen af Spetzbergens Alger, Tillägg, however, J. AGARDH does not give any account on this specimen. He simply mentions two species of *Alaria* therefrom, *A. Pylaii* and *A. esculenta*, in the collection of the expedition. It is quite certain that the specimen mentioned has been treated as *A. Pylaii* in the Bidrag. This specimen is decidedly not applicable to *A. Pylaii* GREV. It agrees very well with the figure of *A. elliptica* in Alg. Arct. Sea, Plate 23, fig. 2, but in a little more advanced stage. A still slightly more advanced stage of this specimen is excellently represented by the co-type of *A. elliptica* just mentioned above.

In the Herbarium of the Botanical Museum of Upsala, there are two specimens as the type of *A. dolichorhachis* KJELLM. A third specimen collected by SETCHELL in Unalaska Bay is annexed to them, determined by KJELLMAN, but with a question mark. These three belong undoubtedly to one and the same species. I can not find any reason to treat them specifically distinct from the specimens of *A. elliptica* found in the Agardhian Herbarium. KJELLMAN himself observes a close affinity between *A. elliptica*, *A. dolichorhachis* and *A. prælonga*.[1] The last mentioned species, however, is sharply distinguished from them. The descriptions of the other two can hardly give us the distinctions justifying their separation specifically. The describer emphatically states that the peculiarity of the shape of the blade of *A. elliptica* is its unique character. An examination of the type of *A. dolichorhachis*, in comparison with the co-type of *A. elliptica*, and considering the variation of the

1) KJELLMAN: Algae Arct. Sea, p. 222.

shape of the blade of *Alaria*, leaves me with little doubt about uniting the two species into one.

In describing *A. crispa* as an independent species, KJELLMAN seems to have put too much importance on the crispated base of the blade as well as on the characters shown in the cross sections of the midrib. These two points, however, as far as they concern the present case, can hardly be taken as specific distinctions. The shape of the cross section of the midrib and the distribution of the tissue elements shown in it, are to some extent variable, as has been demonstrated before. The crispation of the base of the blade is a character commonly met with in those *Alaria* which have a suddenly narrowed base. It shows that the growth of the blade in length is much quicker than that of the midrib at the transition region, and above this region the growth of the blade in width is more vigorous than in length, the midrib keeping nearly constant speed in the growth in length.

Comparing the type specimen of *A. dolichorhachis* KJELLM. with the illustrations in the Algae of the Arctic Sea, I think I have reason to say that they are quite misleading though not untrue. In the type, the sporophylls are much condensed within a short length of the stipe and have undulated margins; the blade is crispated or plicated. KJELLMAN himself has fully noticed the resemblance of this species and *A. crispa*. The types of these two are indeed inseparable. By merely consulting the illustrations of the former in Algae of the Arctic Sea and the latter in Beringhafvets Algflora, his remark on the affinity of both may not be properly understood.

A specimen from Petropaulowsk with deformed frond is kept in the herbarium of the Academy of Sciences of Petrograd determined by RUPRECHT as "*Alaria esculenta* var. *latifolia* forma

singularis." This, very likely, should be mentioned under this species.

KJELLMAN points out *A. esculenta* mentioned by HARVEY in Flora Esk., p. 49, to be probably referrable to this species. In the herbarium of Trinity College, Dublin, I could not find any specimen which might be supposed to be the source of the information. I doubt if KJELLMAN consulted RATHROCK's sketches of algae before making the remark.

Locality. Spitzbergen (J. AGARDH); Pitlekaj (KJELLMAN); Koljushin Isle (KJELLMAN); Bering Sea (KJELLMAN); Konyam Bay (KJELLMAN); St. Lawrence Island (KJELLMAN); Unalaska Bay (SETCHELL); Agattu Island (SETCHELL and TOWNSEND); Petropaulowsk, Kamtschatka (RUPRECHT); Sakhalin (T. MIYAKE, Herb. S. A. C.).

Alaria marginata POST. et RUPR.

(Plate VI, fig. 1–4; Plate XIX, fig. 4.)

Illustr. Alg., p. 11.—SETCHELL: Critical Notes on Lam., p. 10.—COLLINS: Mar. Alg. Vancouver Isl., p. 110 (excl. var.).

= *Alaria lanceolata* COLL., HOLDEN et SETCH.: Phyc. Bor.-Amer. No. XLIV.

= *Alaria prælonga* SETCH. et GARDN.: Alg. N. W. Coast of N. Amer., p. 274.

= *Alaria cordata* TILDEN: Amer. Algae, No. 241.—SAUNDERS: Harr. Alaska Exped., Algae, p. 426, Pl. LVI.

= *Alaria striata* J. AG.: in Herb. J. AGARDH.

= *Alaria curtipes* SAUNDERS: Minn. Bot. Studies, Vol. II, p. 561, Pl. 33.

= *Phasganon marginatum* RUPR. Tange des och. Meeres, p. 355.

Definition of the species. Root, holdfast of dendritic ramification. Blade linear, 2–4 meters in length, 15–30 cm. in breadth, thick and coriaceous, finely striated when old, cryptostomata wanting,

margin entire, splitting in the older parts of the blade obliquely or almost transversely to the midrib; base of the blade acute with tapered end; tip of the blade narrowed above, pinnately cleft and generally roughly worn away. Stipe short, 5–10 cm. in length, subcylindrical below, 3–4 mm. in diameter, compressed and broadened upwards into a linear-cuneate form with the maximum breadth about 10–15 mm., narrowed at the transition point; lower half of the length naked, upper and complanated part, except the narrow region, bearing sporophylls. Midrib smooth, complanated, 20–28 mm. broad, elevated above the blade on both surfaces with slanting edges, continuous to the stipe below. Sporophylls holosoric, 10–20 in number, pinnately arranged but closely together on both margins of the complanated part of stipe, adding new ones successively upwards, 20–27 cm. in length, 4–5 cm. in breadth, linear-oblong, more or less curved or sigmoid, with well-defined, short, terete petioles; base of sporophyll obtuse, round or cordate, generally asymmetrical; tip roundish or obtuse. Sorus generally formed in a continuous patch on both surfaces of sporophyll, occupying the whole surface except a narrow border along the margin, very often a certain terminal portion of a sporophyll remaining sterile.

Remarks on the species. This species is easily distinguished from the others by the peculiarities of the sporophylls. Their size and substance are ample to tell the species. *A. fistulosa* alone may be compared with the present in this respect, but their roundish or cordate base is a character not duplicated in other species. The thick coriaceous substance of the blade and the complanated broad midrib also show unmistakable features of this species. A conspicuous fine striation on the older parts of the blade must also be mentioned as one of its remarkable specific distinctions. Briefly

speaking, the striation runs obliquely ascending from the midrib towards the blade margins, without relation to the pinnate cleaving. They are coarse at first, counting 10–12 streaks in 1 cm. in the dried specimens. The streaks ramify towards the blade margins so as finally to number 16–20 in 1 cm. The streaks are not continuous lines but are composed of small dots. These dots are also at regular intervals. Hence another striation results, though much more irregular, intersecting with the first one. The general appearance of such a portion of the blade may be roughly compared with the curved lines engraved on a watch-case by a rose-engine, or with finely shagreened leather.

Remarks on the synonyms. The present writer actually observed and collected *A. cordata* TILDEN at the type locality with the establisher of the species herself. So he may be permitted to say that his knowledge of the species is sufficient to distinguish it from the allied forms. On studying the type of *A. marginata* P. et R. in the herbarium of the Academy of Sciences of Petrograd, he was at once certain that both were one and the same species. SETCHELL and GARDNER[1] remark that "as far as the incomplete description goes, *A. marginata* P. et R. seems to resemble *A. laticosta* KJELLM." They further note that *A. cordata* TILDEN seems to have no character to separate it from *A. Pylaii* GREV. This undoubtedly resulted from either their unsatisfactory acquaintance with a complete specimen of Miss TILDEN's, or otherwise the non-uniformity of the specimens in her exsiccatæ.

HARVEY[2] reported the occurrence of this species about Fuca Strait adjacent to Vancouver Island. Curious to say, the specimens kept under this species in the herbarium of Trinity College,

1) SETCHELL and GARDNER: Algae of N. W. Coast of N. Amer., p. 275.
2) HARVEY: Notices of a Collection of Algae, etc., p. 165.

Dublin, are all except one, *Cymathere triplicata;* and the excepted one is an incomplete specimen, which SETCHELL[1] has identified with *Pleurophycus Gardneri* SETCH.

DE TONI[2] states that ANDERSON reported the present species from the Californian coast, but this statement has been apparently discredited by SAUNDERS.

A specimen of the present species is found in the Agardhian Herbarium at Lund bearing the name *A. striata* J. AG. This specific name originates undoubtedly from the fine striations on the matured blades. J. AGARDH once brought *A. marginata* P. et R. under *A. esculenta*[3] but afterward discarded this view.[4]

SETCHELL[5] stated, after he had seen the original of *A. marginata* P. et R. in Petrograd, that the plant he and GARDNER referred to *A. prælonga* is really to be placed under *A. marginata* P. et R., and also that the plant distributed in the Phyc. Bor.-Amer., No. XLIV under the doubtful name of *A. lanceolata*, should be referred to the same species. He further expressed the view that *A. marginata* P. et R. may probably replace both the names of *A. prælonga* KJELLM. and *A. laticosta* KJELLM. On examining the originals of these two species at Upsala, I could by no means agree with his view. The specimen in the Phyc. Bor.-Amer., in a copy I have seen, was surely not of *A. marginata* P. et R. as noted under the preceding species. There must have been some non-uniformity in the exsiccatæ.

A close affinity between *A. curtipes* SAUNDERS and *A. prælonga* KJELLM. has already been pointed out by SAUNDERS himself.[6]

1) SETCHELL: Critical Notes on Lam., p. 10.
2) DE TONI: Syll. Alg. III, p. 332.
3) J. AGARDH: Spec. Alg, p. 143.
4) J. AGARDH: Grönlands Lam. och Fuc., p. 23.
5) SETCHELL: Critical Notes on Lam. p. 10.
6) SAUNDERS: Harr. Alaska Exped., Algae, p. 561.

SETCHELL and GARDNER unhesitatingly announced the identity of both species. But what these two writers meant by *A. prælonga* KJELLM. is, as may be understood from the remark alluded to above, nothing but *A. marginata* P. et R. The figures sketched by SAUNDERS in Minn. Bot. Studies, l. c., Plate 33 show small specimens of the present species though not typical. It appears rather curious to me how he came to describe his plant as new, considering that he had already reported *A. cordata* TILDEN with illustration from Yaktat Bay. In Mar. Alg. of Vancouver Island, p. 110, COLLINS follows SETCHELL's amendment of *A. marginata* in bringing *A. curtipes* SAUNDERS under it. But that he mentioned *A. nana* SCHRAD. in its varietal rank shows his unfamiliarity with both species.

The specimen distributed by Miss TILDEN as No. 521 American Algae under *A. curtipes*, in the copy I have seen, agrees satisfactorily with *A. valida* SETCH. et KJELLM. And, No. 241 of the same exsiccata under *A. cordata* TILDEN can safely be identified with *A. marginata* P. et R.

Locality. St. Paul Island (TOWNSEND and SETCHELL); Yaktat Bay (SAUNDERS); Kadiak Island (SETCHELL); Unalaska (POSTELS and RUPRECHT); Juan de Fuca Strait (TILDEN); California (BERGGREN and J. AGARDH, in Herb. J. AG. under *A. striata*); Central California (SAUNDERS).

Alaria Pylaii GREV.

(Plate VII; Plate VIII, figs. 1–2.)

Alg. Brit. Syn., p. XXXIX.—HARVEY: Alg. N.-W. Coast of N. Amer., p. 165.—J. AG.: Grönland Lam. och Fuc., p. 24.—Id.: Spec., I, p. 143.—SETCH. et GARDN.: Alg. N. W. Amer., p. 272.

= *Alaria Pylaii* GREV. *α typica*. ROSENV.: Grönl. Havalger, p. 838.—Id.: Deux. Mém. p. 48.—JÖNSS.: Mar. Alg. East Greenl., p. 21.
= *Alaria Pylaii* GREV. *β membranacea* ROSENV.: Grönl. Havalger, p. 839.
= *Agarum Pyalii* BORY: in Dict. Class. IX, p. 194.
= *Laminaria Pylaii* DE LA PYL: Flora Terr. Nouv., p. 29.
= *Laminaria Despreauxii* BORY: mscr. (sec. J. AGARDH).
= *Alaria membranacea* J. AG. *p.p.* Grönl. Lam. och Fuc., p. 26.
= *Alaria esculenta* var. *latifolia* FARL.: Mar. Alg. New Engl., p. 97.
= *Alaria tenuifolia* SETCH.: in COLL., HOLD. et SETCH.: Phyc. Bor.-Amer., Fasc. B. No. XLV. — SETCH. et GARDN.: Alg. N. W. Amer., p. 272. — SETCH.: Critical Notes on Lam., p. 12.
= *Alaria tenuifolia* SETCH. f. *typica* SETCH.: in SETCH. et GARDN. Alg. N. W. Amer., p. 273, Pl. 22.
= *Alaria tenuifolia* SETCH. f. *amplior* SETCH. et GARDN.: Alg. N. W. Amer., p. 274.
= *Alaria fragilis* SAUNDERS: Harr. Alaska Exped., p. 425, Pl. 54.
?= *Alaria muscæfolia* J. AG. *p.p.* Grönl. Lam. och Fuc. p. 23.
?= *Alaria esculenta* DICKIE: Algae Southerland, p. 140. (sec. ROSENVENGE).
?= *Laminaria esculenta* var. *remotifolia* DE LA PYL: in Ann. Sci. Nat. IV, p. 178, Pl. 9, Fig. E.

Definition of the species. Root, holdfast of dendritic ramification. Blade linear, 1–? meter in length, 12–20? cm. in breadth, membranaceous, frosted with cryptostomata, margin entire, undulating, splitting obliquely to the midrib in the older part; base of blade acute for a short length, suddenly expanding into an obtuse or even cordate form. Stipe 17–50 cm.* in length, terete below, 3–4 mm.* in breadth in the dried specimens, complanated for the greater part of the whole length, measuring 5–7 mm.* in breadth, quickly narrowed at the transition point; lower half of the length naked,

* The measurements with asterisks are from dried specimens.

upper half bearing the sporophylls, especially in the region near the base of the blade. Midrib smooth, complanated, 4–6 mm.* broad, often as broad as 10 mm.,* elevated above the blade on both surfaces with roundish edges. Sporophylls, metasoric, 20–30 or often more in number, pinnately arranged on both sides of the stipe, the lower ones much separated, gradually more approximate in the upper, adding new ones successively above, oblong-obovate, or elongate-elliptical, 8–15 cm.* in length, 2.5–4.0 cm.* in breadth, membranaceous, with well-defined, cylindrical petioles; base of sporophyll obtuse or round, sometimes asymmetrical; tip obtuse or round. Sorus on both surfaces of each sporophyll in a continuous patch, generally occupying the lower half of the whole area, and leaving a narrow border along the margin sterile.

Remarks on the species. The earliest appearance of the specific name *Alaria Pylaii* is in GREVILLE'S Algae Britanicae Syn. p. XXXIX (1830). The name is formed by transferring *Agarum Pylaii* BORY (1826?) to the genus *Alaria* which he had then newly established. The specific limitation held by BORY or GREVILLE was naturally quite ambiguous, as the specimens from which the species has been described were very likely incomplete and sterile. The name practically covered all the forms of *Alaria* from the west side of the North Atlantic. In 1840, POSTELS and RUPRECHT reported three species of *Alaria* from the North Pacific, namely *A. esculenta*, *A. fistulosa* and *A. marginata*. J. AGARDH could not but acknowledge the marvelous plant *A. fistulosa* in his Spec. Alg., I, but doubtingly mentioned *A. marginata* under *A. esculenta*. At this time, the Atlantic forms of *Alaria* belonged either to *A. esculenta* or to *A. Pylaii* in the opinion of the European algologists. In the collection from Greenland, J. AGARDH first came in contact

* The measurements with asterisks are from dried specimens.

with various forms of *Alaria* and undoubtedly with astonishment. He determined certain forms as *A. Pylaii* and others he divided into various new species. The concrete knowledge of *A. Pylaii*, though still ambiguous, held by modern algologists, we owe to the work of J. AGARDH "Grönlands Laminariaceer och Fucaceer." By the rule of priority, however, we have to mention GREVILLE as the establisher of the species. The specific limitation of course has gradually undergone much amendment and fluctuations since GREVILLE's time.

The ambiguity and uncertainty of *A. Pylaii* arose first of all from the fact that the early algologists had an insufficient knowledge of the variation of the forms according to the stages of development as well as to the condition of the place where the plant grows. In the second place, authentic specimens distributed by the establisher of the species have not been uniform or else some of the later referrers to the species have not properly consulted the original specimens. The original of *Laminaria Pylaii* was from Newfoundland. Specimens from Greenland, Spitzbergen, Vancouver Island, B. C., &c., were identified with it. Some of these, however, as it appears to me, have been so identified merely because either the sporophylls were soft, membranaceous and distant, or the blade thin and its base round.

In the first-year fronds of *A. esculenta* GREV., *A. prælonga* KJELLM. and *A. grandifolia* J. AG. (=*A. oblonga* KJELLM.), etc., the sporophylls are often oblong and distant. In such a stage, the substance of the frond is naturally soft and membranaceous and the stipe very slender. It is not unlikely for a herbarist to refer such a form, when the specimen has come from a colder sea of the North Atlantic, to *A. Pylaii* GREV. One might mistake with excuse a specimen as illustrated by KJELLMAN in Alg. Arct. Sea,

Pl. 23, fig. 1 under *A. elliptica* KJELLM. as a form of the present species if the specimen had not been growing with a matured form of *A. oblonga* KJELLM.

Most species of *Alaria*, as far as the observations of the present writer extend, when grown in quiet water of less salinity, are more or less liable to have the stipe long, the blade thin, soft and broad, the sporophylls thin, broad and few in number, in a greater degree than the species typically ought to have; in a word, more or less approaching in the general aspect the present species. Therefore, the collector should be warned when he has found an *Alaria* resembling *A. Pylaii* GREV. to pay special attention to the condition of the place where it was growing.

Remarks on the synonyms. I have seen neither the original specimen of *Agarum Pylaii* nor of *Laminaria Pylaii* DE LA PYL. J. AGARDH remarks in Spetzbergens Alger, Tillägg, p. 30, that he thinks *Agarum Pylaii* BORY to be different from *Laminaria Pylaii* DE LA PYL. and compares the latter with *Phasganon macropterum* RUPR. It is now almost impossible to decide the exact specific limitations of the two.

BÖRGESEN[1] announces that *A. Pylaii* is founded by J. AGARDH from BORY's species. The priority of the specific name, as alluded to above, must be given to GREVILLE. The modern specific conception comes down since J. AGARDH has modelled from the Greenland specimens. He has not based his opinion upon BORY's specimens, as he says BORY's *Agarum Pylaii* is rather a doubtful species. Cfr. Grönlands Lam. och Fucaceer, p. 24. One of the specimens kept in the Agardhian Herbarium at Lund (No. 2094) bearing the name "*Laminaria Pylaii* BORY" is a young and sterile form not positively determinable as to species (Plate VIII). Another specimen (No. 2091)

1) BÖRGESEN: Mar. Alg. of the Faeröes, p. 451.

is a matured form referrable to *A. esculenta* GREV. with utmost certainty. Again, *Laminaria Despreauxii* BORY is represented in the Herbarium by a single specimen, very likely one of the specimens distributed by DELISE under the name. This specimen is kept in the Herbarium in the species cover of *A. Pylaii*. RUPRECHT[1] has also remarked that *Laminaria Despreauxii* BORY agrees with *Agarum Pylaii* BORY. Consulting the specimen in the Agardhian Herbarium, the plant is undoubtedly a fully matured, first-year form of *A. Pylaii* GREV., with the sporophylls fully developed and the greater part of the blade rubbed away (Plate III).

A. membranacea J. AG. mentioned in Grönl. Lam. och Fuc., p. 26, should undoubtedly be amalgamated with the present species, as has been already stated by ROSENVENGE.[2] The specimen from Greenland kept in the Agardhian Herbarium shows that it is a young form with thin and membranaceous blade and a few young and sterile sporophylls. On the other hand, however, some of the specimens from Spitzbergen are inseparable from *A. grandifolia* J. AG., while some others are comparable with the Greenland specimens. The former circumstance has already been noted by KJELLMAN[3] who states emphatically that the young individuals of *A. grandifolia* J. AG. collected in Spitzbergen answer in all particulars to *A. membranacea* J. AG. He goes as far as to say, "alla de unga skulle tillhöra en art, men alla äldre utan undantag en annan." He[4] also admits that *A. membranacea* has a certain resemblance to *A. Pylaii* GREV.

Laminaria muscæfolia DE LA PYL is a species very hard to understand. The description and figure given by the author are

1) RUPRECHT: Tange des och. Meeres, p. 358.
2) ROSENVENGE: Grönlands Havalger, p. 839.
3) KJELLMAN: Spetzbergens Thallophyter, II, p. 12.
4) KJELLMAN: Alg. Arct. Sea, p. 216.

applicable to more than one species in our present conception. In the Agardhian Herbarium, it is represented by a portion of a blade, cleft decussately from the midrib, recalling a Musa leaf (Specimen No. 2105). It may or may not be *Alaria Pylaii* GREV. In Grönlands Lam. och Fucac., p. 23, J. AGARDH brings various "species" to synonymous positions with *A. muscæfolia* (DE LA PYL). It is a question how far this synonymization may be relied upon. DE TONI[1] entirely follows J. AGARDH's view and further adds *A. esculenta* f. *muscæfolia* KJELLM. to the synonym list. KJELLMAN states in Spetzbergens Thallophyter, II, p. 12, "Mellan *A. esculenta* och *muscæfolia* är skillnaden icke betydlig." This is perhaps why he proposes the forma. But KJELLMAN's specimen of f. *muscæfolia* can never be compared with "*L. muscæfolia* DE LA PYL" in the Agardhian Herbarium. The specimen from Spitzbergen (No. 2101) bearing the name is beyond doubt to be identified with *A. dolichorhachis* KJELLM.

