



HOKKAIDO UNIVERSITY

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Author(s)	MIYABE, Kingo
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Chapter 1

CLASSIFICATION OF THE LAMINARIACEAE

LINNAEUS (1737-1758) once placed the marine algae as a whole in a single genus *Fucus*. In 1813, LAMOUROUX first established the genus *Laminaria* and placed in it all of the so-called kelps. In 1826, BORY classified *Laminaria* and several other similar genera in the family Laminariaceae.¹⁾ Some of them, however, were revealed later to need exclusion from this family. After that, DECAISNE (1842), ENDLICHER (1836-1847), KÜTZING (1849), and J. G. AGARDH (1848, 1867, 1868, 1870, 1872) engaged successively in the taxonomic study of the Laminariaceae. Among the systems established by those workers, AGARDH'S was most complete in those days.

In 1893, SETCHELL published a new system, laying stress on the nature of the blade, whether simple or divided, and on the character of the formative tissue at the transition place. In his system, the Laminariaceae consists of three subfamilies and nineteen genera as follows:

Subfamily 1. *Laminariideae*. Blade simple, except in *Thalassiophyllum*. Among the genera belonging to this subfamily, *Chorda*, *Laminaria*, *Costaria*, *Agarum*, *Thalassiophyllum*, and *Arthrothamnus* are represented in the region under consideration.

Subfamily 2. *Lessoniideae*. Blade simple only while young, later splits at the transition place and finally becomes compound. No representative of this subfamily is found in Japan.

Subfamily 3. *Alariideae*. Blade compound, being divided pinnately. *Undaria*, *Ecklonia*, and *Alaria* are to be listed here.

In the same year, KJELLMAN published his system which appears to be nearly a perfect one. A part of his key which is concerned with the genera represented in the Japanese waters will be quoted here as follows:

1) The name Laminariaceae was first proposed by BORY in 1822, and is used as the name of a subfamily in the Laminariaceae by SETCHELL and GARDNER (1925, p.594). The proper family name Laminariaceae was first used by REICHENBACH in 1823 (cf. SETCHELL and GARDNER, *loc. cit.*, p. 593). (Footnotes are all by Jun TOKIDA).

- A. Paraphyses with the apical walls not markedly thicker than the lateral ones
- (1). Stipe wanting; blade filiform, hollow, the cavity separated by diaphragms into many chambers (1) **Chordeae**
 1. Sporangial sori cover the whole surface of the blade except the basal portion 1. **Chorda**
- B. Paraphyses with markedly thickened apical walls which are mucilaginous in substance and laterally connected with each other; distinction between stipe and blade portions clear
- (2). Blade dotted on surfaces with minute depressions which have tufts of hairs or cryptostomata; mucilage lacunae absent; a centrally located midrib present; thin membranous in the marginal portions (2) **Alarieae**
 2. Stipe giving rise on both sides of its upper portion to many leaflets which are covered with sporangial sori on both surfaces; blade at the top of the stipe undivided 2. **Alaria**
 3. Stipe giving rise on both sides of its lower portion to a strongly undulate wing which is covered with sporangial sori on both surfaces; blade at the top of the stipe divided deeply into pinnate segments 3. **Undaria**
 - (3). Blade with numerous small perforations; mucilage lacunae and cryptostomata absent (3) **Agareae**
 4. Blade simple, a midrib present 4. **Agarum**
 5. Blade terminating each branch of the repeatedly divided stipe, inrolled at the lower margins, midrib absent 5. **Thalassiophyllum**
 - (4). Blade with no perforation, mucilage lacunae usually present but sometimes absent, cryptostomata absent (4) **Laminarieae**
 6. Stipe undivided; blade simple, entire and more or less ruffled on the margins, or split palmately into several segments, longitudinal ribs absent; mucilage lacunae present or absent . . . 6. **Laminaria**
 7. Blade giving rise to entire or deeply lobed leaflets on the margins, mucilage lacunae present, longitudinal ribs absent . . . 7. **Ecklonia**
 8. Blade with five longitudinal ribs, mucilage lacunae absent 8. **Costaria**
 9. Stipe branching dichotomously, each branch bearing a simple terminal blade; blade with an auriculate outgrowth on each side of the lower margin, the outgrowth becomes the meristem which gives rise to a stipe and blade in the succeeding year; mucilage lacunae present 9. **Arthrothamnus**

According to the result of the present study on the Laminariaceae of Hokkaido, KJELLMAN's system is in need of a little amendment in some respects. Namely, KJELLMAN classified *Costaria* in the Laminariaceae stating that it lacks cryptostomata. However, that organ has been discovered in specimens of *Costaria Turneri* at hand. On the basis of the character of the paraphysis, the genus *Costaria* is to be placed between the subfamilies Chordeae and Alarieae.²⁾

2) In modern systems, the kelps or the Laminariaceous plants are placed in one order, Laminariales (cf. KYLIN, 1917, p. 308; OLTMANN, 1922, p. 121; SETCHELL and GARDNER, 1925, p. 590). The Laminariales are classified into two families, viz., Chordaceae DUMORTIER (1822) and Laminariaceae REICHENBACH (1828), in the systems arranged by several authors, such as OLTMANN, (1922), SCHMIDT (1938), and OKAMURA (1936); or into five families, viz., Chordaceae, Laminariaceae, Lessoniaceae SETCH. et GARDN., Alariaceae SETCH. et GARDN., and Haligeniaceae in the system proposed by SETCHELL and GARDNER (1925); or into four families, viz., Chordaceae, Laminariaceae, Lessoniaceae, and Alariaceae, in the system adopted by PAPENFUSS (1951, p. 150). As enumerated by PAPENFUSS (*l. c.*), the Laminariales of the world contain at present thirty-one genera, of which fifteen genera have been reported from Japan and adjacent waters. Their names and classification are as follows:

Order Laminariales KYLIN, 1917.

Family 1. Chordaceae DUMORTIER, 1822.

Chorda STACKH., 1816.

Family 2. Laminariaceae REICHENBACH, 1828.

Subfam. 1. Laminarieae BORY, 1822.

Laminaria LAMOUR., 1813.

Kjellmaniella MIYABE, 1902.

Subfam. 2. Cymathaereae SETCH. et GARDN., 1925.

Cymathaere J. AGARDH, 1867.

Subfam. 3. Agareae KÜTZING, 1843.

Agarum BORY, 1826, *emend.* POST. et RUPR., 1840.

Costaria GREVILLE, 1830.

Thalassiophyllum POST. et RUPR., 1840.

Subfam. 4. Hedophylleae SETCHELL, 1912.

Streptophyllum MIYABE et NAGAI, *in* NAGAI, 1940.

Arthrothamnus RUPRECHT, 1848.

Family 3. Alariaceae SETCH. et GARDN., 1925.

Subfam. 1. Alarieae SETCHELL, 1912.

Alaria GREVILLE, 1830.

Pleuropterum MIYABE et NAGAI, 1932.

Undaria SURINGAR, 1873, *emend.* OKAMURA, 1915.

Subfam. 2. Ecklonieae SETCHELL, 1912.

Ecklonia HORNEMANN, 1828.

Eisenia ARESCHOUG, 1876.

Eckloniopsis OKAMURA, 1927.

Chapter 2

DESCRIPTION OF GENERA AND SPECIES

1. *Laminaria* LAMOUROUX

LAMOUROUX, Essai, 1813, p. 20 (*pro parte*).

Holdfast is filiform or disc-shaped. Stipe is simple, directly continuous to a single entire or palmately splitted blade. Blade is without a midrib but thickened and elevated on one surface longitudinally in the central portion, which is called the median fascia and in young blades of some species is provided with a row of bullations along both its sides or in other species with a smooth surface from the beginning. Zoosporangial sori are on the surface of the blade, not uniform in shape and development according to the species. Mucilage canals are present in both stipe and blade in some species but lacking entirely from the stipe in some others.

Among the genera of the Laminariaceae, *Laminaria* is most rich in species and most valuable for practical use. According to the latest survey, there are about forty species of *Laminaria* in the world, of which twelve are known to occur in Hokkaido and vicinity.