A. tenuifolia SETCH. and f. *amplior* are inseparable from the Greenland form of *A. Pylaii*. The specimen collected by LYALL at Esquimalt, Vancouver Island, B. C., identified by HARVEY as *A. Pylaii* GREV. and now kept in the herbarium of Trinity College, Dublin, is a young individual with immatured sporophylls, but satisfactorily agreeing with *A. tenuifolia* SETCH. f. *typica*. SETCHELL states in Fertilizer Resources of the United States, p. 162, "*A. tenuifolia* SETCH. is to be distinguished by its long, flattened stipe, only moderately broad midrib, short and relatively broad sporophylls and blade broadly cuneate at the base." This statement holds equally good for the Atlantic form of *A. Pylaii* GREV. An examination of the type specimen of *A. membranacea* J. AG. induces us to come to the conclusion as SETCHELL who says that

1) DE TONI: Syll. Alg. III, p. 327.

they are far from satisfying. Some of them are indeed difficult to separate from what J. AGARDH calls *A. grandifolia*. Others (for example, No. 2111), though not fully matured, are hardly specifically distinct from *A. tenuifolia*.

SETCHELL and GARDNER[1] in their joint work amalgamated *A. fragilis* SAUNDERS with *A. Pylaii* GREV. The author of the species[2] notes that it "differs essentially from the description of *A. Pylaii* GREV. in having a long stipe and the sporophylls few and distinct." But what he points out as the peculiarities of his species are nothing but those of *A. Pylaii* GREV. The author also quotes KJELLMAN'S view on his plant, viz., "Dr. KJELLMAN compares this plant to HARVEY'S specimen labelled *A. Pylaii* GREV. from Vancouver Island, but he agrees that HARVEY'S specimen is distinct from *A. Pylaii* of the Atlantic and Polar Seas and is an undescribed species." But as above stated, HARVEY'S specimen does not give any support to this view. It is to be stated here that the description and figure of the species by SAUNDERS are to a great extent applicable to *A. elliptica* KJELLM. The latter species is in my opinion the same as *A. dolichorhachis* KJELLM. and identical with what J. AGARDH labelled *A. muscæfolia* J. AG. from the Spitzbergen collection. Some of its forms resemble in a certain degree *A. grandifolia* J. AG. and to *A. Pylaii* GREV. as well.

The synonymization of *A. esculenta* var. *latifolia* FARL. in the list above given is wholly on the authority of SETCHELL'S view in Phyc. Bor.-Amer., No. XCIV.

Locality. North-west coast of Europe; Færöese Islands (BÖRGESEN), Beeren Island (KJELLMAN), Trömsö (KJELLMAN), Finmarken (KJELLMAN): Greenland; Hekla Havn (ROSENVENGE), Smalsund

1) SETCHELL and GARDNER: Alg. N. W. Amer., p. 278.
2) SAUNDERS: Harr. Alaska Exped., Algae, p. 425.

(JÖNSSEN): Greenland side of Baffin Bay; Julianshaab, Sukkertoppen, Jakobshavn, Claushavn (J. AGARDH): North-west coast of North America from Unalaska to Puget Sound; Kadiak Island, Orca (SETCHELL), Kukak Bay, Prince William Sound, Glacier Bay (SAUNDERS), Vancouver Island (LYALL, HARVEY).

Alaria crassifolia KJELLM.

(Plate IX, figs. 1–3; Plate X, figs. 1–3; Plate XVIII, figs. 1–18.)

KJELLM. och PETERSEN: Om Japans Lamin., p. 276, Tab. X, fig. 9–12.—DE TONI: Syll. Alg. III, p. 330.—OKAMURA: On Laminaria of Japan, p. 99.—MIYABE: Lamin. of Hokkaido, p. 54, Pl. 23 (in Japanese).

Definition of the species. Root, holdfast of dendritic ramification. Blade linear-lanceolate, 0.5–1.5 meters in length, 5–20 cm. in breadth, membranaceous but leather-like when old, richly frosted with cryptostomata on both surfaces, margin entire, splitting in the older parts of the blade obliquely or almost transversely towards the midrib; base of blade generally acute, but often abruptly expanded at some distance above the transition point; tip of blade narrowed above, pinnately cleft and generally roughly eroded away. Stipe 4–15 cm. in length, cylindrical below, 2–3 mm. in diameter, gradually terete and broadened above, measuring 3–4 mm. in width, but quickly narrowed at the transition point; lower half of the length naked, upper and compressed part except the narrowed region bearing the sporophylls. Midrib smooth, complanated, 2–6 mm. broad, elevated, often prominent above the blade on both surfaces with angulate edges, continuous to the stipe below. Sporophylls, metasoric, numerous, pinnately arranged on both margins of the complanated part of the stipe, a few lowermost

ones at wide intervals, but middle and upper ones approximate and regularly disposed, adding new ones successively upwards, long linear, 5–20 cm. in length, with well-defined cylindrical petioles; base of sporophyll acute or obtuse, very often asymmetrical; tip, when entirely soriferous, attenuate with obtuse apex, and when partially soriferous the upper sterile part often abruptly expanded with round margin. Sorus generally formed in a continuous patch on both surfaces of each sporophyll, occupying the entire surface except a narrow border along the margin, resulting in a considerable thickness of the sporophyll; or often leaving a sterile portion at the upper part of the sporophyll. In the latter case, the upper limitation of the sori is gradual and faint.

Remarks on the limit of variations. The species is characterized by having unrivalled thick sporophylls when they become fully matured. MIYABE states, l. c., p. 54, that the margins of immature sporophylls are finely serrated. But this statement is resulted from a false observation of the fine crispation of the sterile margins frequently met with, certainly due to the greater growth of the marginal parts than the soriferous area (Plate X).

In the mode of attachment of sporophylls to the stipe, the present species agrees exactly with *A. esculenta* GREV. While the sporophylls have not yet matured and the peculiarity of the species is not conspicuously manifested, both species are hardly separable one from the other.

Specimens from the type locality have generally the matured sporophylls enormously thickened and frequently entirely free from the sterile portion, as illustrated by KJELLMAN. Very often, however, the upper part of some sporophyll is broadened and remains sterile and membranaceous for the whole life. This aberrancy grows greater and greater as we trace the species towards

the eastern and the southern coast, considering the type locality as the center of its distribution.

Remarks on the relationship to other species. The present species has a close resemblance in many respects to *A. esculenta* of the Atlantic coasts. If both had been found near each other, one might well have been taken as a variety of the other. The only and marked distinction between them lies in the considerable thickening of the matured sporophylls of the present species. The species, however, has only a limited area of distribution and can not in any way represent in the Pacific the position of *A. esculenta* in the Atlantic.

The specimens collected on the coast of Hidaka Province generally have the sporophylls much thinner and broader than the typical form and the matured ones apparently holosoric. The characteristic arrangement of the sporophylls is obliterated in them. They are to be determined as *A. prælonga* KJELLM. better than as the present, if the blades had not been frosted with rich cryptostomata. It is not seldom to find a specimen which appears to link the two species. This view is much strengthened by the relative positions of their distributive areas. *A. prælonga* is found in the southern part of Kamtschatka, and then along the Kurile group as far south as near Cape Erimo, Hidaka Province, on the coast of Hokkaido. It there disappears and in its stead the present plant occupies the coasts further southwestward. As the intermediate forms are usually confined to about the crucial region of the two species, one might be regarded as a variety of the other due to the locality. The typical forms of both, however, are so well marked that I can not bring them together in our present conception of species.

A parallel example may be given in *Laminaria*. The vicinity

of Cape Erimo is a frontier of *Laminaria longissima* MIYABE,[1] a Kurile species, and *L. angustata* KJELLM. which has exactly the same distributive area as *A. crassifolia*. Both species of *Laminaria* are very much alike, but are still distinct.

Locality. Hakodate (KJELLMAN and PETERSEN)(!); Todohokke (MIYABE); Shitsukari (MIYABE); Muroran (MIYABE); Urakawa (MIYABE); Kamaishi, Rikuchu Prov. (Y. TANAKA); Tashiro-jima, Rikuzen Prov. (Y. TANAKA); Oma, Mutsu Prov. (!).

Alaria esculenta GREV.

(Plate XI, fig. 1–3.)

Alg. Brit., p. 25, Pl. IV.—HOOKER: Brit. Fl. II, p. 271.—ENGL. BOT.: Pl. 1759.—KÜTZ.: Phyc. Gen., p. 347, Taf. 32, Fig. 1 (excl. synon.).—HARV.: Phyc. Brit. Pl. 79 (excl. synon.)—Id.: Manual, II Edit., p. 29, Pl. 3.—J. AG.: Spec. Alg. I, p. 143 (excl. synon.).—Id.: Grönl. Lam. och Fuc., p. 22.—STRÖMF.: Algenveg. Island Kuster, p. 38.—KJELLM.: Alg. Arct. Sea, p. 212.—Id.: Handbok, p. 19.—BÖRGES.: Alg. Faeröes p. 448 (excl. var. *pinnata*).—Id.: Mar. Alg. Shetlands, p. 5.—COLL., HOLD. et SETCH.: Phyc. Bor.-Amer., Fasc. D, No. XCIII.—ROSENV.: Om Frem. Alger Jullands Vestkyst, p. 94.

= *Fucus esculentus* L.: Mantissa, p. 135.

= *Fucus esculentus* LYGHTF.: Flora Scot., Tab. 117.—STACKH. Ner. Brit., Tab. 29.—TURNER: Hist. Fuc., Tab. 117.

= *Fucus esculentus* GUNN.: Acta Nidaros, IV, Tab. VIII, Fig. 1.

= *Fucus teres* GOOD. et WOODW.: in Trans. Linn. Soc., III, p. 140.

= *Fucus tetragonus* GOOD. et WOODW.: in Trans. Linn. Soc., III, p. 140.

= *Ceramium esculentum* STACKH.: Ner. Brit., p. XXIV.

= *Musœfolia esculenta* STACKH.: in Mem. Soc. Mosc., II, p. 66.

= *Orgyia esculenta* STACKH.: Ner. Brit. Edit. II, p. 98.

= *Phasganon esculentum* GRAY: Arrang. Brit., Pl. I.

1) MIYABE: Lam. of Hokkaidō, p. 37, Pl. 4.

= *Laminaria esculenta* LAMX.: Essai Thalass., p. 22. — AG.: Synopsis, p. 16.—Id. Systema Alg., p. 269.—Id.: Spec. Alg., p. 110.—STRÖMF.: Act. Havn, 10, Tab. F, fig. 2.—LYNGB.: Hydrophyt. Dan., p. 23.
= *Laminaria esculenta tæniata* DE LA PYL: Flora Terr. Nouv. in Ann. Sci. Nat., IV, p. 177.
= *Laminaria esculenta* var. *Noltii* HORNEM.: Dansk Oekon. Plant, II, p. 737.
= *Laminaria linearis* DE LA PYL: Flora Terr. Nouv., p. 37.?
= *Laminaria Noltii* AG. in litt. (Herb. Trinity Coll., Dublin).
= *Alaria musæfolia* KJELLM. Algenveg. Murm. Meeres, p. 35.
= *Alaria esculenta* f. *australis* KJELLM.: Alg. Arct. Sea, p. 212.
= *Alaria esculenta* f. *musæfolia* KJELLM.: l. c.
= *Alaria esculenta* f. *pinnata* FOSL.: Mar. Alg. Norw., I, p. 71 (excl. synon.).
= *Alaria esculenta* f. *typica* BÖRGES.: Alg. Faeröes, p. 449.
= *Alaria esculenta* f. *fasciculata* STRÖMF.: Algenveg. Island Kuster, p. 38.
= *Agarum esculentum* BORY: Dict. Class. IV, p. 194.
?= *Alaria esculenta* HARV.: in Smith. Inst. for 1867, p. 463.

Definition of the species. Root, holdfast of dendritic ramification. Blade linear-lanceolate, 1–6 meters long, 5–20 cm. broad, membranaceous, frosted with cryptostomata on both surfaces, margin entire, splitting in the older parts of the blade obliquely towards the midrib; base of blade gently tapering below when young, acute in adults; tip of blade narrowed above, generally pinnately cleft and roughly worn away. Stipe 8–20 cm. in length, subcylindrical below, 2.5–3.0 mm. in diameter, gently broadened and terete upwards, measuring 4–6 mm. in width, but quickly narrowed at the transition point; lower half of the length naked, upper half bearing the sporophylls. Midrib smooth, complanated, elevated above the blade equally on both surfaces with angulate edges, continuous to the stipe below. Sporophylls, metasoric, numerous, pinnately arranged on both margins of the complanated part of

the stipe, a few lowermost ones at wide intervals, but middle and upper ones approximate and regularly disposed, adding new ones successively upwards, narrow cuneate, 5–15 cm. in length, tapering gently into cylindrical petioles towards the attachment point to the stipe; tip round or obtuse. Sorus in a continuous patch with sharp boundary on both surfaces of each sporophyll, occupying lower half area of the surface except a narrow border along the margin.

Remarks on the limit of variation. In Illustr. Alg., POSTELS and RUPRECHT distinguished various formæ under the present species, viz., *angustifolia*, *latifolia* and *pinnatifida*. As will be stated below, the specific conception taken by these authors is much wider than as we now define the species. The three formæ, therefore, must be separated from the present heading. What are meant by these formæ will be treated later on.

FARLOW mentions a variety of the present species, var. *latifolia*, in Marine Algae of New England, p. 97. It has been referred to *A. Pylaii* GREV. by SETCHELL. Cfr. Phyc. Bor.-Amer., No. XCIV.

KJELLMAN distinguished two formæ, f. *australis* and f. *musæfolia*, and referred to some old descriptions under each name. But the specimens collected by FOSLIE at Lödingen and determined by KJELLMAN as f. *musæfolia*, now kept in the Agardhian Herbarium, do not agree with the authentic specimens of *Laminaria musæfolia* DE LA PYL in important points and are nothing but a typical form of *A. esculenta* GREV.

STRÖMFELT distinguished a form with densely aggregated sporophylls under f. *fasciculata*. BÖRGESEN[1] remarks that this form comes quite near to what he called *A. esculenta* f. *typica*. He mentioned another forma, f. *pinnata* and refers to *Fucus pinnatus*

1) BÖRGESEN: Mar. Alg. Færöes, p. 449.

GUNN. It is to be remarked here that in Tange des ochotischen Meeres, p. 364, RUPRECHT says: "*Alaria esculenta pinnatifida* Illustr. Alg. p. 11 vielleicht mit Ausschluss des synonyme von GUNNER, ist die fiederförmig eingeschnittene Form, die wohl bei dem breit —als auch schmalblättrigen *Ph. alatum* und den übrigen unsicheren Arten vorkommen kann."

The plant undergoes various modifications in the shape of the frond according to its environment. In some cases, when it grows in an open sea with comparatively rough water and full sunlight, the blade becomes longer and the sporophylls generally approximate, narrower and longer, as to agree with f. *fasciculata* STRÖMF. On the other hand, the plant has some tendency to approach *A. crassifolia* KJELLM., especially when the sporophylls are entirely soriferous and much thickened. The present writer holds the view that these two species are very closely related to one another, the former inhabiting the Atlantic and the latter the Pacific, acquiring more or less distinct local characters.

Some authors regarded the general shape of a cross section of the midrib as important enough for specific distinction. RUPRECHT, STRÖMFELT, GUNNER, etc., have mentioned various species based on this character, while otherwise they may be taken as mere forms within the specific limitation of *A. esculenta* GREV. BÖRGESEN also applied the character in separating *A. esculenta* and *A. Pylaii*. He, however, notes that the young specimens of *A. esculenta* often have midribs which must properly be called two-edged. As this question is not yet fully settled, I do not at present attempt to amalgamate the two imperfectly known species, *A. linearis* STRÖMF. and *A. flagellaris* STRÖMF., with the present species.

However the frond may vary in the shape, the mode of

arrangement of the sporophylls is nearly constant and unrivalled in its regularity among the Atlantic members of the genus. When the sporophylls are densely aggregated, the plant may often show a character comparable with *A. grandifolia* J. AG. On the contrary, when they are widely separated, such as in an immature specimen, the plant may often be taken as a form of *A. Pylaii* GREV. In the present species the narrow cuneate sporophylls and their regular arrangement, with each petiole distinctly separated, are well defined and most important characters for distinguishing it from its allied species.

Remarks on the synonyms. In the sense of the old writers, *Fucus esculentus*, now called *Alaria esculenta*, covers almost all species of what at present we bring under the genus *Alaria*. Even to such a keen observer as HARVEY, distinctions between various specimens accessible to him have not been regarded as important enough for separation into independent specific rank. In the floristic lists of the North Pacific, written by early writers, therefore, the name *Alaria esculenta* is repeatedly mentioned. The Pacific Ocean, however, does not produce this species so far as our present researches extend, hence the specific name in such lists does not mean more than "*Alaria* sp."

When RUPRECHT worked out Tange des ochotischen Meeres, he distinguished three species of *Alaria*, viz,, *A. esculenta*, *A. fistulosa* and *A. marginata*. He chose, however, to call them by the genus *Phasganon* instead of *Alaria*, and *A. esculenta* was synonymized under *Phas. alatum*, which specific name he found in CARGILL'S work. It is therefore quite natural that we find various different species of *Alaria*, in our specific conception, from the North Pacific under the species cover of *Phas. alatum* in the herbarium of the Academy of Science of Petrograd. Two authentic

specimens from RUPRECHT are now kept in the Agardhian Herbarium at Lund, one annexed with *A. prælonga* KJELLM. and the other with *A. angusta* KJELLM. In Grönlands Lam. och Fucaceer, p. 23, J. AGARDH notes that RUPRECHT's specimens come quite near *A. esculenta*. Another specimen distributed by RUPRECHT under *Phas. alatum* is to be found in the Botanical Museum of Berlin, and to me it seems to belong to *A. valida* SETCH. et KJELLM.

The name *Fucus alatus* established by CARGILL in 1620 may be the first botanical name proposed for the plant. This is why RUPRECHT has chosen to call the plant *Phasganon alatum*, and a lengthy history of the name is given by him in his Tange des ochotischen Meeres, p. 266–377. To cast away the name *Alaria esculenta* so commonly known to us, giving the priority to a pre-Linnean ambiguous description, seems by no means acceptible.

The name *Fucus pinnatus* GUNN. is found placed in a synonymous position under various species by different writers. In Grönlands Lam. och Fucaceer, p. 23, J. AGARDH refers to it under *A. musæfolia*, regarding it as a synonym of *Laminaria musæfolia* DE LA PYL. In Illustr. Alg., p. 11, POSTELS and RUPRECHT mention the name under *A. esculenta* f. *pinnatifida*. This forma is discussed by RUPRECHT in Tange des ochotischen Meeres, p. 364, under *Phas. alatum* var. *pinnatifida*, and he seems to hold the view that the pinnately cleft blade is indifferent to the age of the plant but is a peculiarity of the species or forma. In the latter work he excluded GUNNER's species as a synonym of the forma mentioned in Illustr. Alg. The original specimens in the herbarium of the Academy of Science of Petrograd show that they are to be separated into more than two species, simply having the pinnately cleft blades as a common character.

HARVEY[1] mentions *Fucus pinnatus* FL. NORV. as a synonym of *A. esculenta* GREV. The same view is adopted by the Scandinavian algologists such as KJELLMAN,[2] FOSLIE,[3] BÖRGESEN,[4] and JÖNSSON.[5] GOBI[6] also holds the same view but chose the name *Orgyia pinnata* instead of *A. esculenta* GREV. on account of priority. He further stated that some of the specimens which he calls *Orgyia pinnata* seem to stand very near "f. *membranacea* J. AG."[7] This resulted in an ambiguous disposition of GOBI's species in DE TONI's Syll. Alg., III, p. 327, in which *Orgyia pinnata* GOBI is found in a synonymous position under *A. membranacea* J. AG.

The views enumerated above are so widely divergent from each other that I am unable even to model a general character of the plant. I have not seen GUNNER's type specimen nor any co-type of it. GUNNER's original description and illustration can not help us to catch the exact specific characters in the modern sense. It is, however, almost beyond doubt that the plant which GUNNER has designated as *Fucus pinnatus*, occurring on the Norwegian coasts, must have been *A. esculenta* GREV.

RUPRECHT seems to have believed that *Fucus platycarpus* GMEL., illustrated in Hist. Fuc., Pl. XXXI, might have been a stipe of *A. esculenta* or as he later calls it, *Phas. alatum.* But what GMELIN has figured is undoubtedly a stipe of an old and decayed plant of *Thalassiophyllum clathrus.* Specimens exactly agreeing with GMELIN's figure may be found everywhere on the coasts of the northern

1) HARVEY: Phyc. Brit. Pl. 79.
2) KJELLMAN: Handbok, p. 29.
3) FOSLIE: Mar. Alg. Norway, I, p. 71.
4) BÖRGESEN: Mar. Alg Færöes, p. 448.
5) JÖNSSON: Mar. Alg. of East Greenl. p, 24.
6) GOBI: Alg. Weissen Meeres, p. 77.
7) GOBI simply mentions this form-name without giving any hint as to which species this forma should belong. So far I could refer to, such form-name has never been proposed by J. AGARDH for either *A. esculenta* or *A. Pylaii.*

Kuriles and southern Kamtschatka after a stormy weather during August-September.