In classifying the *Laminaria* species of Hokkaido, the author has generally followed the system proposed by GUIGNARD (1893).

This French author is of opinion that some species of *Laminaria* lack mucilage canals in both stipe and blade, and for an example of such species he mentioned of *L. angustata*. However, the result of the present study has shown that *L. angustata* possesses the canals in the blade. However, they do not form a continuous network as in other species but are interrupted here and there so that a cross section of the blade may sometimes happen to show no canal. So a close examination of the other three exotic species, which GUIGNARD enumerated as other examples of such kind of species, may disclose the presence of mucilage canals as observed in *L. angustata*. If the entire absence of the canals in those species is proved, it should be better, the author believes, to remove them from the genus *Laminaria*.

KEY TO THE SPECIES

I. Blade entire

A. Mucilage canals present in both stipe and blade

a. Hapteres not verticillate but mainly in vertical rows

 α . Blade coriaceous

1. Blade linear-lanceolate, broad, rather round at the base, with the insertion of the stipe not in the center of the basal margin 1. *L. japonica* ARESCH.
2. Blade linear-oblanceolate, usually cuneate at the base 2. *L. ochotensis* MIYABE

 β . Blade fragile

3. Stipe short (4-6.5 cm), blade narrow (15-20 cm) 3. *L. fragilis* MIYABE
4. Stipe short (6-12 cm), blade broad (ca. 40 cm) 4. *L. diabolica* MIYABE
5. Stipe long (50-60 cm), blade broad (ca. 52 cm) 5. *L. longipedalis* OKAMURA

b. Hapteres verticillate

6. Blade quite smooth on the surface even while young, with no bullations⁵⁾ 6. *L. religiosa* MIYABE
7. Blade with a row of bullations along both sides of the median fascia while young, becoming smooth on the surface and crispate on the margins at maturity 7. *L. cichorioides* MIYABE

B. Mucilage canals absent from the stipe, present only in the blade

a. Mucilage canals discontinuous, being scattered here and there; (canals rarely present in the stipe too)

8. Sori on the upper surface⁶⁾ of the blade along the margins but not on the median fascia, and developing from the base upwards 8. *L. angustata* KJELLMAN

b. Mucilage canals a continuous network

9. Blade very long, up to twelve fathoms; sori formed from the base upwards, on both surfaces 9. *L. longissima* MIYABE

5) Bullations are present in *L. religiosa* while the frond is young. (cf. YENDO, 1913, p. 302; OKAMURA, 1936, p. 246; MIYABE in OKAMURA, 1936, p. 284).

6) Dr. MIYABE (1902, p. 4) stated in his introductory remarks under the heading of "External morphology" as follows: "The median fascia is elevated on one surface and depressed on the other. The elevated surface is commonly called the upper surface whereas the depressed is called the under, because the former is believed to face usually the light in the natural state." However, YENDO (1911, p. 302) describes rightly that the elevated surface faces the substratum and the depressed faces the light in the natural state, so the latter is to be called the upper surface whereas the former the under.

10. Blade short, coriaceous and rigid, sori formed only near the distal end of the blade 10. *L. coriacea* MIYABE
- II. Blade palmately splitted
- A. Mucilage canals present in both stipe and blade
11. Holdfast composed of fibrous, branched hapteres
. 12. *L. Ruprechtii* (ARESCH.) DE TONI
- B. Mucilage canals in the blade only but absent from the stipe
12. Holdfast disk-shaped 11. *L. yezoensis* MIYABE

1. *Laminaria japonica* ARESCHOUG

(Plate 1)

ARESCHOUG, *Phyceae capenses*, p. 29, 1851.

Illustration. WADA and NOZAWA, Hokkaido Suisan Yosatsu Chōsa Hōkoku, Plate V, 1892; SURINGAR, *Algae Japonicae*, Tab. XI & XII, 1870; IWASAKI, *Honzō Zufu*, Vol. 34, Plate XXII, 1828.

Japanese name. Makombu.