Again, RUPRECHT[2] considers *Fucus fimbriatus* GMEL., Hist. Fuc., Pl. XXIXa, to be referrable to *A. esculenta β latifolia* P. et R. But judging from the figure, I believe that it may be *Cymathere triplicata* J. AG.

The original specimen of *A. esculenta* f. *muscæfolia* KJELLM. in the Herbarium of the Botanical Museum of Upsala shows all the characters of *A. esculenta* GREV., so it is not worth mentioning under a special forma. In Spetz. Thall., II, p. 12, KJELLMAN states, "Mellan *A. esculenta* och *muscæfolia* är skillnaden icke betydlig." By "*muscæfolia*" KJELLMAN certainly means *A. muscæfolia* J. AG. As may be understood from what has been stated on p. 91 and 102, *A. muscæfolia* J. AG. can not be identical with *Laminaria muscæfolia* DE LA PYL, and shall be referred to *A. dolichorhachis* KJELLM. The limitation of DE LA PYL's species seems to me to vary greatly as the writers differ. This question will be treated under *Laminaria muscæfolia* DE LA PYL.

HARVEY mentions *A. esculenta* from Alaska based on RATHBOCK's sketches of the algæ of Alaska. SETCHELL and GARDNER mention this reference under *A. esculenta* GREV. In the Herbarium of Trinity College, Dublin, there was no specimen which could be supposed as its source. HARVEY may have identified it simply by the sketch. It is quite impossible to imagine to which species of *Alaria* the sketch was referrable. In HARVEY's time, botanists had a poor knowledge of the Alaria of the North Pacific. KJELLMAN hesitatingly referred to the information under *A. dolichorhachis*, as noted on p. 93.

Locality. Mototschikin Sharr, Rogatschin Bay, Nova Zembla (KJELLMAN, under *A. muscæfolia*); Maasö (KJELLMAN), Svärtholt

(Foslie), Mehaon (Foslie), Mandal (Wille), Norway; Fanö (Rosenvenge), Denmark; Roscoff, France (Sauvageaux); Færöese Islands (Lyngbye, Börgesen, etc.); Iceland (Lyngbye); Shetland (Börgesen); Clare Island (Cotton); Cumberland (Hudson and Harvey); Anglesea and Isle of Man (Davies and Harvey); Durham and Northumberland (Winch and Harvey); Cornwall (Turner); North coast of Devonshire (Mrs. Griffiths and Harvey); Weymouth (Stackhouse); Orkney (Clouston); Angmagsalik (Rosenvenge, under *A. flagellaris*), Tasinsak (Jönssen under *A. esculenta* var. *pinnata* Kjellm.), Greenland.

Alaria valida Setch. et Kjellm.

(Plate XII, figs. 1–3.)

In Setch. and Gardn.: Algæ N. W. Amer., p. 278, Pl. XXI.—Setch.: Critical Notes on Lam., p. 11.—Id.: Kelps U. S. and Alaska, p. 163.

= *Alaria valida* f. *longipes* Setch. et Gardn.: Algæ N. W. Amer., p. 279.

= *Alaria curtipes* Tilden: Amer. Algæ, No. 521.

= *Alaria grandifolia* Collins: Mar. Algæ of Vancouv. Island, p. 110.

Definition of the species. Root, holdfast of dendritic ramification. Blade linear lanceolate, 3–4 meters in length, 15–25 cm. in breadth, coriaceous, cryptostomata wanting, margin entire, undulating, splitting in the older parts of the blade obliquely towards the midrib; base of blade attenuated for a short length, soon expanding upwards into an acute form. Stipe 6–10 cm. in length, lower half cylindrical, 3–5 mm. in diameter, gently terete and broadened above, but narrowed again at the transition point, the cylindrical part naked, the upper terete part bearing the sporophylls. Midrib

smooth, complanated, elevated above the blade equally on both surfaces with angulate edges, continuous to the stipe below. Sporophylls metasoric, 8–15 in number, pinnately arranged on both margins of the complanated part of the stipe, a few lowermost ones distant, but middle and upper ones disposed at short regular intervals, adding new ones successively upwards, linear-lanceolate, 15–50 cm. in length, 3–6 cm. in breadth, with a well-defined, short, terete petiole, margin undulate; base acute; apex varying from acute to roundish. Sorus in a continuous patch on both surfaces of each sporophyll occupying nearly the whole area of surface of sporophyll except a narrow border along the margin and often a small portion of the tip.

Remarks on the synonyms. This species was first described by SETCHELL under joint authorship with KJELLMAN in the paper cited above. He reserved the identity of the species with *A. marginata* as a question. Afterwards, in Critical Notes, l. c., he stated that his examination on the type of *A. grandifolia* J. AG. in the Agardhian Herbarium convinced him of the identity of *A. grandifolia* and *A. valida*. The specimen distributed as Phyc. Bor.-Amer., No. CV, under *A. grandifolia* J. AG. by COLLINS, HOLDEN and SETCHELL seems to have been placed by following this view. It agrees well with the description given in Algae N. W. Amer., p. 278. Although it is noted on the label of the exsiccata: "The plant here distributed are of longer form agreeing well with J. AGARDH's description and type specimen," the specimen in the copy I have seen shows a marked difference from any of the type specimens of *A. grandifolia* J. AG. The type specimens are distinguished by J. AGARDH into three formæ, *junior*, *intermedia* and *adulta*. They are equally provided with long, narrowly cuneate sporophylls. The stipe is very stout, the largest one measuring

45 cm. in length, in dried state as thick as the middle finger, cylindrical below and gradually terete above. The specimen in the Phycotheca has the stipe cylindrical nearly to the transition region, hardly 3 mm.* in diameter, the sporophylls are linear-oblong, with roundish bases and sharply defined, short petioles. In the shape and texture of sporophyll the plant approached very much *A. marginata* P. et R., but differed from it by having a distinctly narrowed midrib and in the mode of sporophyll arrangement. I wrote my questions on these points to Prof. SETCHELL and requested him to spare me a typical specimen of *A. valida*. He was kind enough to favour me with two well-prepared specimens. They are quite similar to the specimen above remarked, hence I have no more hesitation in mentioning the plant as a valid and well-defined species. In his latest work "The Kelps of the United State and Alaska," p. 163, SETCHELL mentions *A. valida* in an independent specific position.

The specimen distributed by Miss TILDEN under *Alaria curtipes* as American Algae, No. 521, in the copy I have seen, is to be identified with the present species. SETCHELL and GARDNER[1] compared the description of *A. curtipes* SAUNDERS with *A. prælonga* KJELLM. Her specimen, however, does not agree with the description, and its sporophylls show the characteristics of the Metasoria.

Locality. Unga, Alaska (SETCHELL); Whidby Island (GARDNER).

Alaria nana SCHRADER.

(Plate XIII, figs. 1–3.)

Minn. Bot. Stud., III, Part II, p. 157, Pl. 24–26.

1) SETCHELL and GARDNER: Algæ N. W. Amer., p. 274.

= *Alaria prælonga* f. *nana* SETCH.: in COLL., HOLD. and SETCH.: Phyc. Bor.-Amer., No. 1292.
= *Alaria marginata* f. *nana* COLLINS: Mar. Alg. of Vancouv. Island, p. 110.

Definition of the species. Root, holdfast of dendritic ramification. Blade linear-lanceolate, 30–50 cm. in length, 6.0–8.5 cm. in breadth, coriaceous, finely striated when old, cryptostomata wanting, margin entire, splitting in the older part of the blade obliquely to the midrib; base of blade acute, tip narrowed above, pinnately cleft and generally roughly worn away. Stipe 4–8 cm. in length, cylindrical at the base, terete or compressed above, measuring 4–6 mm. in breadth, and more or less narrowed at the transition point, lower half of the length naked, upper half bearing the sporophylls. Midrib smooth, complanated, 5–8 mm. in breadth, elevated above the blade equally on both surfaces with roundish edges, continuous to the stipe below. Sporophylls metasoric, numerous, often 40 or more, obliquely pinnately arranged on both margins of the stipe, a few lower ones at wide intervals, but middle and upper ones approximate and regularly disposed, adding new ones successively upwards, long-cuneate, 6–12 cm. long, 7–25 mm. broad, with more or less well-defined petiole; base of sporophyll tapering or obtuse, generally asymmetrical; tip obtuse or truncate, generally irregularly dentated. Sorus, on both surfaces of each sporophyll, in a continuous patch occupying the lower half of the surface with obscure and fading boundary.

Remarks on the species. The present species has a well-marked character making it readily distinguishable from the others. The sporophylls are always attenuated towards the base to form comparatively long petioles, the lower side being more developed than the upper, resulting in an oblique ascending base. This

unique peculiarity has been passed over by SCHRADER. The resemblance of the species to *A. prælonga* KJELLM. is in the texture of the blade and in the mode of the midrib, on which, however, much specific importance should not be laid. The older part of the blade is finely striated in the same manner as in *A. marginata.*

Locality. Port San Juan, Vancouver Island (SCHRADER); Lands End, San Francisco (SETCHELL).

Alaria grandifolia J. AG.

(Plate XIV.)

Grönlands Lam. och Fuc., p. 26.—KJELLM.: Spetzberg. Thall. II, p. 10.—Id.: Alg. Arct. Sea, p. 217.—Id.: Algenveg. Murm. Meeres, p. 35.—FOSLIE: Mar. Alg. Norway, I, p. 73.

= *Alaria membranacea* J. AG.: (Specimina Spitzbergenses partim).

= *Alaria membranacea* KJELLM.: Alg. Arct. Sea, p. 215.

= *Alaria membranacea* FOSLIE: Mar. Alg. Norway, I, p. 72 (excl. synon.).

= *Alaria Pylaii* var. *grandifolia* JÖNSS.: Mar. Alg. East Greenl., p. 21.—ROSENV.: Mar. Alg. N. E. Greenl., p. 112, fig. 5.

= *Alaria Pylaii* β *membranacea* JÖNSS.: Mar. Alg. East. Greenl. p. 21.—Id.: Mar. Alg. Jan Mayen, p. 306.

= *Alaria oblonga* KJELLM.: Alg. Arct. Sea, p. 220, Pl. 25, fig. 21–24.

?= *Alaria esculenta* EATON: List, p. 44 (sec. J. AGARDH).

?= *Laminaria esculenta* LINDL.: Bot. Not., p. 157 (sec. J. AGARDH).

Definition of the species. Root, holdfast of dendritic ramification. Blade linear, a few or perhaps several meters in length, 20–30 cm.* in breadth, coriceous, cryptostomata wanting(?), margin entire, undulating, splitting in the older part of the blade obliquely to the midrib; base of blade acute, often tapering. Stipe up to 125 cm.* in length, cylindrical below, up to 2 cm.* in diameter,

gradually broadened and terete or ancipitous upwards, 2–3 cm.* in width, quickly narrowed at the transition point, lower half of the length naked, upper half bearing the sporophylls. Midrib smooth, terete, elevated above the blade equally on both surfaces with roundish edges. Sporophylls metasoric, numerous, pinnately arranged on both margins of the anticipitous region of the stipe, some lowermost at wide intervals (6–10 mm.*), but middle and upper ones approximate, adding new ones successively upwards, linear-cuneate, 30–60 cm.* in length, 3–7 cm.* in breadth, tapering gently downwards into cylindrical petioles; tip of sporophyll obtuse or roundish; margin undulating plicate. Sorus in a continuous patch, on both surfaces of each sporophyll, occupying lower half area of the surface except a narrow border along the margin, and fading downwards near the base of the sporophyll.

Remarks on the synonyms. This is the second largest *Alaria* hitherto known. It is specifically described as attaining an enormous size in every part, to such extent as has never hitherto been reported of other allied species. In Spetzbergens Thallophyter, II, p. 10, KJELLMAN reports the largest specimen he has measured:— stipe, 125 cm. long, 2 cm. in diameter, bade over 100 cm. long, 30 cm. broad, sporophylls 60 cm. long, 7 cm. broad. The largest specimen of *A. grandifolia* in the Agardhian Herbarium at Lund has the stipe much shorter, but in other parts nearly the same measurement.

The original specimens of the present species at Lund are not many in number so that we are unable to trace all modifications of fronds according to the age of the plant. Specimen No. 2256, which is called forma *adulta* by J. AGARDH, is the most complete one among the set. It has a certain resemblance to a fully grown form of *A. macroptera*, but its sporophylls are long linear, tapering downwards, and the blade is not corrugated in the way

peculiar to the latter (Plate XIV). Comparing the original with *A. oblonga* KJELLM., and judging from observations on the North Pacific species, I am strongly inclined to believe that the latter may represent a young stage of the present plant. The differences between them are merely in substance of blade and size of frond, which can never be considered specific. In the Agardhian Herbarium, co-types of *A. oblonga* KJELLM. and *A. macroptera* (RUPR.) are joined together under the species cover of the latter. But, as above stated, the typical form of *A. macroptera* (RUPR.) is easily separated from *A. oblonga* KJELLM., and eventually from the present. It is not to be denied that RUPRECHT has distributed under *Phasganon macropterum* RUPR. many specimens not specifically uniform. Its co-type in Trinity College, Dublin, is more referrable to *A. dolichorhachis* KJELLM. than to any other.

JÖNSSON identified some specimens from the east coast of Greenland with the present species but mentioned them as a variety of *A. Pylaii* J. AG. The limitation taken by him for the latter species is the same as by ROSENVENGE in Grönlands Havalger, p. 838; hence, not exactly agreeing with GREVILLE or J. AGARDH. ROSENVENGE naturally followed the view in arranging his specimens from the north-east coast of the same land. The identifications by the two botanists appear to be quite correct, but to bring *A. grandifolia* J. AG. down to a variety of *A. Pylaii* GREV. seems to be open to criticism. The limits of the varieties or the forms of *A. Pylaii* have so far not been very clear. Yet I can not readily acknowledge that the form within the specific conception of the present species may be directly related with that of *A. Pylaii* GREV. A discussion on this matter is a discussion on the specific definition of *A. Pylaii* GREV.

The same writer also mentions *A. Pylaii* β *membranacea*

Rosenv. as having been collected in the same region. He remarks the variety to be "so closely connected with *A. grandifolia* J. Ag. that according to our present knowledge of these forms they can not be said to differ in anything, but their size." If he mentions in a varietal rank a specimen which differed in nothing but the size, it is in our conception naturally to be identified with the type. Kjellman has also emphatically stated that the young individuals of *A. grandifolia* collected in Spitzbergen all agree with *A. membranacea* J. Ag. Cfr. Spetzbergens Thallophyter, II, p. 12. Some of the original specimens of the latter at Lund justify the view of Jönsson and Kjellman, but some of them, especially those from Greenland, appear to me hardly distinct from *A. Pylaii* Grev. The specimens treated by Kjellman as *A. membranacea* in Algæ Arct. Sea, p. 215, are to be brought under the present species.

Locality. Jan Mayen (Jönsson): Norwegian coasts; Nordlanden (Kjellman), Finmarken (Kjellman), Maasö (Kjellman), Gjesvær (Kjellman), Berlevaag (Foslie), Kiberg (Foslie), Kjöllefjord (Foslie): Spitzbergen; North Gänse Cape (Kjellman), South Gänse Cape (Kjellman): Siberian Sea; Irkaipi (Kjellman): Greenland; Tasiusak (Jönsson), Tiningnekelak (Jönsson), Nualik (Jönsson), Kap Borlase Waren (Jönsson), Ikerasak (Jönsson), Cape Bismark Peninsula (Rosenvenge).

Alaria angusta Kjellm.

(Plate XV, fig. 1–4.)

Om Beringhafvets Algflora, p. 33, Tab. 3, fig. 1–4.—De Toni: Syll. Alg. III, p. 332.

= *Alaria laticosta* Kjellm.: Om Beringhafvets Algflora, p. 40, Tab. 6, fig. 1–3.—De Toni: Syll. Alg. III, p. 331.

?= *Alaria esculenta* P. et R.: Illustr. Alg., p. 11. *p.p.*

Definition of the species. Root, holdfast of hemispherical shape in general outline, with the rhizines at first thick and complanated, and broadened outwards, soon ramifying quickly and irregularly, each final segment terminating in a hapter. Blade linear-lanceolate, 1–2 meters in length, 4–8 cm. in breadth, coriaceous, cryptostomata wanting, margin entire, but splitting obliquely or almost transversely to the midrib in the older part, outer border of segments often subulate and curved upwards; base acute or tapering, not rarely more or less abruptly expanding upwards. Stipe 4–10 cm.* in length, cylindrical below, 2–5 mm.* in diameter, terete above, suddenly narrowed at the transition point. Midrib smooth, complanated, 4–6 mm.* broad but sometimes as broad as 9.5 mm.* in the dried specimens, prominent above the blade equally on both surfaces with angulate edges. Sporophylls metasoric, numerous, fasciculate, condensed to a broadened short length near the upper end of the stipe, adding new ones upwards as well as between the older ones, long, linear, 6–10–15 mm.* in breadth, 25–40 cm.* in length, attenuated towards the base, ending in filiform petioles, round or acute at the apices. Sori gradually fading towards the apex of sporophyll.[1)]

Remarks on the limit of variation. The present and the next species have various peculiarities in common, so that one may be taken as a variety of the other. Still, as both are pretty safely separable from each other by the shapes of the sporophylls, I choose to keep them both in specific rank. When yet young, a few sporophylls are produced from the margins of the stipe more or less apart. In such a stage of development, the plant may be taken as a young form of *A. esculenta*, *A. prælonga*, or the like.

1) The sterile, upper portions of the sporophylls remain in healthy condition for a considerable time. In some specimens the portions are maculated in the manner of shagreen leather.

In the matured forms, however, the sporophylls of this species are found limited to a short length of the stipe near the transition point. The part of the stipe which bears the fasciculate sporophylls is somewhat more broadened than the naked part. New young sporophylls may grow not only successively above the other, but often from a point between the older ones. This mode of localization of the sporophylls should be distinguished from a condensed pinnation in which a large number of the lower sporophylls has dropped owing to age. KJELLMAN, in defining the three species, *A. prælonga*, *A. lanceolata*, and *A. laticosta*, made no distinction in the modes of disposition of the sporophylls and simply diagnosed "sporophyllis numerosissimis, fasciculatis,...."

The size of sporophylls and blades, consequently the breadth of the midribs are variable in this species. This is perhaps due more to the roughness or salinity of the water than to the age of the plant. KJELLMAN appears to have put too much stress on this sort of variation as to describe individuals of different size in different specific position.

Remarks on the synonyms. I propose to combine *A. laticosta* KJELLM. with the present. The former was established from a single specimen cast ashore in the same locality as the latter. By comparing the type specimens of both at Upsala and referring to their descriptions I can not find out any marked difference between them except in the breadths of the midribs. This is by no means of specific importance as can be proved from the specimens at my disposal. In the type specimens of *A. angusta* the midribs vary from 4 mm. to 6 mm. in breadth in the dried state, while the type of *A. laticosta* measures 9.5 mm. KJELLMAN gave the measurements from wet preparations.

SAUNDER'S[1] has identified a plant from Kukak Bay with *A. laticosta*. He quotes KJELLMAN'S opinion on his specimen which reads; "The form, color and consistency of the blade, and the form, width and rigidity of the sporophyll differ somewhat from this species." I do not understand how SAUNDERS could dare identify his specimen with *A. laticosta* KJELLM. in spite of such an opinion from the author. The points mentioned by KJELLMAN are the important characters for specific distinction, and the breadth of the midrib, on which SAUNDERS seems to have put great stress, is hardly of specific importance as stated above.

There are two specimens of *Alaria*, kept in the herbarium of the Academy of Science of Petrograd under *A. esculenta*, collected by POSTELS in 1849. The locality is given as "Sitka (an St. Paul?)" in RUPRECHT'S handwriting. One of them is a big plant with the blade about 6 feet in length, 3–4 inches in breadth, the base attenuating and the midrib prominent, 3–4 mm. in breadth; the stipe is hardly an inch long, but provided with fasciculate, numerous sporophylls of about a foot in length and one third of an inch in breadth. The other specimen has the sporophylls about an inch in breadth and 5 inches in length. These are undoubtedly the specimens related to in RUPRECHT'S Tange des ochotischen Meeres, p. 360. I could not determine them with accuracy but they seemed to me very likely to be referrable to this species or to *A. lanceolata*.

Locality. Bering Island (KELLMAN); ?Sitcha (POSTELS); Urup Island and Etorofu Island, South Kuriles (K. MIYABE, Herb. S.A.C.).

1) SAUNDERS: Harr. Alaska Exped., Algæ, p. 425.

Alaria tæniata KJELLM.

(Plate XVI, figs. 1–5.)

Om Beringhafvets Algflora, p. 36, Pl. 7, fig. 1–3.
= *Alaria esculenta angustifolia* P. et R.: Illustr. Alg., p. 11, *p.p.*

Definition of the species. Root, holdfast of hemispherical shape in general outline, with the rhizines at first thick and complanated and broadened outwards, soon ramifying quickly and irregularly, each final segment terminating in a hapter. Blade linear or band-form, attaining to 3.70 meters in length, but measuring 3.5–5.0 cm. in the maximum breadth, coriaceous, cryptostomata wanting, margin entire, splitting obliquely to the midrib in the older parts; base of blade cuneate or attenuate; Stipe 5–6 cm. in length, cylindrical below, 2.5–3.0 mm. in diameter, terete above, and suddenly narrowed at the transition point. Midrib smooth, complanated, 2–3 mm. broad, prominent above the blade on both surfaces with angulate edges, continuous to the stipe below. Sporophylls metasoric, numerous, fasciculate, limited to an abruptly expanded short length near the upper end of the stipe, adding new ones successively upwards as well as between the older ones, linear-lanceolate, attenuated towards the base ending in filiform petioles, acute or tapering at the apices. Sorus occupying a greater part of the surface of sporophyll, leaving a terminal portion and a narrow border along the margin sterile.

Remarks on the species. After a close study of the original specimen of *A. tæniata* KJELLM. in the Botanical Museum of Upsala I have little doubt of its identity with the Alaskan specimen of *A. esculenta angustifolia* P. et R. in the herbarium of the Academy of Science of Petrograd. The limitation of f. *angustifolia* P. et R.

taken in Illustr. Alg. is quite ambiguous even when we try to draw a definite conception from the original specimens. I choose therefore to take the specific name proposed by KJELLMAN to the present plant. POSTELS and RUPRECHT refer *Laminaria esculenta tæniata* DE LA PYL to their forma, but this forma has been referred by many algologists to *A. esculenta* GREV.

KJELLMAN relates (l. c., p. 37) that he collected only one specimen of this species, cast ashore on Bering Island. The species, however, as already supposed by KJELLMAN, seems fairly common in the northwestern Pacific as it is often found along the Kurile Islands as far southwest as Hidaka Province in Hokkaido. As stated by KJELLMAN, the plant, especially when sterile, considerably resembles the Atlantic species *A. esculenta*. The sporophylls, however, are strictly limited to a short length of the stipe, 40–50 sporophylls aggregated within 6–8 mm. on each side. The same writer remarks also that this species stands nearest to *A. fistulosa*. He mentioned the shapes of the midribs as the reason. This, however, appears to me quite opinionate as has been already pointed out on p. 78.

In Fertilizer Resources of the United States, p. 162, SETCHELL has provisionally combined *A. angusta* and *A. crispa* KJELLM. with the present species. As SETCHELL states in it, all these three species have not been seen since the original collection. In our collections the material is ample enough to conclude that *A. tæniata* KJELLM. is a good and distinct species. It stands quite near the preceding species as already stated, but the present plant has invariably small sporophylls of lanceolate shape with acute or tapering apex.

Locality. Bering Island (KJELLMAN); Kushiro Province (K. WADA, Herb. S.A.C.), Hidaka Province (K. MIYABE, Herb. S.A.C.), Hokkaido.

Alaria lanceolata KJELLM.

(Plate XVII, figs. 1–3.)

Om Beringhafvets Algflora, p. 39, Tab. 5, fig. 1–3.—DE TONI: Syll. Alg. III, p. 331.

?=*Alaria lanceolata* SAUNDERS: Harr. Alaska Exped., Alagæ, p. 426, Pl. LIII.

?=*Alaria dolichorhachis* SETCH.: in COLL., HOLDEN and SETCH.: Phyc. Bor.-Amer., No. XLI.

Definition of the species. Root, holdfast of dendritic ramification. Blade linear-lanceolate, 1–2 meters in length, coriaceo-membranaceous, with cryptostomata except in lower portion, margin entire, more or less undulately plicated, base cuneate. Stipe very short, hardly a few centimeters in length, subterete. Midrib smooth, complanated, 4–7 mm. broad, slightly prominent. Sporophylls metasoric, numerous, limited to a short length of the stipe, but distinct, linear-cuneate or cuneate-spathulate, 6–10–15 mm. in breadth, 12–20 cm. in length, subcoriaceous. Sorus on both surfaces of each sporophyll in a continuous patch, generally occupying a greater part of the surface, leaving a terminal portion and a narrow border along the margin sterile.

Remarks on the affinity to other species. This has been a rather incompletely defined species. SAUNDERS, SETCHELL, COLLINS, etc., reported the present species from the northwest coasts of North America. I am, however, of the opinion that the specimens which they have determined as this may be more safely referred to other species, such as *A. prælonga* KJELLM., *A. marginata* R. et R., or *A. dolichorhachis* KJELLM.

The present species has some resemblance to *A. angusta* KJELLM., *A. tæniata* KJELLM. and *A. prælonga* KJELLM. It can be

distinguished from them by the presence of cryptostomata in the blade. In some specimens, however, they are often absent in a lower portion, and in some old ones they remain simply a brownish dots on the blade, losing all the hairs from the very base. Thus the distinguishing character is frequently unreliable. In such case it may be separated from the former two species by the holdfast, and from the last one by the sporophylls.

The illustration of *Alaria* delineated by SAUNDERS as Harr. Alaska Exped., Algæ, Plate LIII, under *A. laticosta*, is rather embarrassing for positive determination. He does not give its full description but simply remarks that his determination was after receiving KJELLMAN'S opinion on one of his specimens and that it is easily recognized by the tufts of "long cryptostomata" richly frosted on the surface of the blade. The type specimen of *A. lanceolata* KJELLM. has cryptostomata but not in such a way as to count as a specific peculiarity; and the density of cryptostomata is never of specific importance. The species is diagnosed to have the sporophylls fasciculate and the type specimen shows this character very well. The illustration by SAUNDERS clearly shows that they are condensed but pinnately arranged. In general appearance of frond, SAUNDERS's plant resembles *A. elliptica* to a certain extent. I have not noticed any cryptostoma in the co-type of *A. elliptica* at Lund, and nothing is stated by KJELLMAN relating to this point.

Locality. Sitcha Harbour (SAUNDERS); Glacier Bay (SAUNDERS); Bering Island (KJELLMAN); North Kuriles(!).

Species Doubtful.

Laminaria musæfolia De la Pyl.

Flora Terre Neuve, p. 31.

I have not seen any reliable authentic specimen of this species. In the Agardhian Herbarium at Lund there is a fragment of *Alaria* collected in Newfoundland and sent from De la Pyl under *Laminaria musæfolia*. It is a part of the blade, cut off on both ends, without sporophyll or any other part which shows the specific characters.

In Grönlands Lam. och Fucaceer, p. 23, J. Agardh refers to the descriptions of *Alaria* by various former writers under *Alaria musæfolia* J. Ag., but mostly with ample doubts. Judging from the specimens in the Agardhian Herbarium, J. Agardh's specific conception of *A. musæfolia* J. Ag. seems to be very uncertain. Several of them from the Atlantic coast of North America appear to be satisfactorily identified with *A. Pylaii* Grev. and one from Spitzbergen is, in my opinion, to be determined as *A. dolichorhachis* Kjellm.

In Fertilizer Resources of the United States, p. 163, Setchell mentions *A. musæfolia* J. Ag. in an independent specific rank and assigns it to the Atlantic coast of North America, from Newfoundland to Maine. This may perhaps mean a form which is treated in the present Monograph under *A. Pylaii* Grev.

In Spetzbergens Thallophyter, II, p. 12, Kjellman remarks:— "Mellan *A. esculenta* och *musæfolia* är skillnaden icke betydlig." This is probably the ground on which he reduced *Laminaria musæfolia* De la Pyl to a forma of *A. esculenta* Grev. But what he understood by *L. musæfolia* is not very clear to me. The type

of *A. esculenta* f. *musæfolia* KJELLM., Algæ Arctic Sea, p. 212, is a typical form of *A. esculenta* GREV. He also mentions the species in the list of algæ from Nova Zembla. Cfr. Algenveg. Murman. Meeres, p. 35. He regarded it as a northern form of *A. esculenta* (Algæ Arctic Sea, p. 213).

I am inclined to suppose that DE LA PYL meant by *Laminaria musæfolia* those individuals of *Alaria* which have the blades transversely cleft so as to resemble a *Musa* leaf, and by *Laminaria esculenta* var. *platyphylla* those which have blades still young and plain, without placing much importance on the other characters.

Alaria Delisii GREV.

Alg. Brit. Synop., p. 39.
= *Agarum Delisii* BORY: in Dict. Class., IX, p. 194.
= *Orgyia Delisii* TREVISAN: Nomencl. Alg., p. 28.

This species has been established on the material brought to Europe by DELISE from Newfoundland. I did not see any authentic specimen. RUPRECHT doubts the species, thinking it referrable to *Laminaria esculenta* var. *remotifolia* DE LA PYL. Cfr. Tange des ochotischen Meeres, p. 364.

Alaria linearis STRÖMF.

Alg. Island. Kust., p. 38, Tab. II, fig. 2–3.

Alaria flagellaris STRÖMF.

Alg. Island. Kust., p. 42, Tab. II, fig. 4–6.

These two species described by STRÖMFELT are not satisfactorily known to me. The most important and distinguishing characters

of these species seem to lie, as proposed by STRÖMFELT, in the shape of cross section of the midrib. RUPRECHT has also taken a similar point as an important character in discussing *Fucus tetragonus* and *Fucus teres*, comparing them with *A. esculenta* P. et R. BÖRGESEN too, used this character in distinguishing his Færöese specimens into *A. esculenta* GREV. and *A. Pylaii* GREV. What systematic value the rectangular or ancipituous shape of the cross sections of the midrib may have is very doubtful to me. BÖRGESEN notes that young specimens of *A. esculenta* "often have a midrib which must most properly be called two-edged." This fact induces me to suppose, as well as the fact that *A. flagellaris* is known in a sterile stage only, that the two species described by STRÖMFELT are really only one species and also that they may be local forms of *A. esculenta* GREV. It appears almost safe to bring *A. linearis* STRÖMF. down to a synonym of *A. esculenta* GREV. There still remains a question about *A. flagellaris*. It may be regarded as a younger form of *A. esculenta* GREV., or referrable to *A. Pylaii* GREV., or a distinct form or species.

It is to be noted that there are two distinct forms of the cross sections of the midribs of the Atlantic forms of *Alaria* which are passing under *A. esculenta* GREV. One is decidedly rectangular and has a well marked spanning cortex and thick medullary sheath, and the cartilaginous content in the sieve cells is highly developed. The other is elliptical or ancipitous elliptical in the shape, the medullary sheath slightly broader than in the remaining part, the spanning cortex limited to the crucial point and the cartilaginous content of the trumpet hyphæ, so far as I have examined, not recognizable. Experiences teach me that the anatomical differences as here mentioned may not be of much importance in the specific distinctions. Still, these two forms appear to me

not to be due to the age of the plant, as they have been separable in the well developed and matured specimens. If we follow STRÖMFELT'S view, the latter should be referred to *A. flagellaris*.

The material of the Atlantic forms of *Alaria* at my disposal is limited in number and seems by no means to represent every possible form. I think it, therefore, better to leave the point in an unsettled state, for a future investigation by one who may have material enough to command these forms.

ROSENVENGE[1] determined three specimens from Greenland as *A. flagellaris* STRÖMF. Some of these were sporophyll-bearing. According to the measurements of the plants given by him, the largest sporophyll was 40 cm. in length. He remarks:—"Cette espèce paraît être très voisine de l'*A. Pylaii* et de l'*A. grandifolia*: reste á rechercher, si elle en est bien distincte." This may be understood as assuring that his specimens are not referrable to *A. esculenta*. JÖNSSON mentions ROSENVENGE'S *A. flagellaris* under *A. esculenta* var. *pinnata* (GUNN.) KJELLM., though without stating the reason for doing so.

To the above discussion, the observations of GOODENOUGH and WOODWARD must be brought into consideration. In TURNER'S Historia Fucorum, Vol. II, p. 120, it says:—"The excellent authors of observation upon the British Fuci have, in the Linnean Transactions, divided *F. esculentus* into two species, to which they have given the names of *F. teres* and *F. tetragonus* and they have pointed out such striking characters of distinction between them, that, were these only permanent, there could be no question of their being sufficient to establish priority of this separation ...." So TURNER related the unseparableness of two such forms. In my opinion, what the two observers have mentioned as the distinc-

1) ROSENVENGE: Deux. Mém. Alg. Mar. Groenland, p. 50.

tions between the two "species" are mostly the differences of the frond according to the age of the plant.

Species Removed.

Alaria amplexicaulis MARTENS.

Preus. Exped. nach Ost-Asien, Tange, p. 114.

Alaria pinnatifida HARVEY.

Character of New Algæ, p. 329.

Both are synonyms of *Undaria pinnatifida* SURINGAR.

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Published May 30th, 1919.

K. Yendo:

A Monograph of the Genus *Alaria*.

Plate I.

Plate I.

Alaria fistulosa POST. et RUPR.

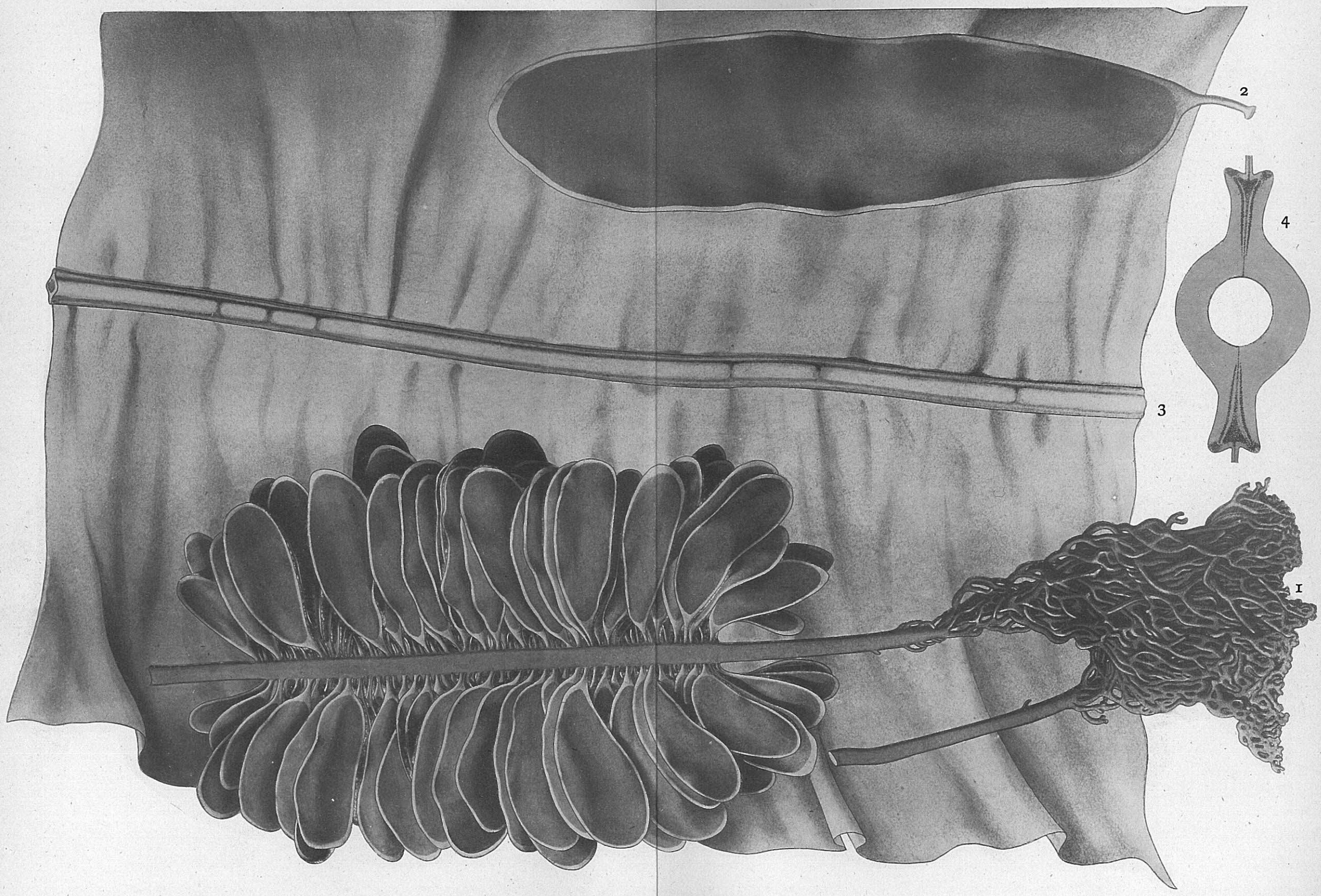
Fig. 1. Basal parts of two matured plants to show the sporophyll-bearing stipe and the holdfasts. $\times \frac{1}{2}$.

Fig. 2. A matured sporophyll in natural size.

Fig. 3. A part of the blade of a comparatively young plant. $\times \frac{1}{2}$.

Fig. 4. Cross section of the midrib. $\times 3$.

(Figs. 1–3 after MIYABE with a little modification).



K. Yendo. Alaria fistulosa Post. et Rupr.

Plate II.

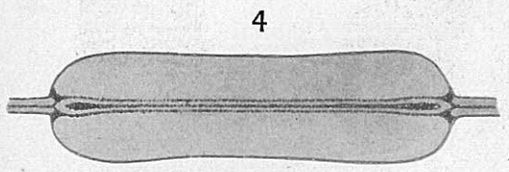
Plate II.

Alaria macroptera (RUPR.)

Fig. 1. A second-year frond in natural size, with fully matured sporophylls; the upper part of the blade cut off.

Fig. 2. An upper portion of the blade to show the fine corrugation of the margins. Nat. size.

Figs. 3–5. Cross sections of the midribs of various specimens. ×5. In the section shown as Fig. 3 the medulla and the perimedullary tissue have not been so distinct as in the others under the low power lense; in the medulla the callus formation was especially rich. The midrib shown as Fig. 5 is abnormal in shape as well as in the distribution of the spanning cortices on both margins. The shape of the cross section recalls the figure illustrated by SETCHELL for *Alaria valida*.



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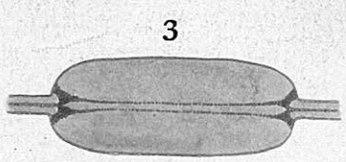

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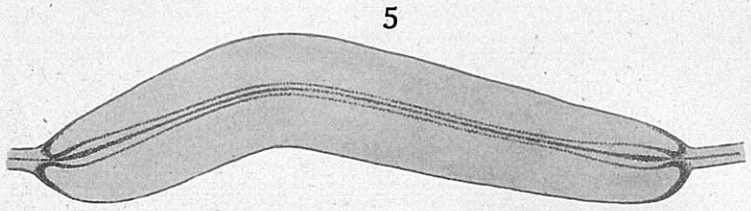

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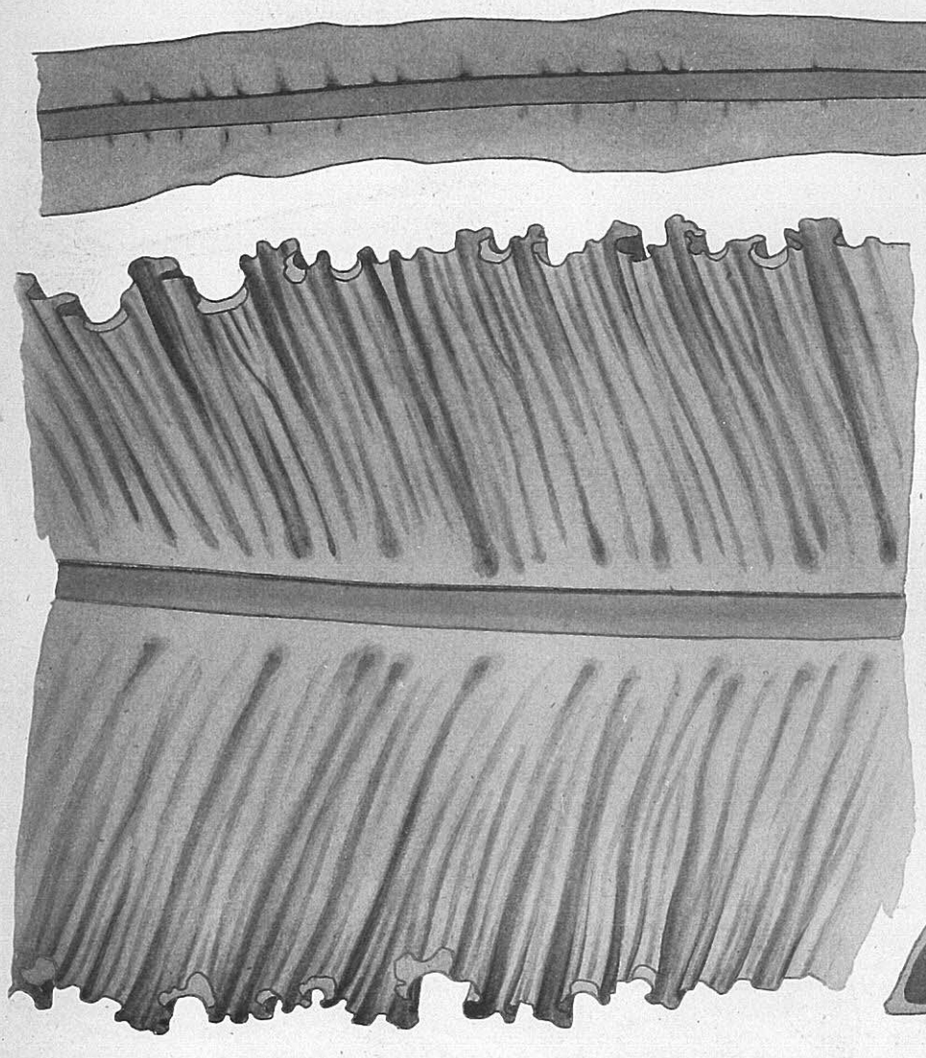