Makombu (Osatsube), Shinori-kombu (Shirisawabe), Hababiro-kombu (Muroran), Oki-kombu (Kikonai), Uchi-kombu (Kikonai), Motokombu (Shikabe, Kayabe), Minmaya-kombu (Tappi in Mutsu Province), Ebisume (*in* "Wamei-shō"), Kombu (*in* "Honzō Kōmoku Keimō"), Hirome.

Holdfast composed of filiform hapteres arising from the lower part of the stipe in irregular vertical rows and branching from seven to twelve times dichotomously; several fronds generally fasciculate on an entangled mass of holdfasts. Stipe short, thick, elliptic or compressed in cross section at the lower portion, becoming more flattened and broadened above into the blade, 3–10 cm in length, 1.5 × 1.0 cm and 1.5–2.0 × 0.4–0.7 cm in elliptic and compressed cross sections of the lower portion respectively. Blade entire, linear-lanceolate, broad, attaining the maximum breadth in the portion a little below the middle of the overall length, gradually decreasing in breadth below, round at the base, with the insertion of the stipe not at the center of the basal margin; median fascia thick and broad, 1/2 to 1/3 as wide as the total breadth of the blade, up to 3–4 mm in thickness; marginal portions rather thin and slightly undulate; up to 1.8–3.5 m, usually 2–2.5 m in length, up to 20–35 cm, rarely to 45 cm, usually 25–30 cm in width; coriaceous in substance; reproductive organs produced from August or

September on, forming sori on the upper, rarely also on the under surface⁷⁾ of the blade; sori extending from the lower portion of the median fascia upwards, covering nearly its whole surface within a region corresponding to 1/4–1/3 of the overall length of the blade, becoming discontinuous and finally disappearing in areas above that region.

Mucilage canals in the stipe arranged closely in a row in outer cortex, sometimes in two rows as in a compressed stipe of a specimen from Yamakoshi; medulla of the blade rather thin, composed of filamentous cells running generally lengthwise; mucilage canals in a mature blade arranged in two rows in the median fascia (Plate 29, fig. 1), but in one row in the marginal portion. Zoosporangia clavate, with a slight thickening of the membrane at the apex, 100–112.5 μ long, 11.8–13.2 μ broad at the broadest portion; paraphyses filiform, 163.3–174.2 μ long, 5.9–6.6 μ broad, capped with a marked gelatinous thickening of the membrane, 28.3–40.2 μ thick.

Habitat. Growing in clear sea-water along the coasts facing bays and exposed to not very rapid tidal movements, washed by a warm current mingled with a faint distal reach of a cold current, on rocks lying from the maximum low water mark downwards, most abundantly in the depths between 4–5 fathoms and 7–8 fathoms, rarely in the depths of 24–25 fathoms in some localities. Distributed in Hokkaido along the coast from Muroran southwestwards as far as Kikonai of Kami-iso Gun. The dried fronds of *Laminaria* produced from the vicinity of Osatsube Village in Kayabe Gun are known to be of the best quality. Those produced from the vicinity of Shiokubi, Kameda Gun, were once highly estimated in the market being called “Shinori-kombu.” However, they are of thinner substance and somewhat inferior quality as compared with those from Osatsube. The specimens from Muroran, Yamakoshinai, and Kikonai are often found to have a flattened stipe. The dried fronds of *Laminaria* produced from Mimmaya in Aomori Prefecture belong to the present species and bear a close resemblance to “Shinori-kombu” in its quality.

Use. The present species is most rich in the sugar content among our *Laminarias*, and is used for giving flavor to food and for manufacturing sweets.

7) See foot-note no. 6 on page 5.

*Natural enemies.*⁸⁾ *Phyllospadix Scouleri*,⁹⁾ *Alaria crassifolia*, *Costaria Turneri*, *Undaria distans*, and Sargassaceous plants are to be listed here.

2. *Laminaria ochotensis* MIYABE, sp. nov.

(Plate 2)

Japanese name. Rishiri-kombu.

Rishiri-kombu (Rishiri and Rebun), Makombu (ditto), Koteshio (Rumoi), Hosome-kombu (Teshio and Kitami), Shio-kombu (Rishiri and Rebun), Para-kompo (Aino name at Abashiri), Dashi-kombu (Kitami and Abashiri), Menashi-kombu, Birôdo-kombu (Menashi), Teshio-kombu, Kuro-kombu.