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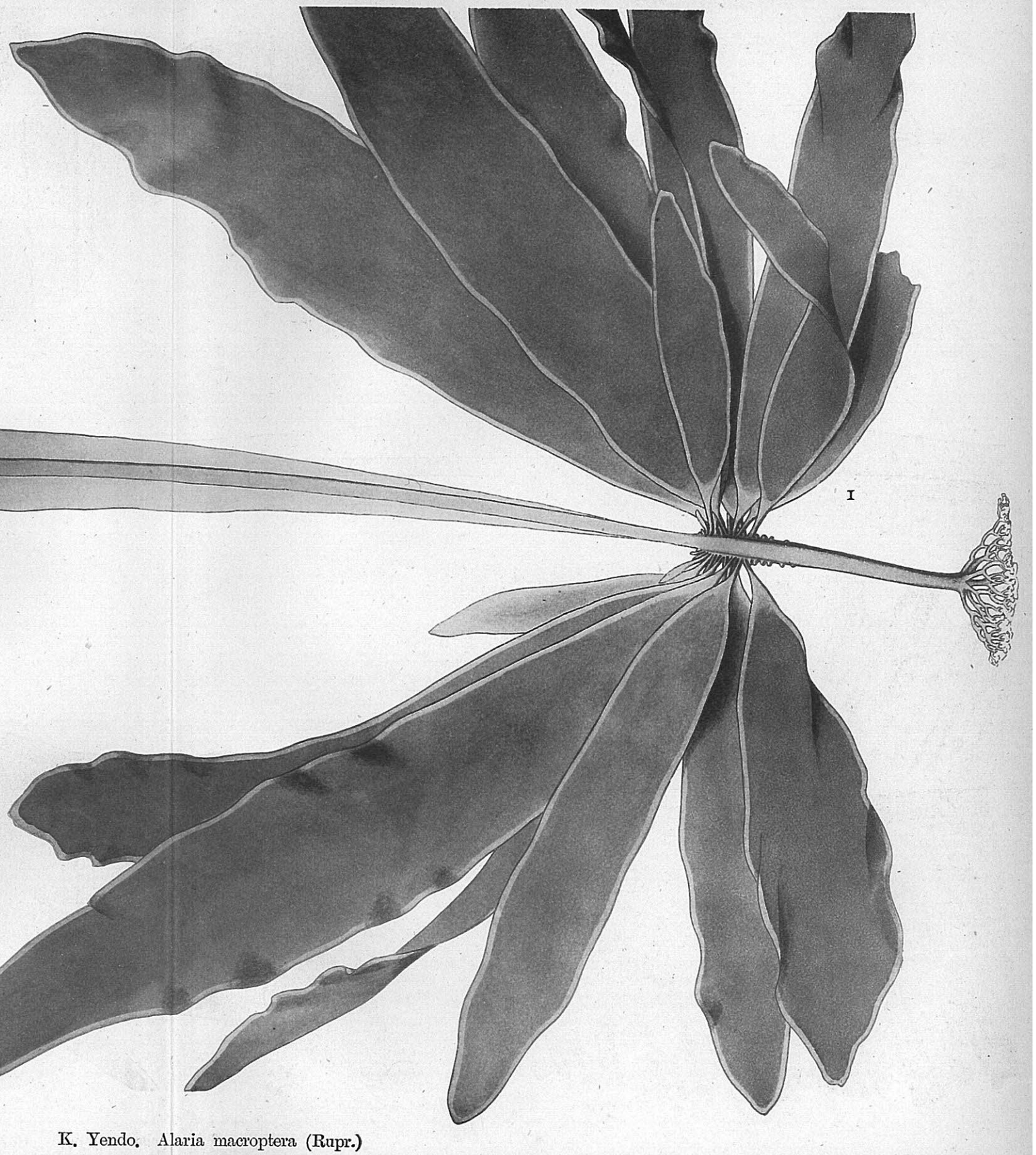

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K. Yendo. Alaria macroptera (Rupr.)

Plate III.

Plate III.

Alaria ochotensis sp. nov.

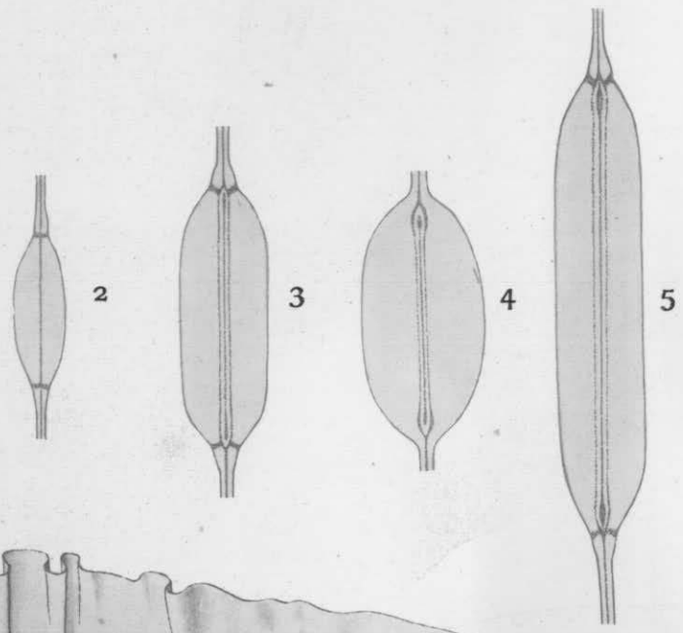
Fig. 1. Plant in natural size, with the upper part of the blade cut off.

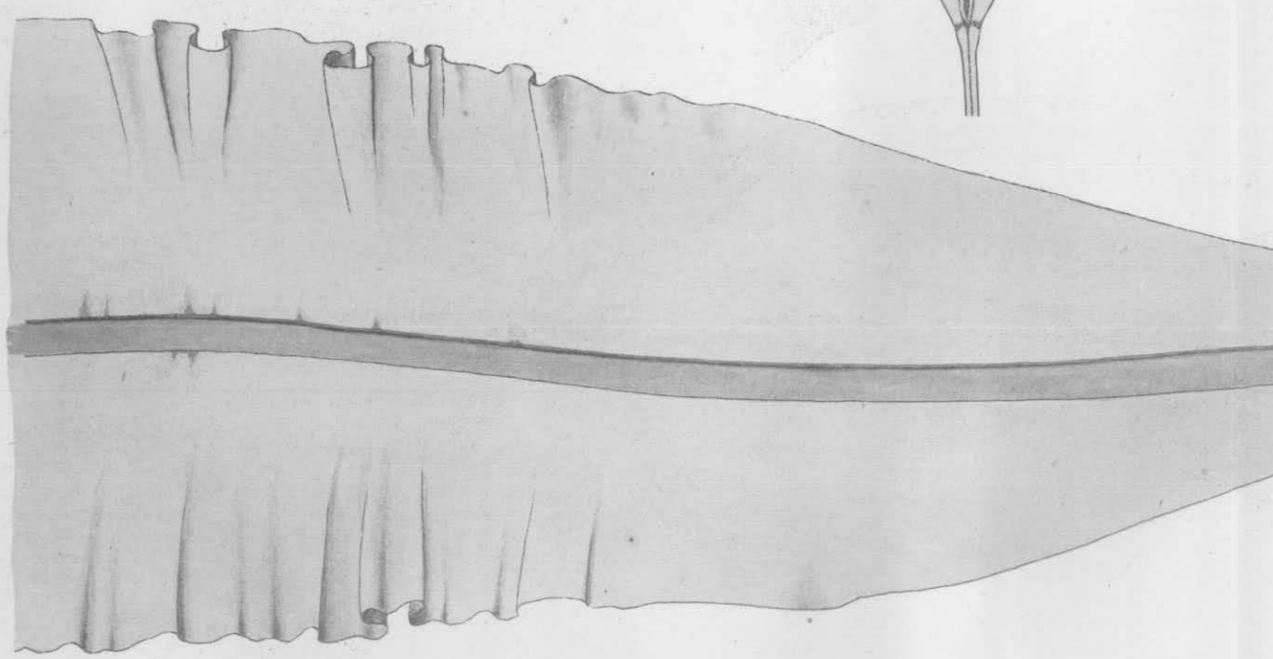
Fig. 2. Cross section of the midrib of a young frond from Jimtaki, Sakhalin. ×5.

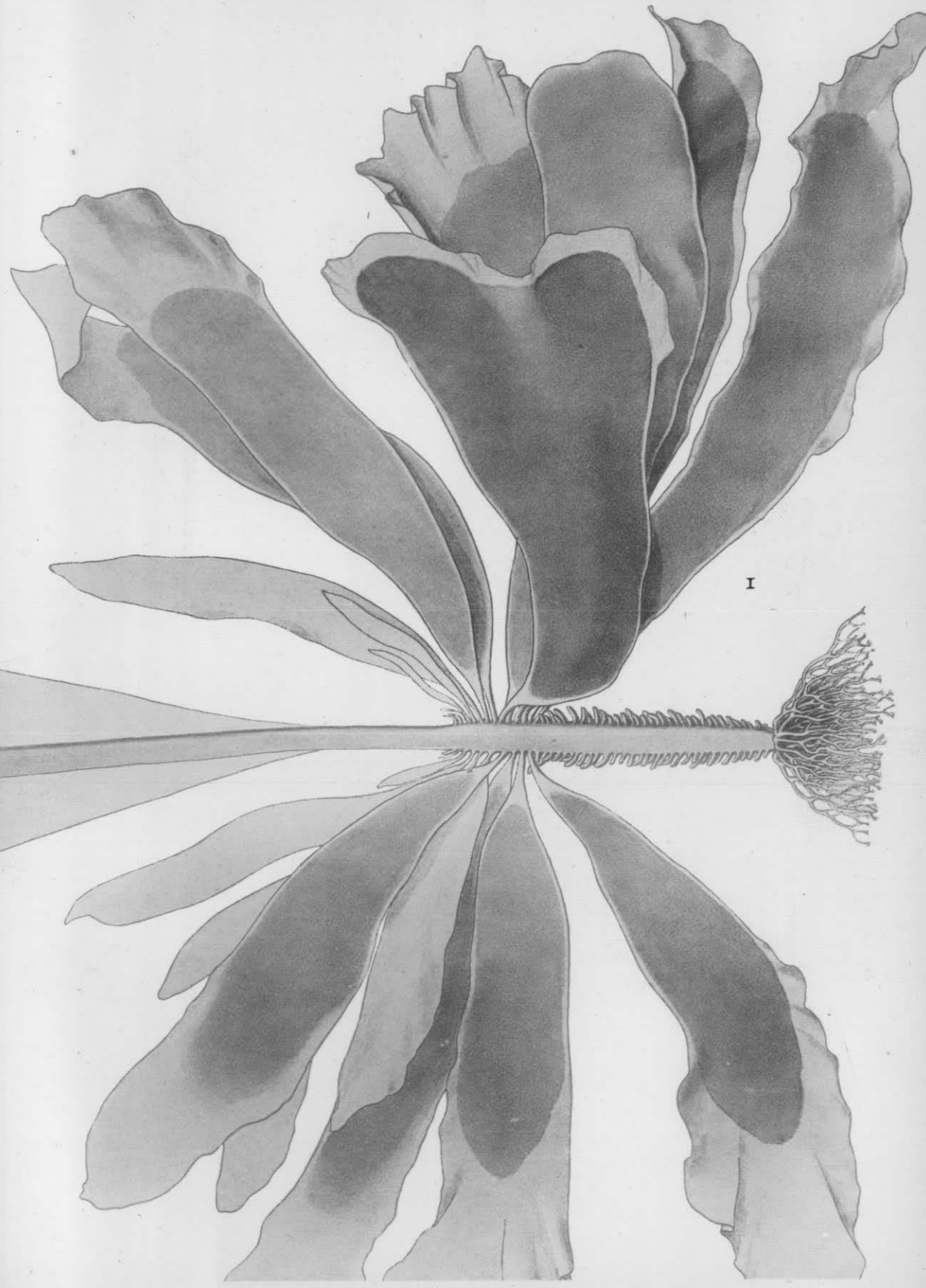
Fig. 3. Cross section of an upper part of the midrib of a matured frond from Aniwa Bay. ×5.

Fig. 4. Cross section of a lower part of the midrib of the same frond. ×5. This is to show an example that the shape of the cross sections of the midrib varies even in one and the same individual.

Fig. 5. Cross section of the midrib of a matured frond from Sorennuiya, Sakhalin. ×5.







K. Yendo. Alaria ochotensis, sp. nov.

Plate IV.

Plate IV.

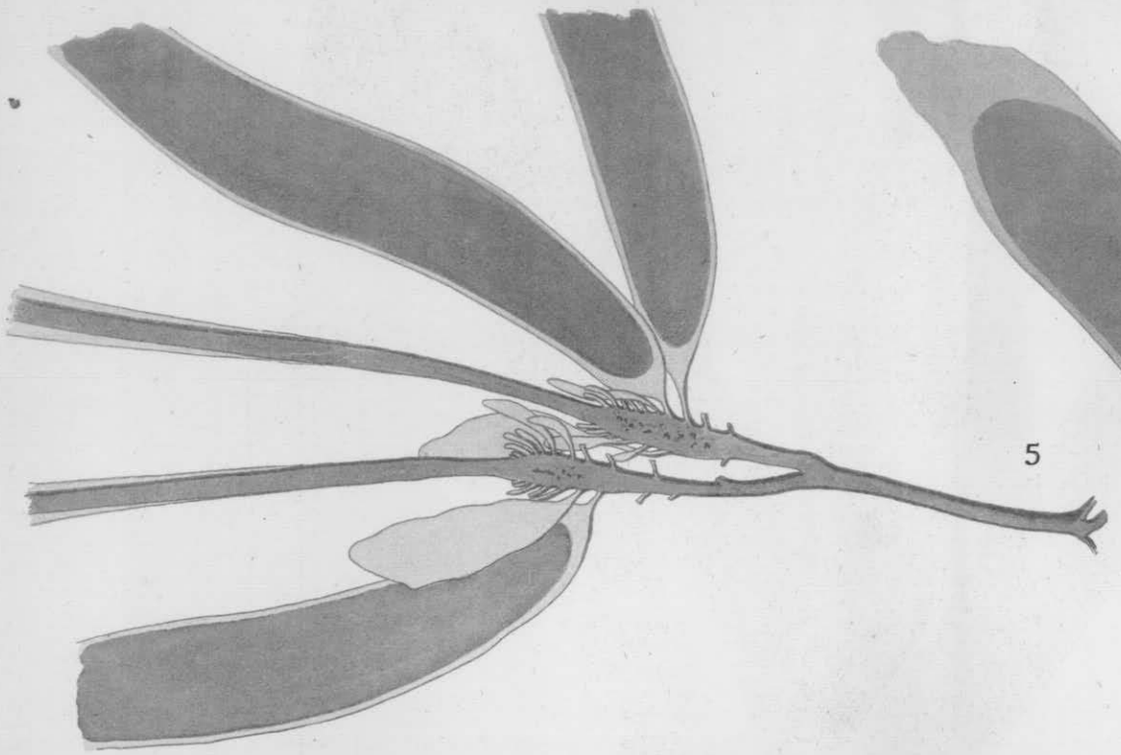
Alaria prælonga KJELLM.

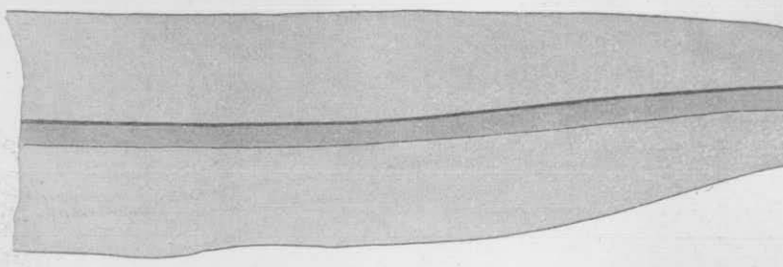
Fig. 1. Frond in natural size, the upper part of the blade cut off.

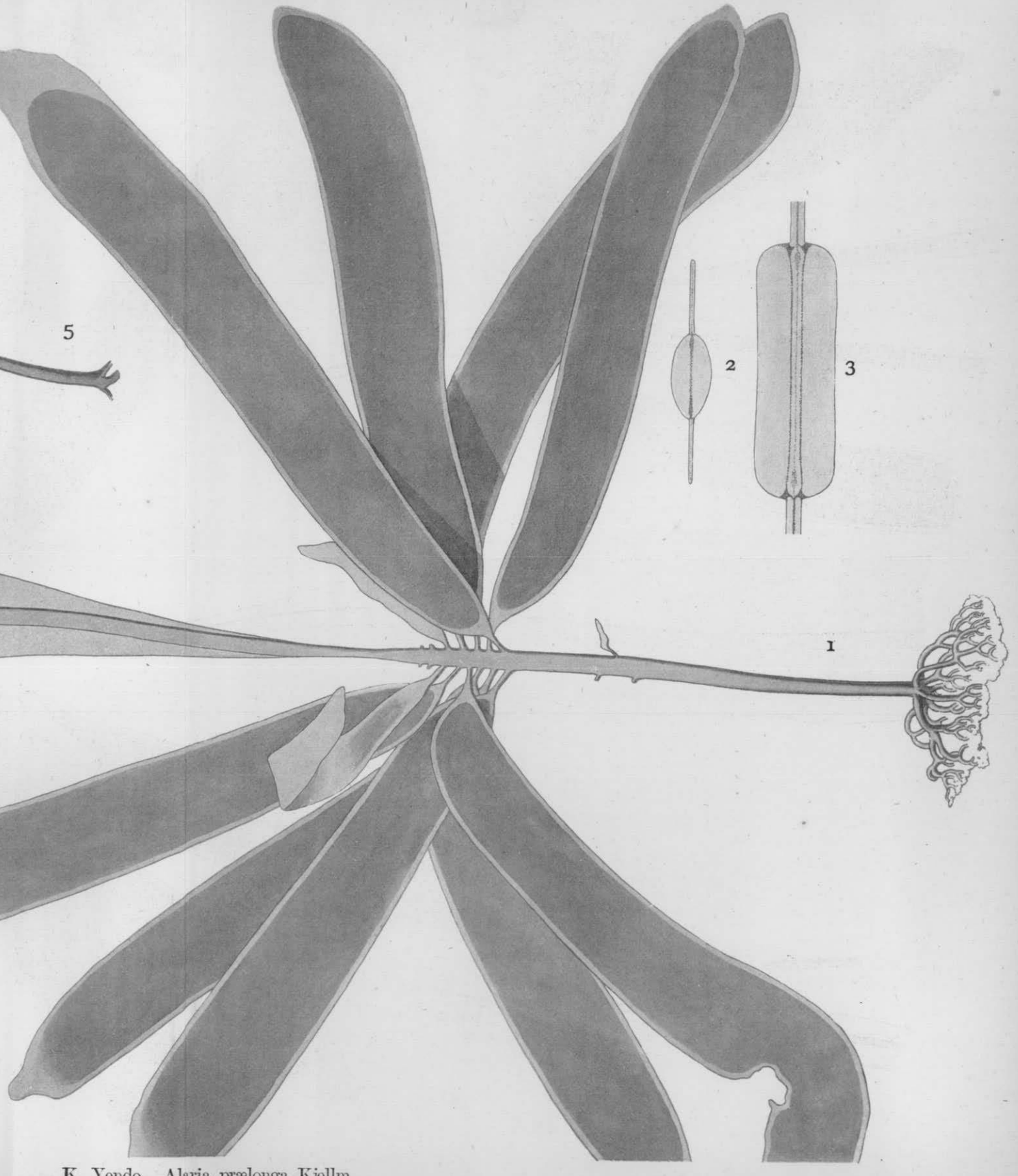
Fig. 2. Cross section of the midrib of a young frond. × 5.

Fig. 3. Cross section of the midrib of a matured frond. × 5.

Figs. 4–5. Two examples of branched stipes. Nat. size.







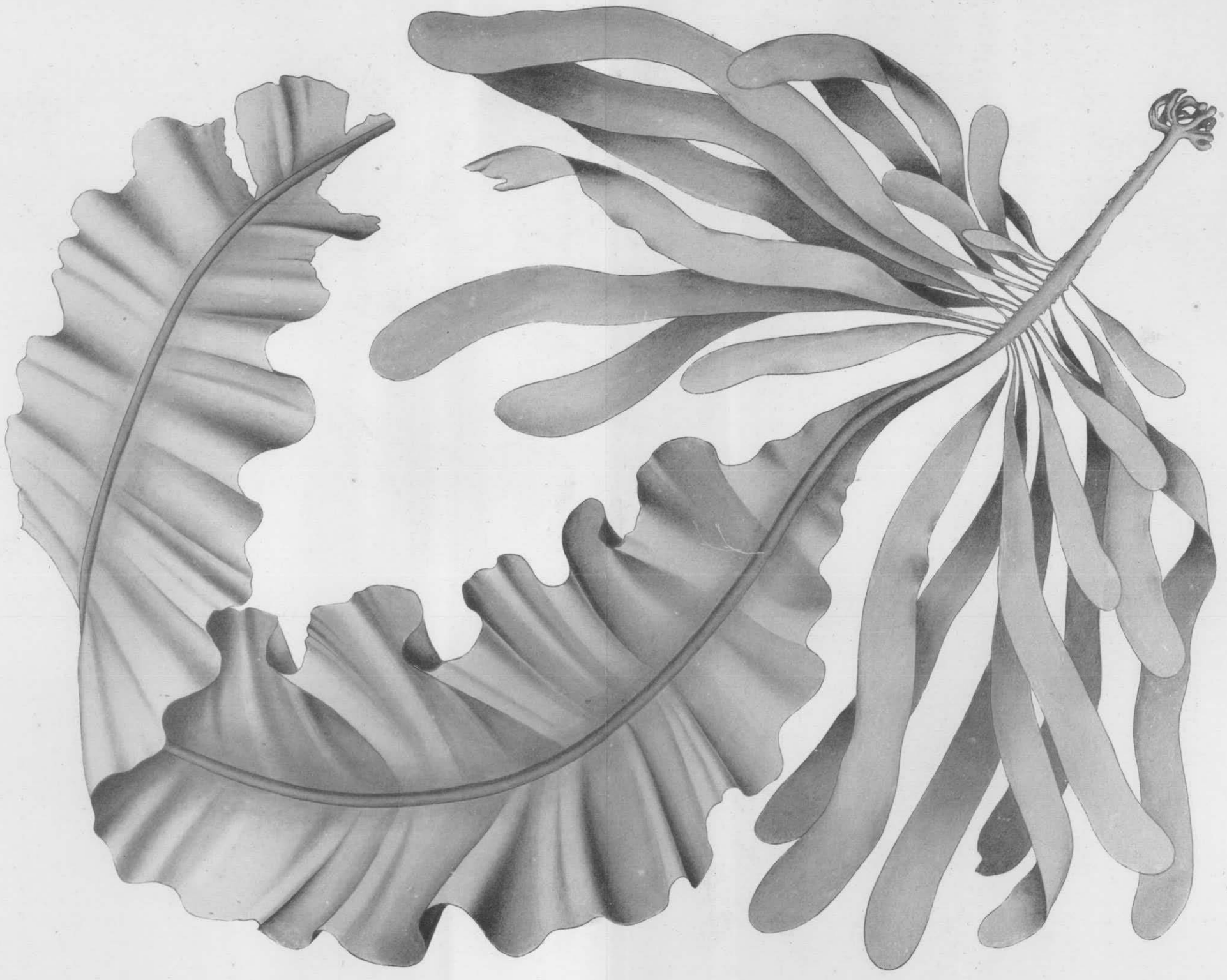
K. Yendo. Alaria prælonga Kjellm.

Plate V.

Plate V.

Alaria dolichorhachis KJELLM.

A young specimen of the plant in natural size. After KJELLMAN.



K. Yendo. Alaria dolichorhachis Kjellm.

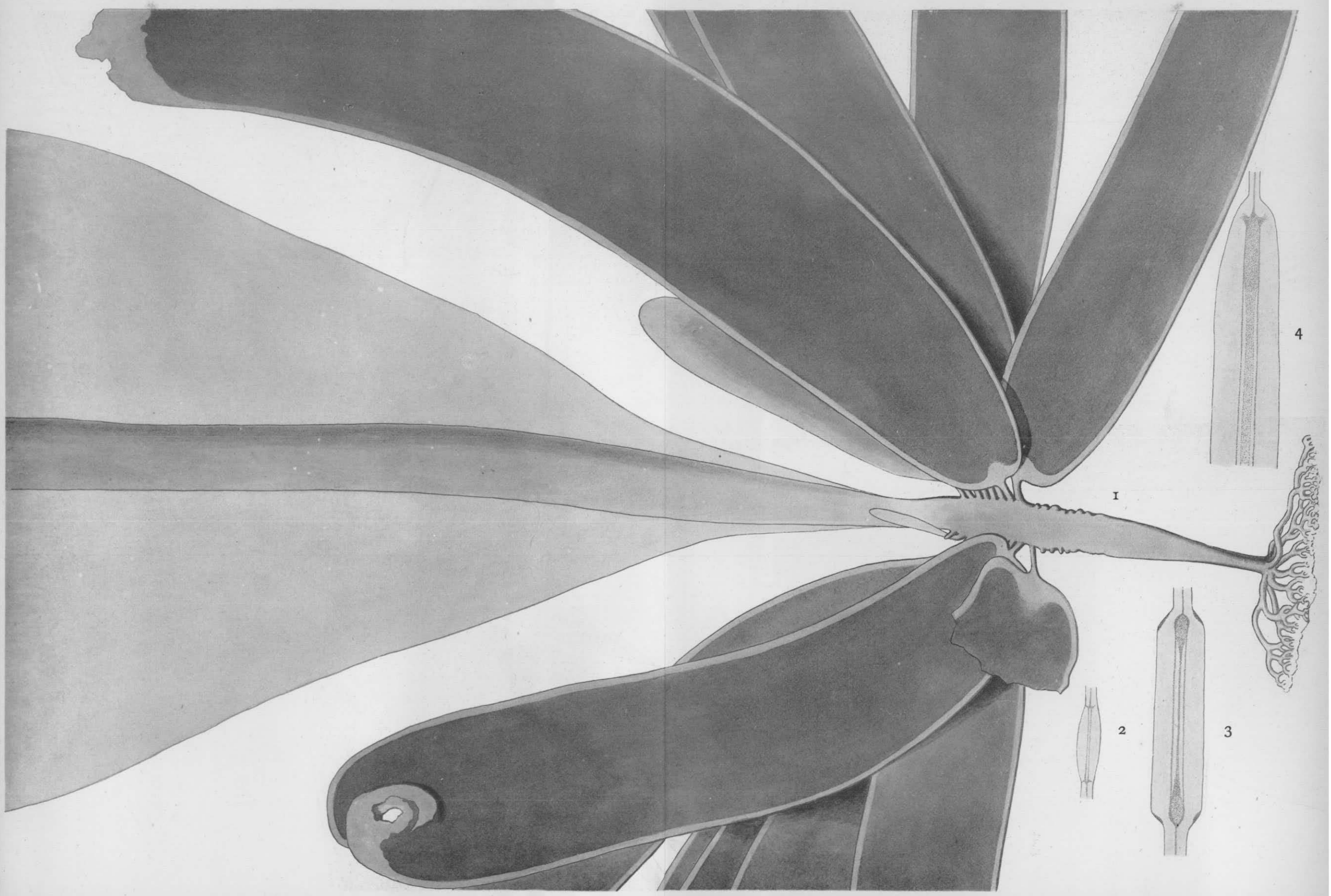
Plate VI

Plate VI.

Alaria marginata POST. et RUPR.

Fig. 1. Basal part of a fully matured plant. Nat. size.

Figs. 2–4. Cross sections of the midribs of a young, half-matured, and a fully matured plant respectively, the last figure showing one half of the breadth. ×5. This species has the spanning cortex poorly differentiated, sometimes not reaching to the epidermis as shown in Fig. 4, and sometimes detached as in Fig. 3. The callus formation has been generally less frequently observed in the marginal swellings of the medulla.



K. Yedno. Alaria marginata Post. et Rupr.

K. Yendo:

A Monograph of the Genus *Alaria*.

Plate VII.

Plate VII.

Alaria Pylaii GREV.

Frond in natural size, with the upper part of the blade cut off. The specimen shown has the blade fully developed but the sporophylls yet immature.

K. Yendo. Alaria Pylaii Grev.

Plate VIII.

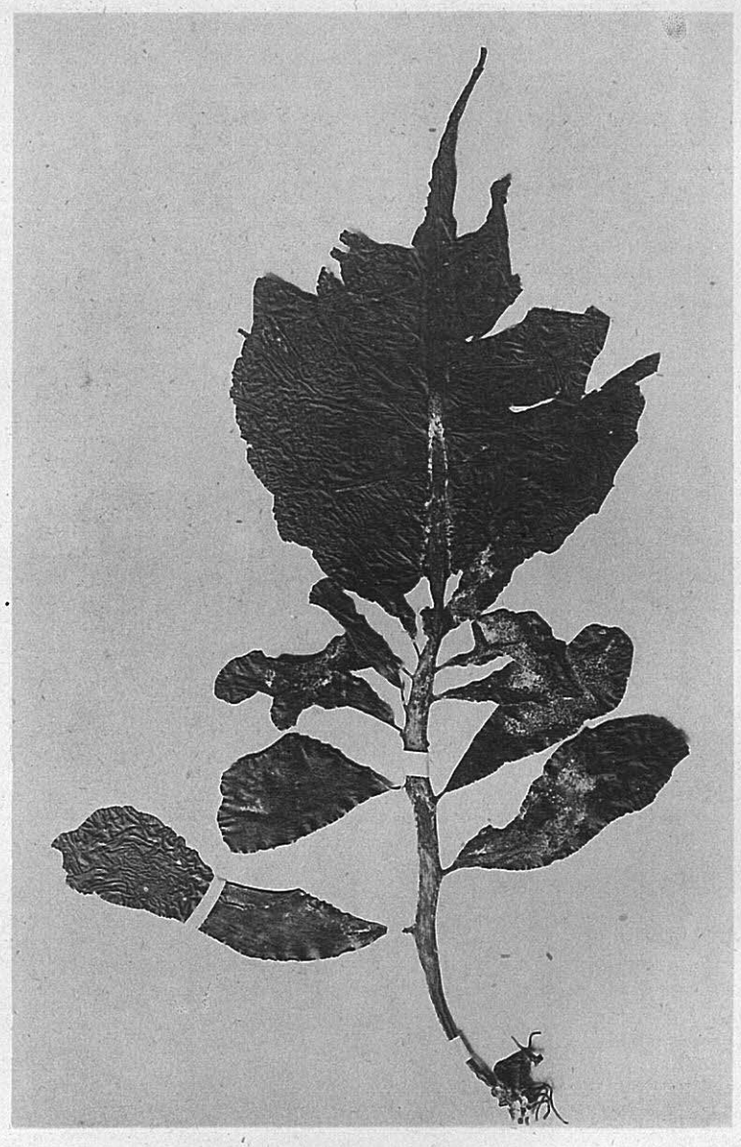
Plate VIII.

"*Alaria Pylaii* GREV."

Fig. 1. Specimen No. 2088 in the Agardhian Herbarium under *Alaria Pylaii* J. AG. On the specimen sheet there is a note in J. AGARDH's handwriting, reading: "Sukkertoppen, BERGGREN. *Al. Despreauxii* BORY. *L. Pylaii* DELAP. vix BORY. *L. muscefolia* var. *remotifolia* DEL."

Fig. 2. Specimen No. 2094 in the same herbarium, bearing the name *Lamin. Pylaii* BORY in AGARDH's handwriting. The specimen does not show the characteristics of *A. Pylaii* GREV. but appears to me to be young fronds of *A. esculenta* GREV.

From photographs kindly supplied by Prof. O. NORDSTEDT.



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K. Yendo. Alaria Pylaii Grev.

Plate IX.

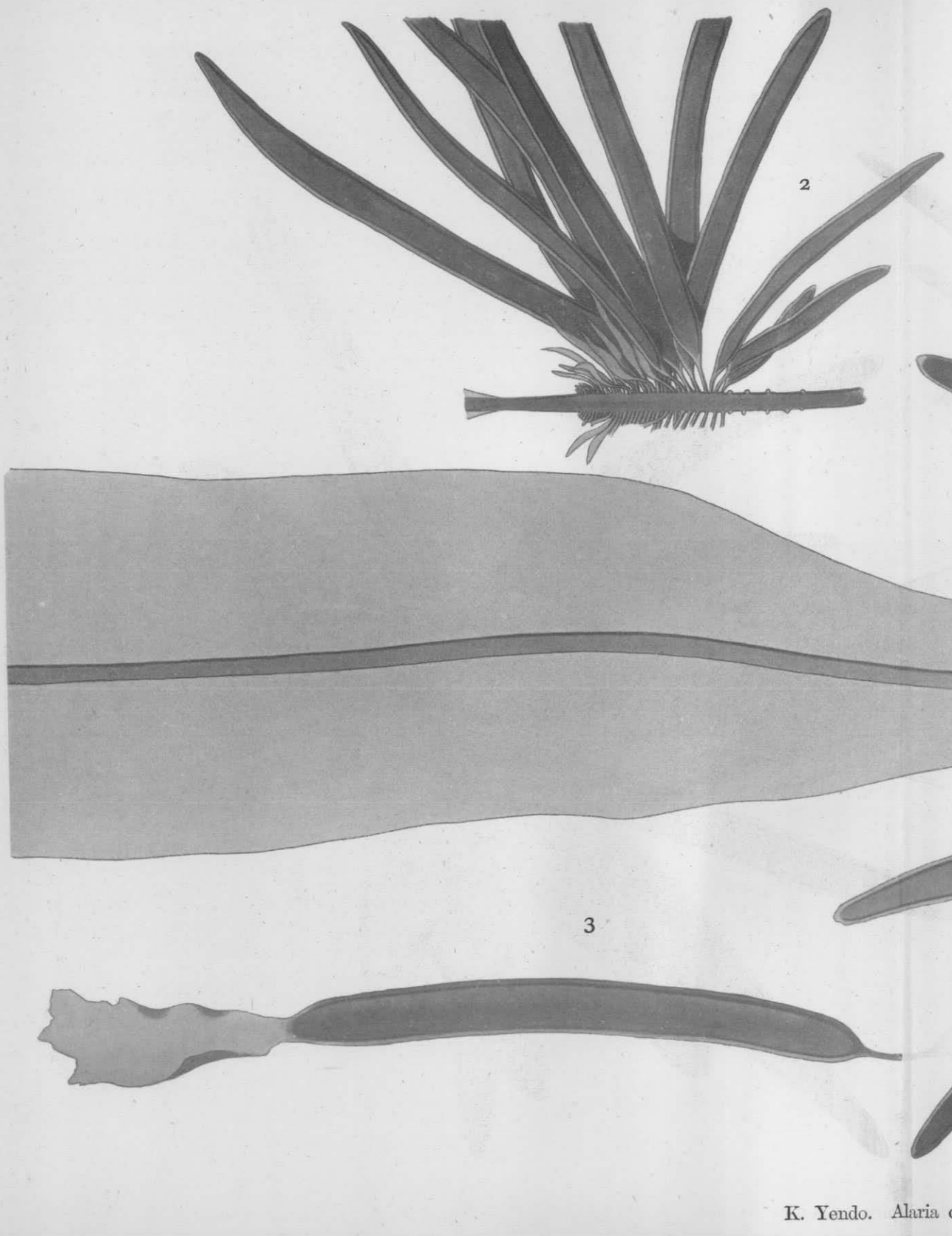
Plate IX.

Alaria crassifolia KJELLM.

Fig. 1. A fully matured, first-year frond in natural size.

Fig. 2. Part of the stipe of a fully matured, second-year frond in natural size.

Fig. 3. A matured sporophyll with the sterile, membranaceous part still attached at the apex. Natural size.



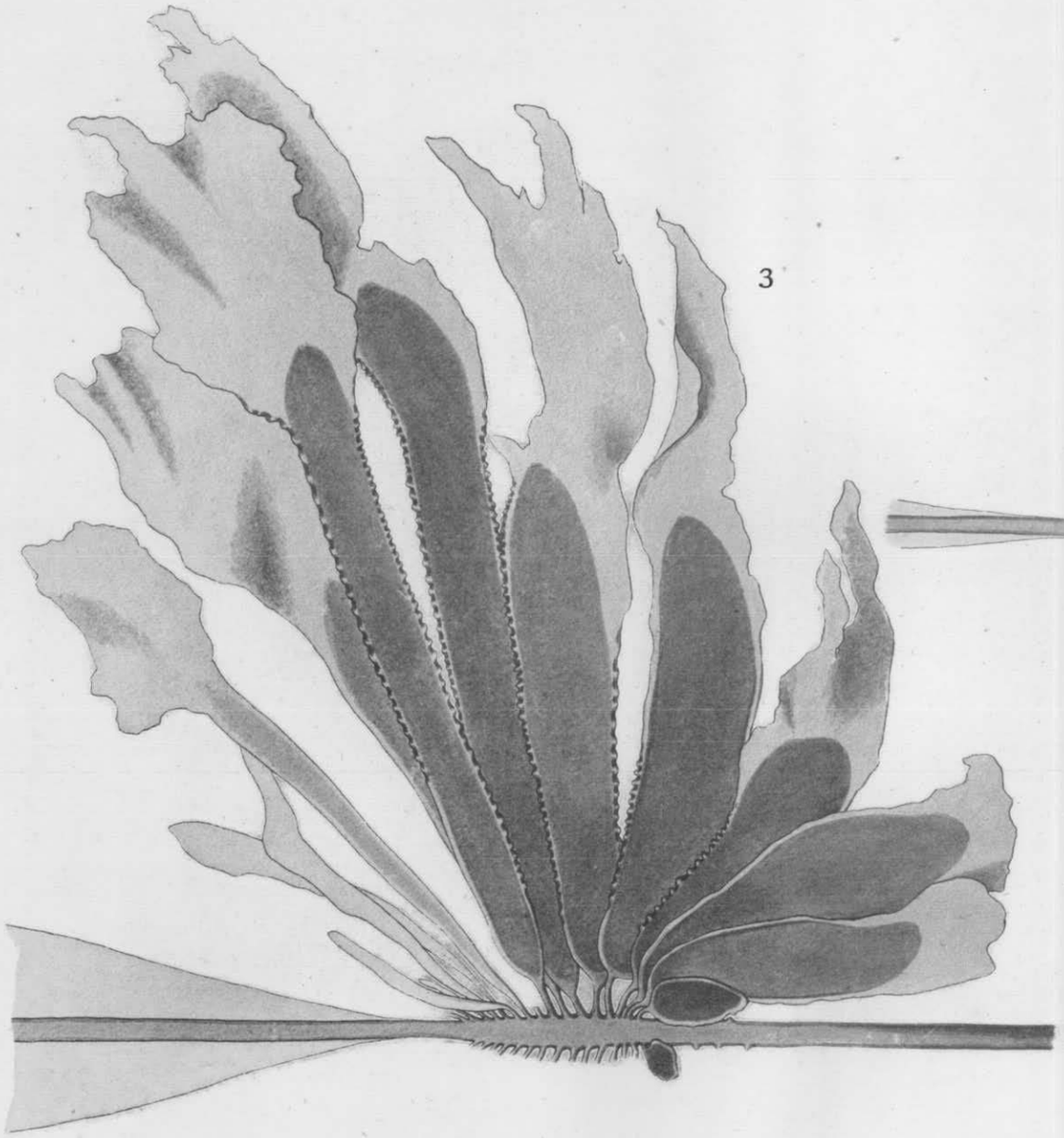
K. Yendo. Alaria crassifolia Kjellm.

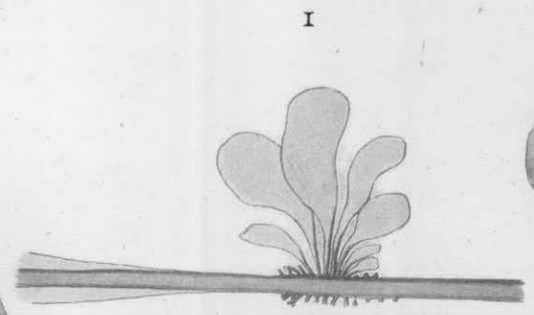
Plate X.

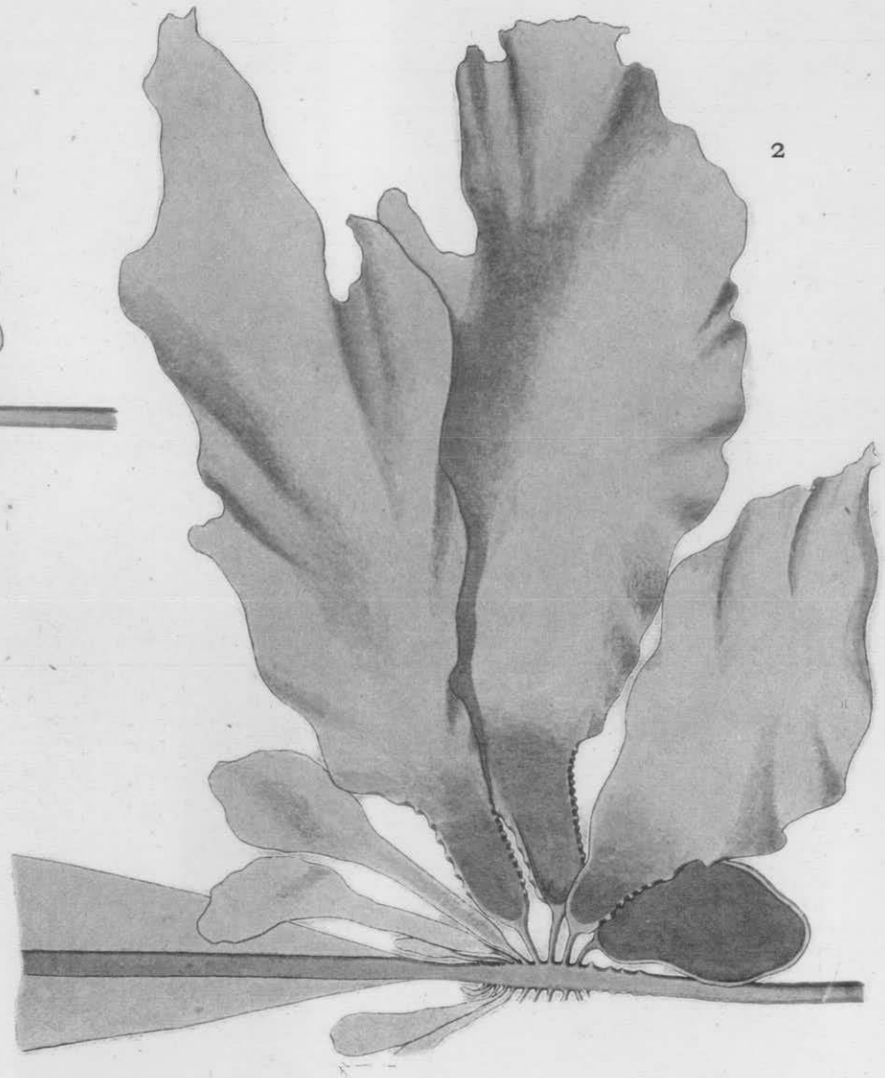
Plate X.

Alaria crassifolia KJELLM.