Holdfast composed of filiform hapteres arising from the lower part of the stipe in four or five vertical rows, branching from eight to nine times dichotomously; seven to twenty fronds fasciculate on a mass of holdfasts, but in a narrow form called "Hosome," twenty to eighty or ninety fronds are usually found to grow in a cluster. Stipe short, smooth on surface, elliptic or round in cross section at the lower portion, becoming flattened and broadened above into the blade, 3–10 cm in length, 1–1.5 cm in diameter at the lower portion. Blade entire, linear-oblongate or linear-spindle in shape, usually cuneate, but rarely round or cordate in plants growing sparsely, at the base; median fascia thick and broad, 1/3 as wide as the entire breadth of the blade; marginal portions thin and slightly undulate; coriaceous in substance and rich in mucilage; blackish-brown in color when matured, hence the plant is called "Kuro-kombu"; at the transition place bending nearly at right angles in a frond growing on the sea bottom; usually 1.5–2.7 m, but in some localities up to 9–13.5 m in length, 15–30 cm

8) Dr. MIYABE (1902, p. 13–14) states in his introductory remarks under the heading of "Natural enemies" as follows: "The natural substrata good for the attachment of *Laminaria* are limited in their capacity. It is not uncommon to find them having been invaded by luxuriant growths of other seaweeds. Species of invaders vary according to the locality. For instance, *Laminaria japonica* finds its competitors in *Phyllospadix*, *Alaria crassifolia*, *Costaria*, *Undaria*, *Sargassum*, etc., whereas *L. longissima* in *Alaria yezoensis*, *Costaria*, etc."

9) The species of *Phyllospadix* distributed in Hokkaido was once referred by MAKINO (1899) to *Phyllospadix Scouleri* HOOKER, a Pacific species of North America. However, MIKI (1933) states that the so-called *Phyllospadix Scouleri* in Japan is nothing but *Phyllospadix iwatensis* MAKINO (1931).

in width, whereas in "Hosome" 1-2 m in length and up to 3-4 cm in width. Sporangial sori quite irregular in shape and position, beginning to appear in August, at first as scattered patches near the base of the blade, later they become confluent with each other, covering nearly the entire surface of the lower part of the blade, extending gradually upwards as scattered patches mainly on the median fascia; formed either on both surfaces or on one surface of the blade, in the latter case more frequently on the upper surface,¹⁰⁾ covering, in matured fronds, the blade surface within a region corresponding to 3/4 of the overall length of the blade or sometimes to the very apex.

Mucilage canals arranged in a row, or rarely in two rows, in both stipe and blade; medulla of the blade thin, with a similar structure to that in *L. japonica*; superficial cells and several underlying outer cortical cells containing very abundant chromatophores.

Habitat. Growing in water about 2 to 5, rarely 7 to 8 fathoms in depth. Distributed along the Japan Sea coast of Hokkaido from Atsuta, Ishikari Province, northeastwards, by way of Yagishiri Island, Teuri Island, Rishiri Island and Rebun Island, along the Ochotsk Sea coast from Kitami Province through Menashi Gun, Nemuro Province, as far as the western coast of Kunashiri Island, where the distal end of a warm current is mingled with a cold current. Of these localities, Teshio Province is known to produce plants of superior quality and its coast north of Onishika is called "Homba" or the best place for this *Laminaria*. The plants from Rishiri and Rebun are of a broad blade, black in color. They are somewhat inferior in quality, but are produced abundantly for the markets. Along the coast of Kitami Province, the harvest of this *Laminaria* shows a tendency of increase in amount year after year in accordance with the increase of population. A species of *Laminaria*, which is collected along the western coast of Saghalien Island and exported to the northern districts of China, is considered from its description to be identical with *L. ochotensis*.¹¹⁾

Use. The present species can be used almost in the same way as *Laminaria japonica*. The plants produced in Teshio Province are most rich in sugar content and good for giving flavor to food.

Addenda. The so-called "Hosome-kombu" growing in company

10) See foot-note no. 6 on page 5.