Figs. 1–3. Various stages of development of the sporophylls of the second-year fronds showing the metasoric morphological change. The first-year sporophylls have mostly dropped off leaving the scars of their attachment points as verrucose processes. Fig. 1, young sporophylls as found at an early part of spring. Fig. 2, a more advanced stage; the basal parts of the sporophylls are markedly thicker and narrower than the sterile upper parts, and the margins are finely crispated. All in natural size.







K. Yendo. Alaria crassifolia Kjellm

K. Yendo:

A Monograph of the Genus *Alaria*.

Plate XI.

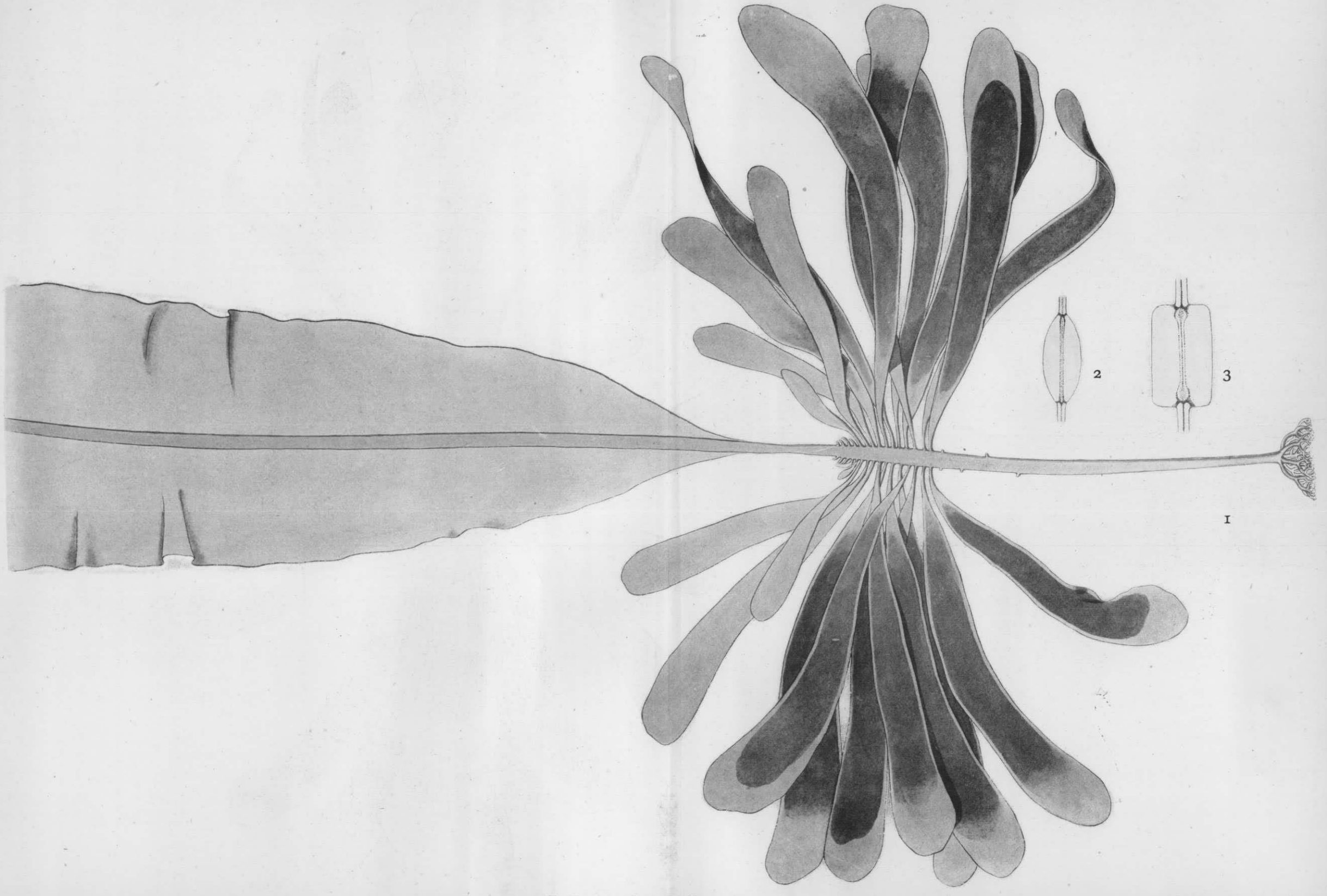
Plate XI.

Alaria esculenta GREV.

Fig. 1. Frond in natural size, with the upper part of the blade cut off. The metasoric character of the sporophylls is not satisfactorily shown in this figure. The gradual morphological changes of the sporophylls as they become soriferous are essentially similar to those shown in Plate X for *A. crassifolia* KJELLM.

Fig. 2. Cross section of the midrib of a young plant. ×5.

Fig. 3. Cross section of the midrib of a well-grown plant. ×5.



K. Yendo. Alaria esculenta Grev.

K. Yendo:

A Monograph of the Genus *Alaria*.

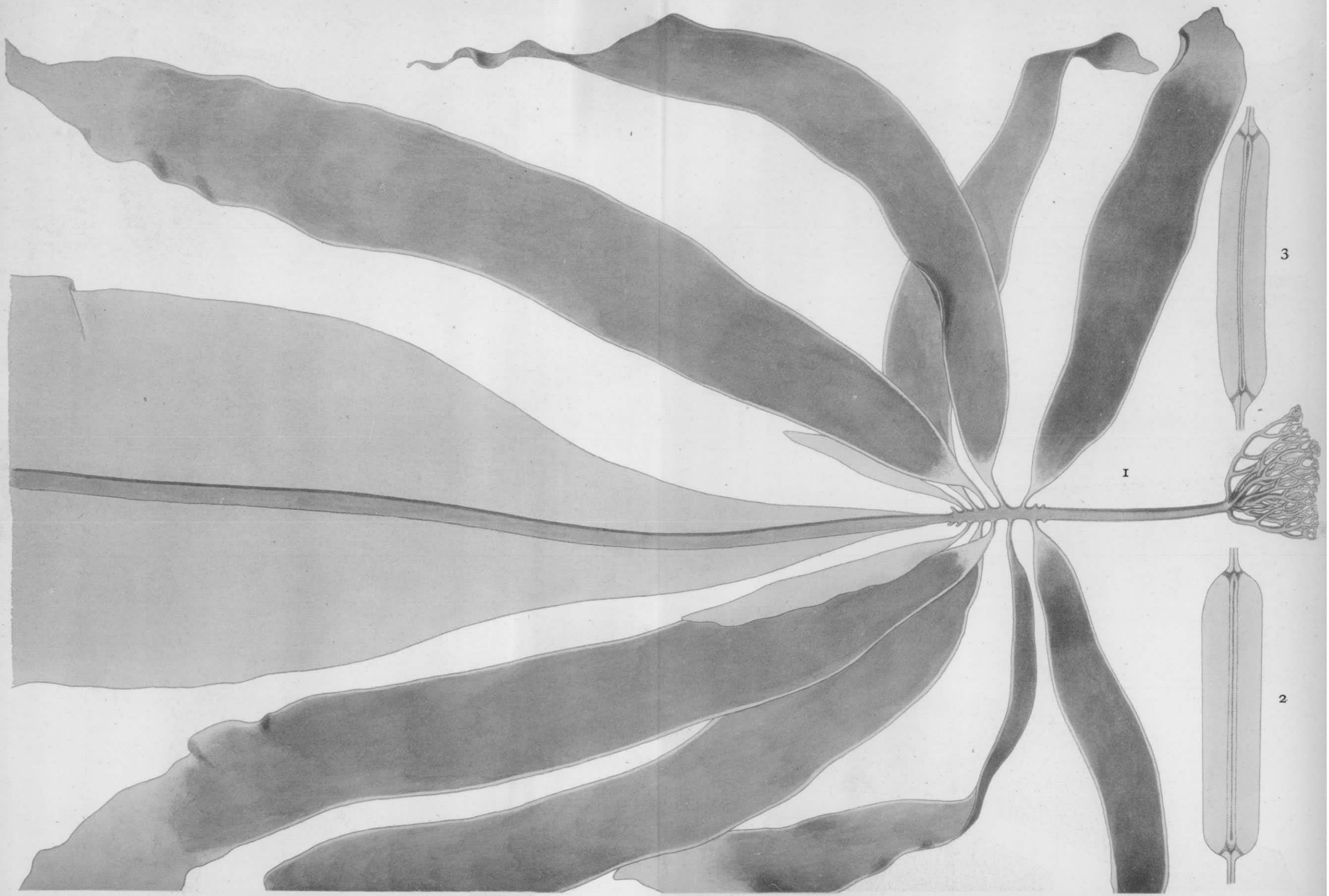
Plate XII.

Plate XII.

Alaria valida KJELLM. et SETCH.

Fig. 1. A matured plant in natural size, with the upper part of the blade cut off.

Figs. 2–3. Cross sections of the mibribs. ×5. The midrib shown in Fig. 3 is dorsi-ventrally assymmetrical, and the spanning cortices at the marginal swellings of the medulla are distributed so as more or less to show the abnormity.



K. Yendo. Alaria valida Kjellm. et Setch.

K. Yendo:

A Monograph of the Genus *Alaria*.

Plate XIII.

Plate XIII.

Alaria nana SCHRADER.

Fig. 1. A plant in natural size, with the upper part of the blade cut off. The specimen here shown is a complete form found in a rather quiet water. The species is habitually found on a surfing reef with the blade roughly torn away, and the holdfast is much less ramified than shown in the figure.

Fig. 2. Cross section of the midrib of a plant about 22 cm. in total height. The spanning cortex not yet differentiated. ×5.

Fig. 3. Cross section of the midrib of a matured plant. ×5.

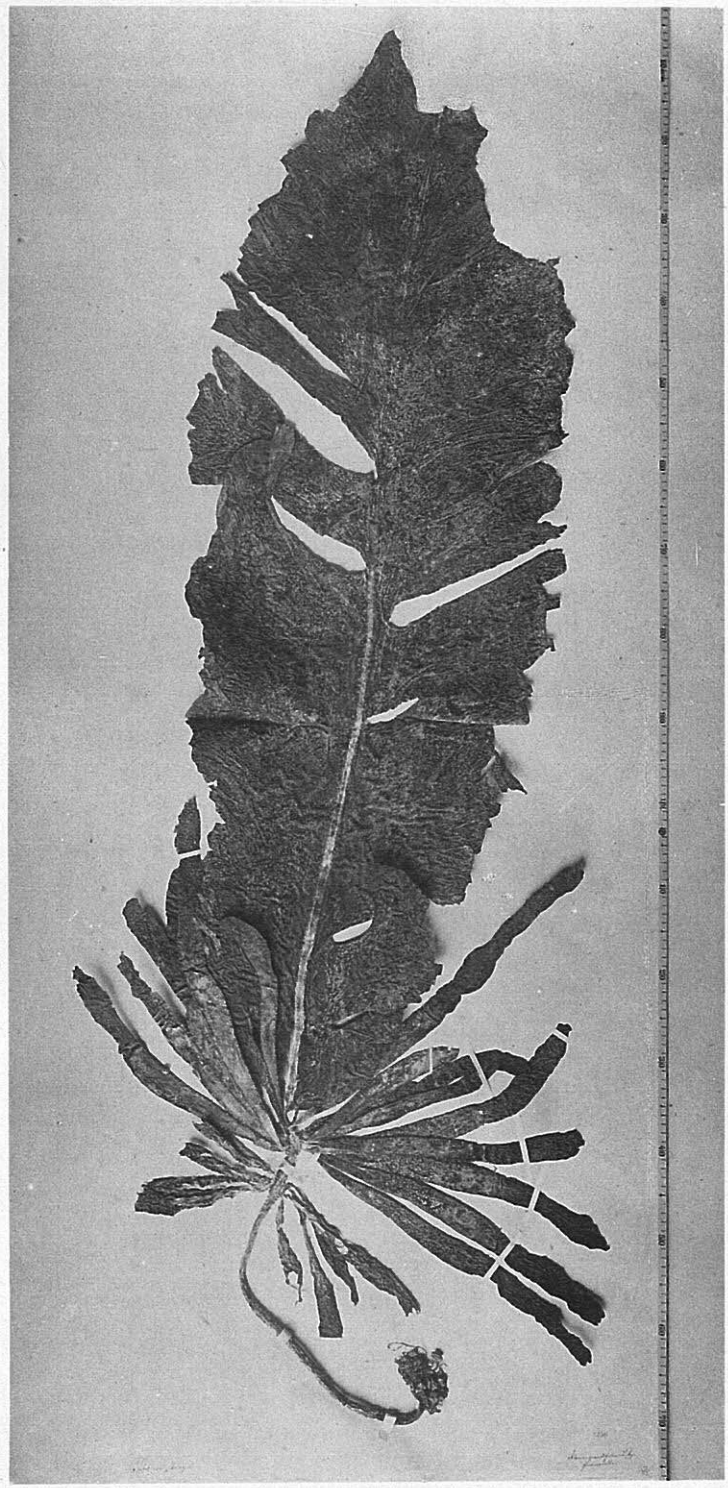
K. Yendo. Alaria nana Schrader.

Plate XIV.

Plate XIV.

Alaria grandifolia J. Ag.

One of the type specimens in the Agardhian Herbarium, under f. *adulta* J. Ag. (specimen No. 2256). Photographed by Mr. Mattsson through the kindness of Prof. O. Nordstedt at the writer's request. The metasoric character of the sporophylls is satisfactorily shown. Scale in centimeters.



K. Yendo. Alaria grandifolia J. Ag.

Plate XV.

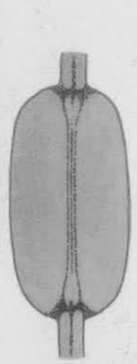
Plate XV.

Alaria angusta KJELLM.

Fig. 1. Frond in natural size. A second-year plant with the sporophylls not yet fully matured.

Fig. 2. An upper part of the blade of a well grown plant. The blade is pinnately cleft with the apices of the segments recurved and subulate.

Figs. 3–4. Cross sections of the midribs at the middle part of the length of the blades. From the specimens collected in the southern Kuriles. ×5.



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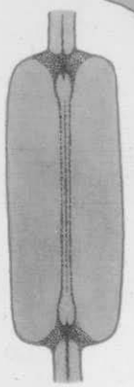

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K. Yendo. Alaria angusta Kjellm.

Plate XVI.

Plate XVI.

Alaria tæniata KJELLM.

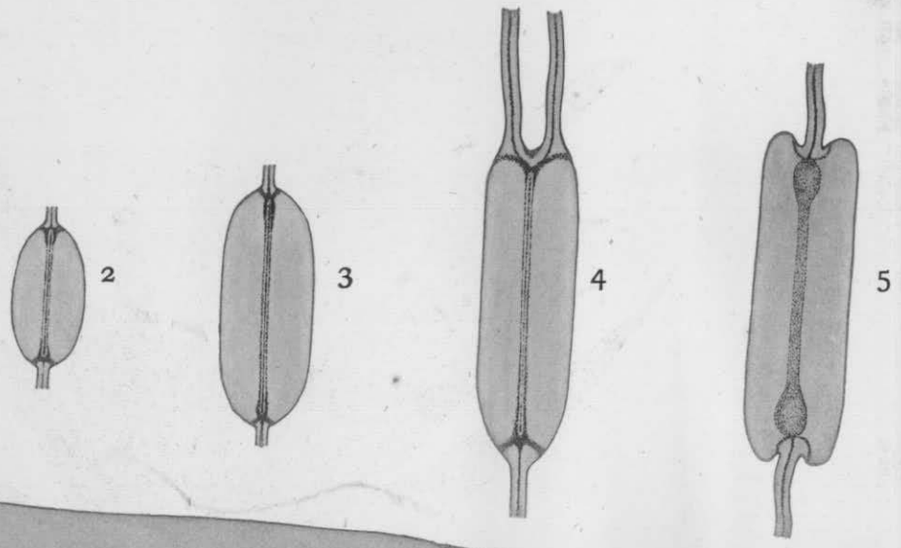
Fig. 1. Frond in natural size, with the greater part of the length of the blade cut off. The metasoric sporophylls have the soral parts evidently broader than the sterile upper parts.

Fig. 2. Cross section of the midrib at a point near the apex of the blade which measures in dry specimen 369 cm. in total length and 2 cm. at the broadest part. ×5.

Fig. 3. Cross section of the midrib at a point about 25 cm. above the transition point of the same specimen. ×5.

Fig. 4. Cross section of the midrib of a frond with duplicated semi-blades. In the duplicated side of the midrib the spanning cortices are curved inwards and a tissue similar to them is found at the sinus of the semi-blades. The medullary layers of the latter diverge at the outer end of the marginal swelling of the medulla of the midrib. ×5.

Fig. 5. Cross section of the midrib after KJELLMAN. The tetragonal form could not be found with our specimens. ×6.



K. Yendo. Alaria tæniata Kjellm.

K. Yendo:

A Monograph of the Genus *Alaria*.

Plate XVII.

Plate XVII.

Alaria lanceolata KJELLM.

Fig. 1. Frond in half natural size.

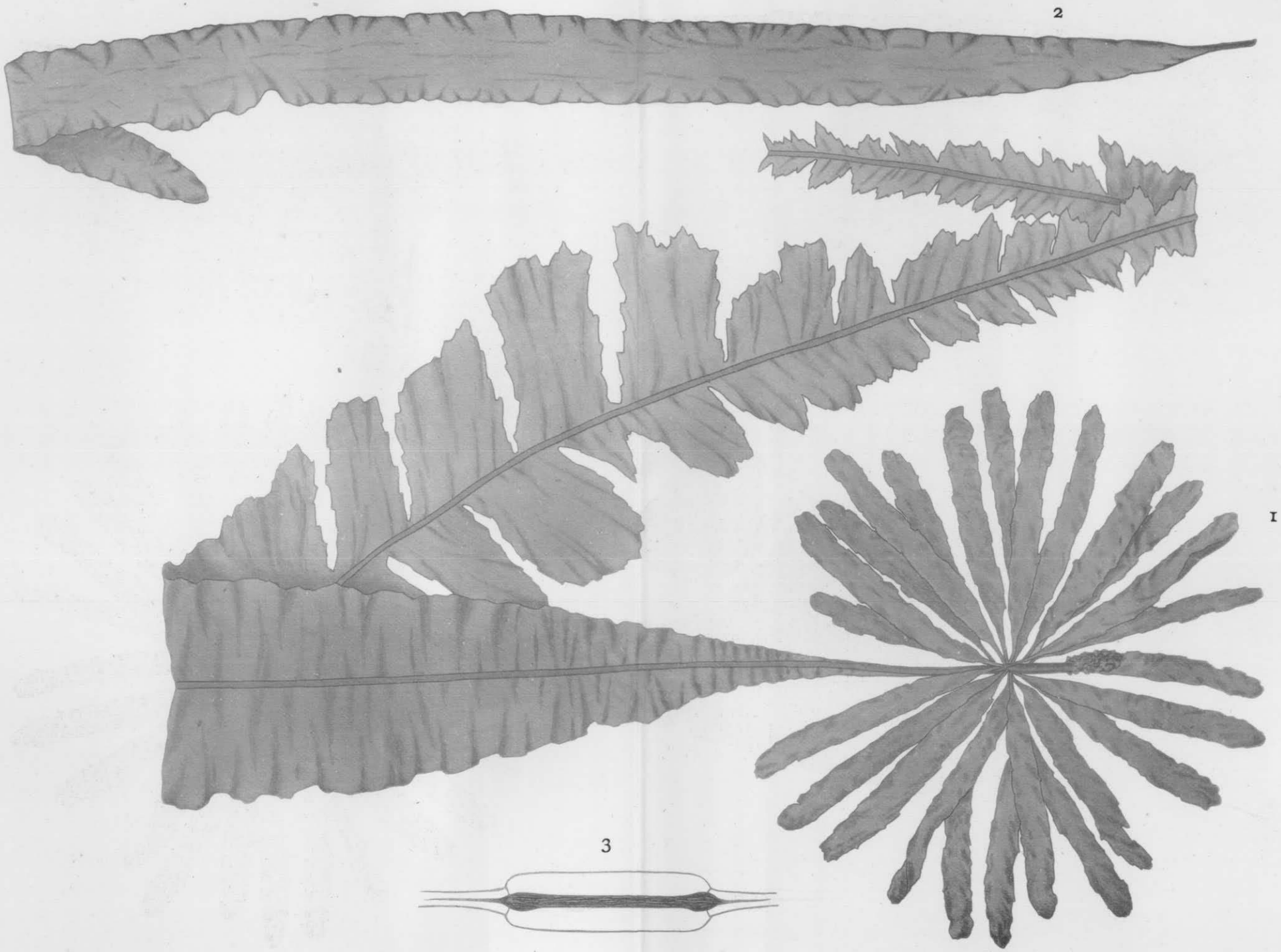
Fig. 2. Sterile sporophyll. Nat. size.

Fig. 3. Cross section of the midrib. ×6.

(All figures after KJELLMAN).

N. B.—The figures can not be said to show the specific character accurately. The specimens in my possession, which I identify with the species, are all too young and can not be shown as to represent the species in a monograph. Hence, the original figures, though far from satisfying, are here taken.

2



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K. Yendo. Alaria lanceolata Kjellm.

Plate XVIII.

Plate XVIII.

Alaria crassifolia KJELLM.

Figs. 1–3. Gametophytes found in nature; simple and sterile, branched and antheridial, and branched and oogonial, respectively. ×450.

Figs. 4–5. Sporelings with unicellular rhizoids. ×450.

Figs. 6–7. Monostromatic embryonal blades to show the cellular arrangement. At the stage shown in Fig. 6 the cells are still disposed in the hyperbolic figure as has been observed in a similar stage of *Costaria Turneri*. ×450.

Figs. 8–11. Mucilage glands observed at a post-embryonal frond of about 15 cm. in total height. Fig. 8, surface view of a marginal part of the frond at about 5 cm. above the transition region. The glands are denser and smaller along the margin, rarer and larger towards the midrib, and finally entirely absent. Beyond the area here delineated no gland could be seen. The glands near the transition region are colourless and granular, those at 3–4 cm. above the transition region and upwards gain darker brownish hue. ×54. Fig. 9, A part of the same enlarged. The epidermal cells overlying the glands are seldom disposed radiately around a gland. ×450. Fig. 10, cross section of the blade at the same point. ×450. Fig. 11, surface view of an upper part of the blade with the four glands fused together but still with the septal membranes between them. ×450.

Figs. 12–14. Diagramatic figures of the cross sections of the basal cylindrical part and the complanated part of the stipe, and the midrib respectively, of a two-year old plant. About ×10. *a*, epidermal layer (limiting layer of SETCHELL); *b*, second year cortex; *c*, outer cortex composed of radially disposed cells; *d*, inner cortex composed of larger parenchymatic cells; *e*, perimedullary tissue; *f*, medullary sheath; *g*, medulla; *h*, marginal swelling of the medulla; *k*, spanning cortex.

Fig. 15. Part of a cross section of the midrib of a matured frond, to show the compact tissue of the medullary sheath about the marginal swelling of the medulla; *e*, perimedullary tissue; *f*, medullary sheath; d, inner cortex. ×240.

Fig. 16. Part of a cross section of the midrib of a matured frond, a point about the median line, stained in an aqueous solution of anilin blue. The cell-wall of the inner cortex and the hyphæ stain very pale, those of the perimedullary tissue deep blue, and the callus of the trumpet cells in the medulla deepest. ×240.

Fig. 17–18. Two trumpet cells; Fig. 15, thick-walled cells, treated first in sulphuric acid and then in chloriodide of zinc. Fig. 16, callus formation, stained in an aqueous solution of anilin blue. ×450.


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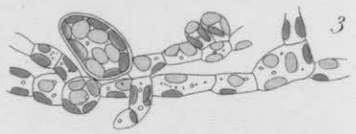
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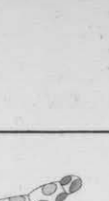
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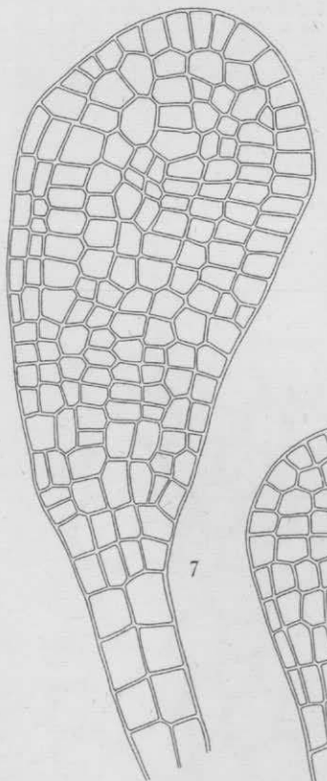
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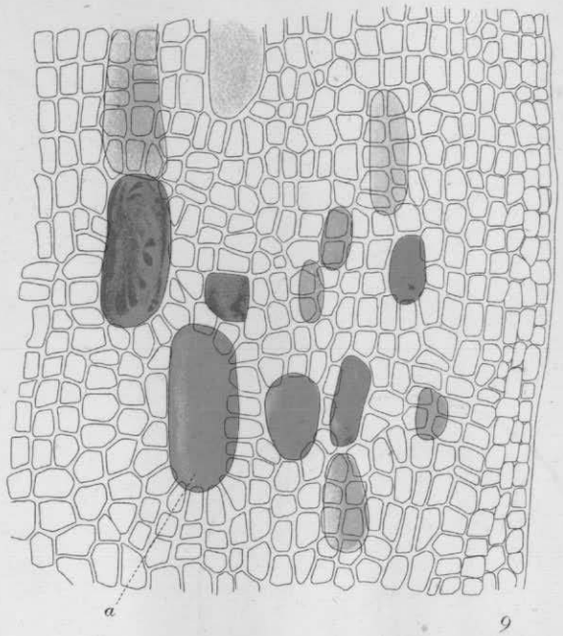
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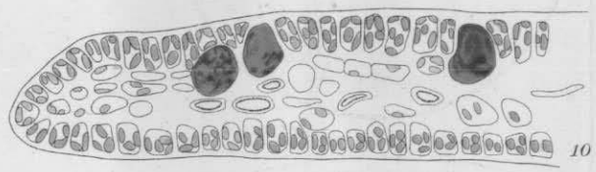
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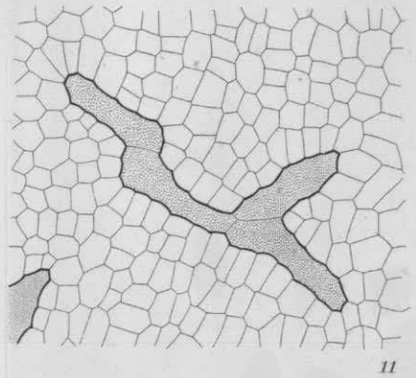
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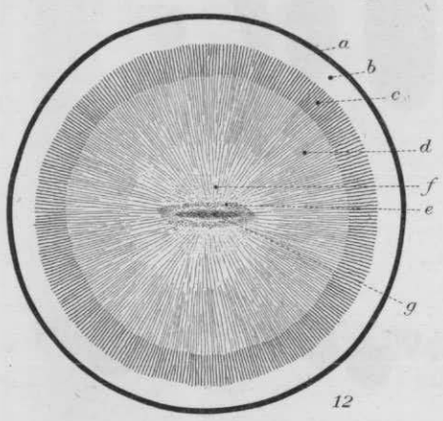
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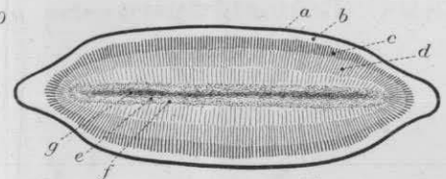
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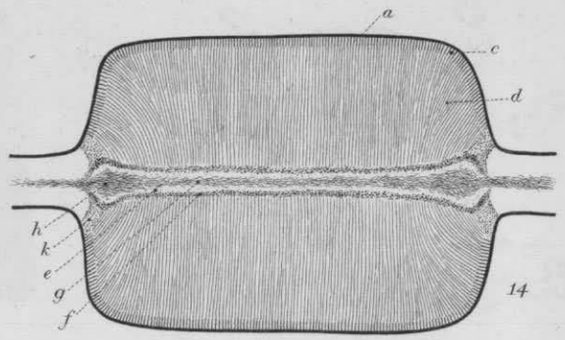
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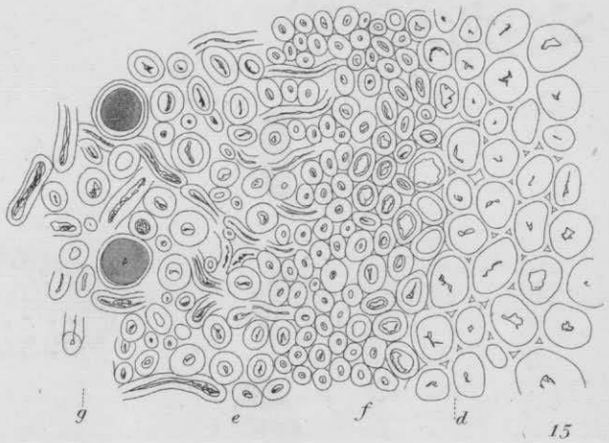
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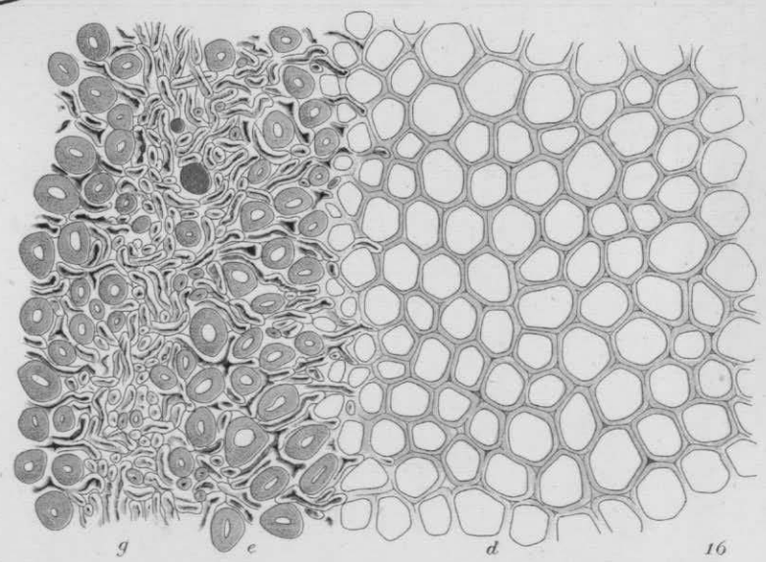
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K. Yendo. Alaria crassifolia Kjellm.

K. Yendo:

A Monograph of the Genus *Alaria*.

Plate XIX.

Plate XIX.

Fig. 1–3. *Alaria ochotensis* sp. nov.

Fig. 1. Part of a cross section of the midrib: the parenchymatic tissue on the left side is the innermost part of the inner cortex; the thick-walled, large cells, with the hyphal strands traversing through the intercellular spaces on the right, belong to the perimedullary tissue; interposed between these two parts, a narrow area of the medullary sheath, composed of the fibrous cells. × 240.

Fig. 2. Surface view of the blade at an upper part to show the distribution of the mucilage glands in a square millimeter. × 54.

Fig. 3. A mucilage gland seen from the surface of frond, through the epidermis. The arrangement of the epidermal cells overlying the gland is more or less disturbed but not under any fixed rule as in *Undaria pinnatifida*: no special pore for the gland is to be seen. × 240.

Fig. 4. *Alaria marginata* Post. et Rupr.

Cross section of the midrib showing a marginal swelling of the medulla and right half of the thickness of the midrib. In this species the perimedullary tissue and the medullary sheath are slightly differentiated; the spanning cortex is also poorly developed in comparison with the other species. × 240.

Figs. 5–12. *Homœostroma latifolium* J. Ag.

Fig. 5. Rhizoidal part of a young plant with embryonal shoots starting from it. About × 50. Somewhat diagrammatic.

Fig. 6. Embryonal shoot of a single row of cells. × 240.

Fig. 7. The same; a more advanced stage. The cells in the upper part of frond are broader than height. The apical hair begins to appear. × 240.

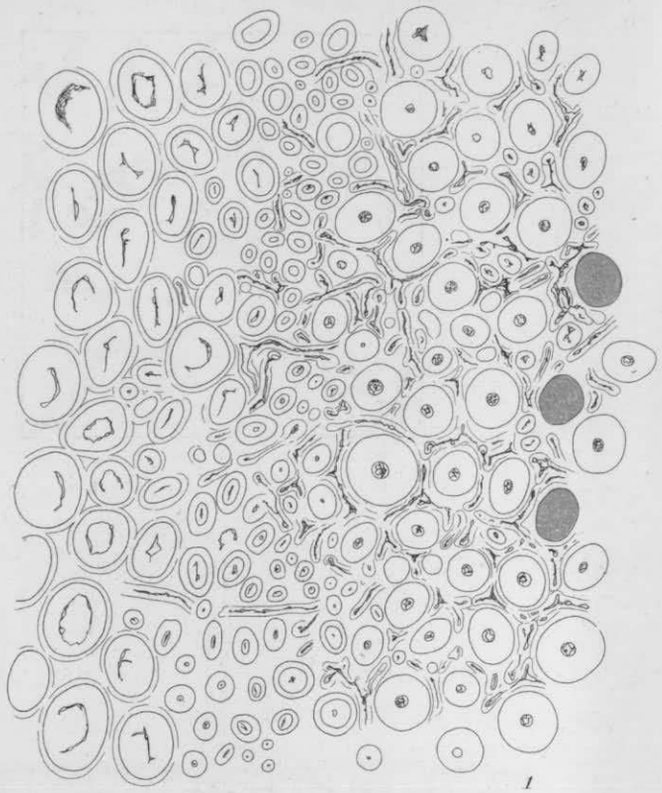
Fig. 8. The same; still more advanced stage. The cells in the middle and upper part of frond are divided longitudinally and transversely to form the monostromatic blade. The apical hair is elongated and septated. × 240.

Fig. 9. A young monostromatic frond, with apical hair completed. The marginal hairs are issued pairwise from the upper corners of "segments." Each "segment" is one cell-areole initiated from a mother cell. × 240.

Fig. 10. A part of margin of a blade of about 3 mm. in length; young hairs starting from the intervals of the older ones as the blade increases in length by cell-multiplication. × 240.

Fig. 11. Cross section of a frond which began to be distromatic. × 240.

Fig. 12. Surface view of the blade to show the starting of a hair-tuft; the epidermal cells are divided into much smaller ones which initiate the hairs. The hair-initiating cells are richer in chromoplasts than the ordinary epidermal cells. × 450.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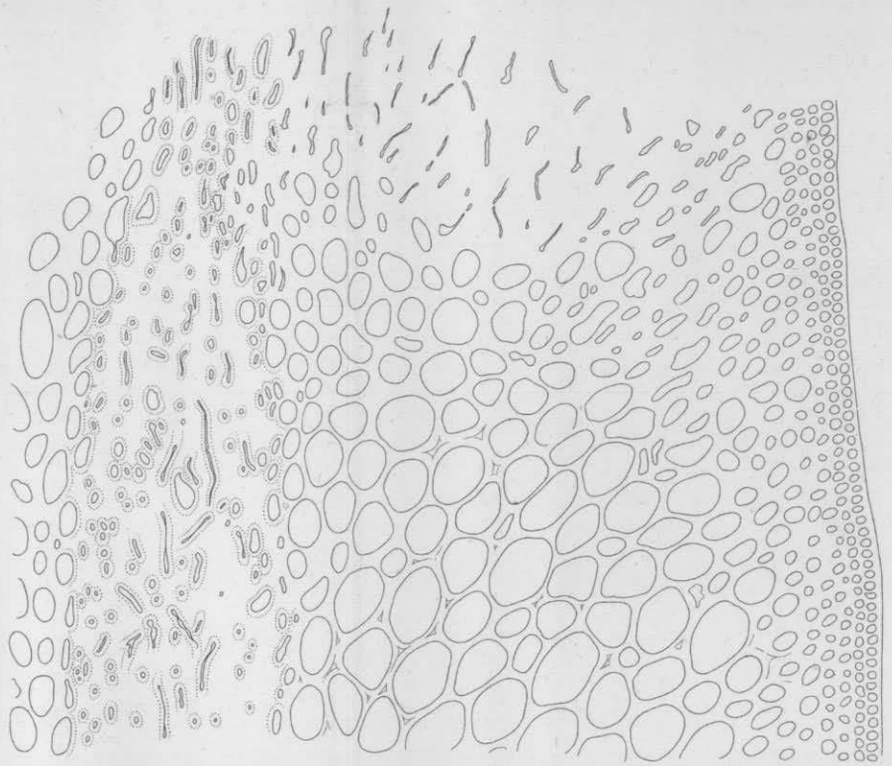
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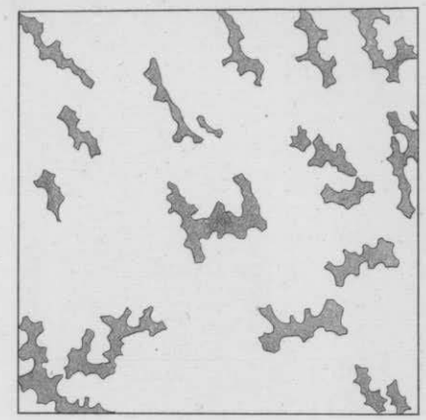
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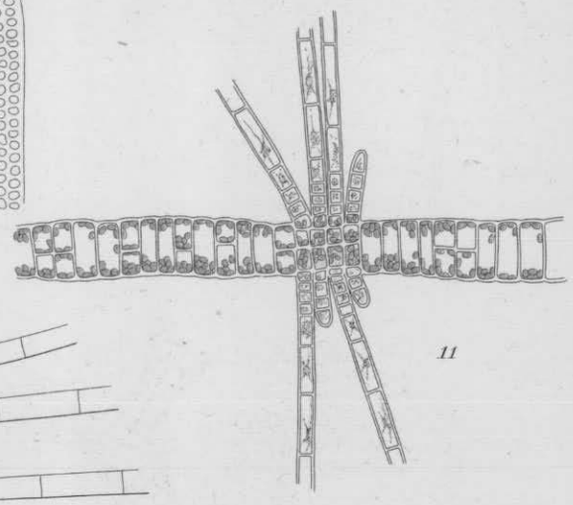
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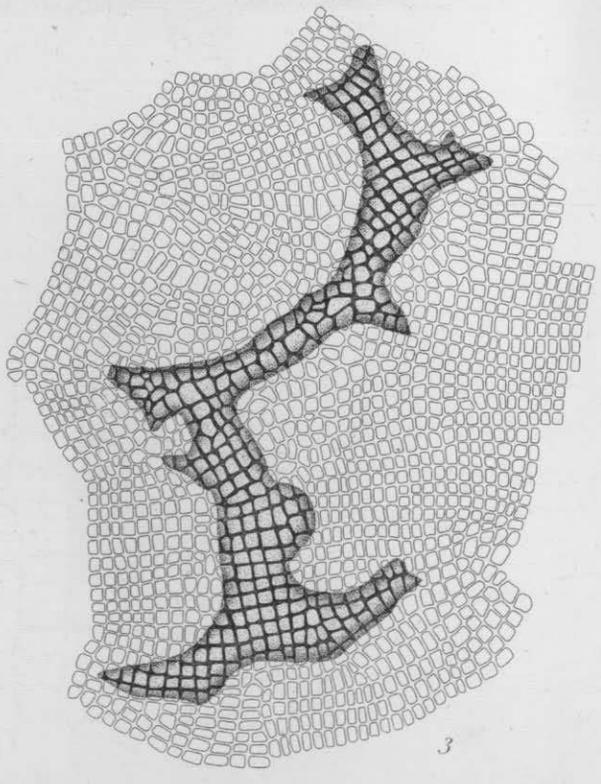
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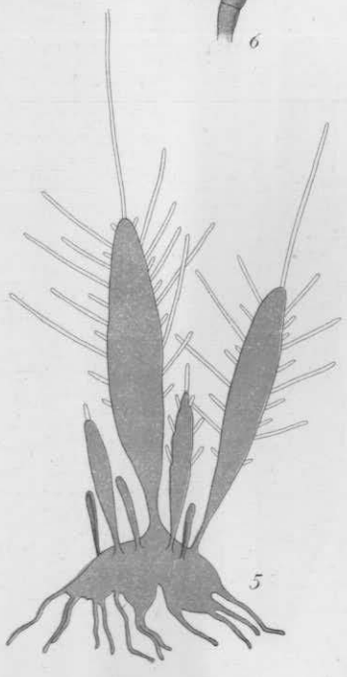
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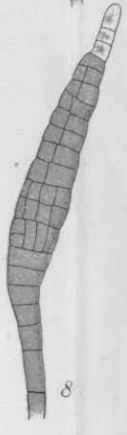
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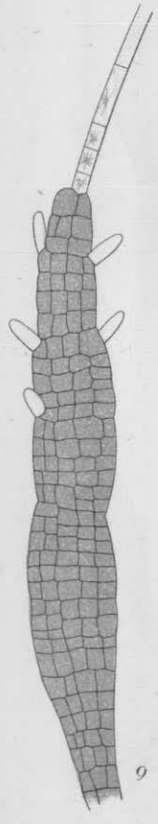
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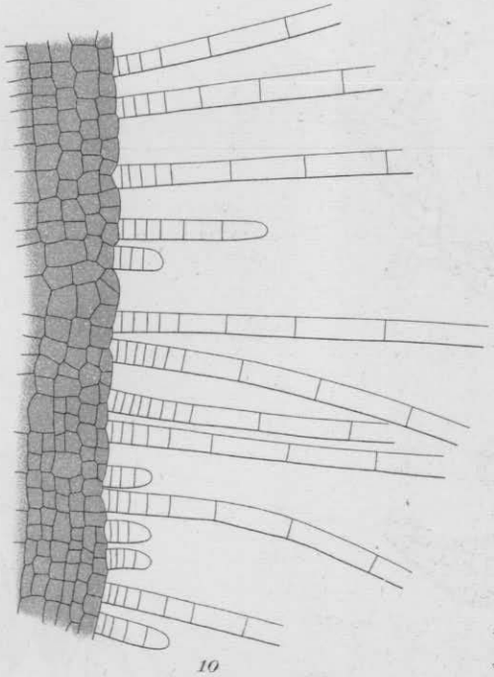
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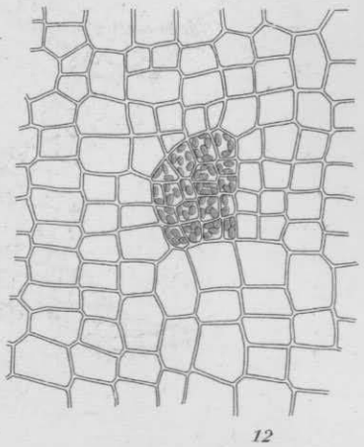
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K. Yendo. 1-3. Alaria ochotensis; 4. Alaria marginata Post. et Rupr; 5-12. Homoeostroma latifolium. J. Ag.