11) MIYABE in OKAMURA, 1936, p. 285; TOKIDA, 1954, p. 118.

with *Laminaria ochotensis* is identical specifically with the latter, showing no difference in the internal structures. As for the characteristic very narrow blade of this plant, it is no doubt due to the suppression of normal growth induced by the overpopulation of the fronds crowded on a single mass of holdfasts.

The present species resembles most closely *Laminaria cuneifolia*, which occurs along the northern coasts of Europe, in the eastern part of the Siberian Sea and in the vicinity of Behring Strait. According to the views of AGARDH and KJELLMAN, *Laminaria saccharina* var. *cuneifolia* mentioned by RUPRECHT in his Tange des Ochotskischen Meeres, p. 351, is probably identical with the species alluded to above. However, RUPRECHT's description is very simple, only mentioning the cuneate base of the blade, the shortness of the stipe, the presence or absence of the marginal undulations, and no more, so that it is impossible without seeing the specimens to decide whether the plant from the Ochotsk Sea is referable to *Laminaria cuneifolia* as AGARDH believes or it is identical with our *L. ochotensis*.

A description of *Laminaria cuneifolia* will be given here for reference.

Holdfast consists of filiform hapteres branching several times. Stipe is short, solid, and somewhat cylindrical in shape. Blade is membranous, elongato-elliptical linear in shape, undulating or not on the marginal portions, and provided with a row of bullations along both sides of the median fascia. Sporangial sori develop first as large spots on the median fascia in the lower portion of the blade. The base of the blade is cuneate, sometimes cordate when matured. Mucilage canals are present in both blade and stipe. Blade has light yellowish tint. As compared with this Arctic species, the present Hokkaido plant is characterized by having a thick, coriaceous blade, which is linear oblanceolate or linear spindle in shape. It has no bullations, at least when grown up to a certain extent, though it is not clear whether a very young blade has bullations along the median fascia or not. The plant is blackish-brown in color being rich in pigments. It is distributed in Hokkaido only along the coasts washed by a distal reach of a warm current, but never along those washed solely by a cold current. So it cannot be considered identical with *Laminaria cuneifolia* which occurs along the coasts of Siberia and in Behring Sea. Hence

the author proposes to name it *Laminaria ochotensis* as a new species. Among the species of Hokkaido, *L. japonica* of Oshima Province is that which our new species resembles most closely. However, they can be distinguished from each other as they have some differences in the shape and inner structure of the blade.

3. *Laminaria fragilis* MIYABE, sp. nov.

(Plate 3)

Japanese name. Yayan-kombu.

Yayan-kombu (Muroran), Shio-kombu (ditto), Daiba-kombu (Hakodate).

Holdfast composed of filiform hapteres arising irregularly from the lower part of the stipe, arranged somewhat spirally but never verticillate, branching seven to nine, or rarely up to thirteen times dichotomously, or sometimes tri- or tetra-chotomously. Stipe smooth on surface, solid, round or elliptic in cross section at the lower portion, markedly flattened at the upper portion, up to ca. 5 cm in length, up to $8 \times 5-6$ mm in diameter. Blade entire, linear-lanceolate, attaining the maximum breadth at the portion below the middle of the overall length, round or rarely cordate at the base, up to 2.5-3.5 m in length, up to 15-24 cm in width; median fascia $1/4$ as wide as the whole breadth of the blade; marginal portions thin, slightly undulate, with a row of bullations along both sides of the median fascia while young, bullations disappear in mature portions; thin and fragile in substance; light brown in color, becoming dark brown when dried. Sporangial sori scattered all over the surface of the blade, more or less confluent on the median fascia but in the form of irregular discontinuous spots on the marginal portions, usually present on one surface of the blade and absent from the other, but rarely formed on both surfaces, densely on one surface and sparsely on the other. The sori begin to develop from about the end of August and come to their maturity in September or October. After that period the blade becomes eroded in the upper parts and covered with many epiphytic Hydrozoan bodies.

The stipe is provided with a single row of mucilage canals, and its medulla is composed of more or less thick filamentous cells running densely, vertically as well as horizontally. The blade is

also provided with a row of mucilage canals which are narrow as compared with those of other species. The medulla of the blade is very thin, and its scanty filamentous cells are located between thick-walled parenchymatous cortical cells.

Habitat. Growing in water 1-2 fathoms in depth along the coasts facing bays and washed by calm waters. Found in the vicinity of Daiba or the fort¹²⁾ in Hakodate Harbor, in Muroran Harbor and at Oinaushi, Muroran.

Use. This species is rich in salt and iodine contents. Its Aino name "Yayan" means a useless thing, and seems to suggest its uselessness due to the high content of salt. It is reported to be exported in a small total quantity to China of late years.

Addenda. Among the hitherto known species of *Laminaria* characterized by the presence of mucilage canals in both stipe and blade, not even a single species can be found to which the plant in question is referable. So the author proposes here to name it *Laminaria fragilis* as a new species.

4. *Laminaria diabolica* MIYABE, sp. nov.

(Plate 4)

Japanese name. Oni-kombu.

Oni-kombu (Kushiro, Nemuro), Hababiro (Kushiro), Ô-hababiro-kombu (ditto), Ita-kombu (ditto), Hanaori-kombu (ditto), Motozoroi-kombu (ditto).

Holdfast composed of filiform hapteres arising from the lower part of the stipe in irregular vertical rows, branching seven to nine times dichotomously. Stipe smooth on surface, solid, round or broad-elliptic in cross section below, complanate and broadened upwards, 6.5-12 cm in length, 12-15 mm in diameter near the base. Blade entire, linear-lanceolate in shape, very broad, round at the base, up to 2.5-4.5 m in length, up to 25-45 (46) cm in breadth; median fascia remarkably thick, sometimes up to 43 mm or more, 1/2-1/4 as wide as the whole breadth of the blade; marginal portions thin, markedly undulate, fragile when dried. Sporangial sori formed on both surfaces of the blade, covering nearly entire surfaces below, becoming irregularly discontinuous and in the form

12) The fort in Hakodate Harbor in those days was situated at the place which the Hakodate Dockyard occupies today.

of scattered clouds on the marginal portions upwards, but on the median fascia usually in a continuous patch even towards the apex, sometimes also in discontinuous spots here and there.

Stipe has a row of mucilage canals. The canals in the blade are arranged in two rows at the median fascia, but in one row at the marginal portion. The inner canals of the median fascia are larger in diameter than the outer ones, and sometimes are replaced by masses of small cells. The medulla is thin, consisting chiefly of vertical rows of filamentous cells.

Habitat. Growing in water one to two fathoms in depth within calm bays situated in the cold current region. Distributed from Akkeshi, Kushiro Province, eastwards, as far as along the coasts of the Nemuro Peninsula and of Etorofu Island, Kuriles. Nothing definite is known now about the presence or absence of this species in the northern region beyond Etorofu Island as it lies outside the area of the author's researches.¹³⁾

Use. This species was once used to make "Hanaori-kombu" and "Motozoroi-kombu"¹⁴⁾ with its middle part of the blade stripped of the fragile marginal portions. But it can hardly meet the market demand because of its inferior quality. At Akkeshi and its neighbourhood this alga is used for the manufacture of iodine.

Addenda. The present species most closely resembles *L. japonica* of Oshima Province. However, it can easily be distinguished from the latter since there are some marked differences in their outer and inner structures. None of the known species is considered to have characters identical with the plant in question, so the author proposes here to recognize it as a new species naming it *Laminaria diabolica* in accordance with the meaning of its common Japanese name "Oni-kombu."

5. *Laminaria longipedalis* OKAMURA

(Plate 5)

OKAMURA, *Laminaria* of Japan, p. 89, pl. VII, figs. 1-3, 1896.

Illustration. OKAMURA, *loc. cit.*, pl. VII, figs. 1-3.

Japanese name. **Enaga-kombu.**

13) NAGAI (1940, pp. 71-74) reports that *Laminaria diabolica* grows in the Kuriles on the coasts of Kunashiri Isl. and Etorofu Isl. only.

14) Hanaori-kombu and Motozoroi-kombu are illustrated in MIYABE's work (1902), pl. 33, figs. 11-12, pl. 35, fig. 4 and pl. 33, figs. 1-10, pl. 35, fig. 1 respectively.

Kakijima-kombu (Akkeshi), Ô-ita-kombu (ditto).

Holdfast composed of filamentous hapteres divided several times. Stipe solid, very long, usually 50–66 cm, sometimes up to 1 m in length, round in cross section below, complanate and broadened upwards. 15–16 mm in diameter near the base. Blade lanceolate, broad, cordate at the base when matured but round or broad cuneate while immature, slightly undulate on the margins, with a median fascia not so distinct as in other species, sometimes up to 33–76 cm in breadth, fragile in substance. Sporangial sori on both surfaces of the blade, in patches similarly shaped to those of *Laminaria diabolica*.

The mucilage ducts are present in both stipe and blade; they are smaller in diameter as compared with those of *Laminaria diabolica*. The medulla of the blade is thin, consisting chiefly of vertical rows of filamentous cells.

Habitat. Growing on dead oyster shells heaped in Akkeshi Lake, a lagoon at Akkeshi, Kushiro Province. Unknown from elsewhere.

Use. Because of its inferior quality, the present alga is not fit to be exported. Its annual yield is said to be only 300–400 koku.¹⁵⁾

Addenda. This species is unique among the *Laminaria* species of Hokkaido in that its occurrence is restricted to a special locality. It grows restrictedly in Akkeshi Lake favored by the calm water of low salinity, and consequently has quite a long stipe and a markedly broadened and thin blade. In other important characters, however, it bears a close resemblance to *Laminaria diabolica*, which grows in Akkeshi Bay at places only a few kilometers distant from the habitat of *L. longipedalis*. In view of this fact, there may be a question as to whether it is more reasonable or not to recognize the latter species as belonging to a variety of the former.¹⁶⁾ The author describes it as a distinct species here following the view of Dr. K. OKAMURA, who named it *Laminaria longipedalis*.

15) One koku is equivalent to 330.6 lbs.

16) MIYABE and NAGAI (1933, p. 88) reduced the preceding described species to a variety of the present, as var. *diabolica* MIYABE, according to the rule of priority, and OKAMURA (1936, p. 250) agreed with their view. However, MIYABE (*in* OKAMURA, 1936, pp. 285–286) treated it again as a distinct species.

6. *Laminaria religiosa* MIYABE, sp. nov.

(Plate 6)

Japanese name. Hosome-kombu.

Hosome (Matsumae), Bon-me (northern districts of Honshû), Iso-kombu (Shiribeshi), Hanaori-kombu (Matsumae).

Holdfast composed of filamentous hapteres branching 6-7 times, of which the uppermost ones arise regularly in a whorl. Stipe smooth on surface, solid, more or less cylindrical at the base, slightly complanate above, of nearly the same diameter at both ends, 50-65 mm in diameter, ca. 5 cm in length. Blade entire, linear-lanceolate, reaching the maximum breadth at a distance of $\frac{1}{3}$ or $\frac{1}{2}$ of the overall length of the blade from the base, round at the base; in the individuals growing on littoral reefs, the blade is up to 0.7-2.0 m, usually 1.3-1.6 m in length, and 5-12 cm, usually 7-10 cm, in breadth, while in those growing in deep waters the length of the blade is nearly the same as in the former, but rarely attains to 3.5 m, and the breadth is 10-29 cm; marginal portion thin, strongly undulate while young, becoming flat with the approach of maturity; median fascia $\frac{1}{3}$ as wide as the entire breadth of the blade, 20 mm in thickness; coriaceous in substance; rich in mucilage; dark brown in color. Sporangial sori on both surfaces of the blade, covering nearly the whole surface in the lower part, becoming discontinuous in the upper portion, occurring chiefly on the median fascia.

Mucilage ducts closely set in a single row in both stipe and blade, situated in the blade nearly at the middle portion between the medulla and the superficial cell layer. Medulla of the blade thin, consisting of filamentous cells mostly arranged in vertical rows.

Habitat. Growing on rocky reefs between the lowest water mark and the depth of 5-6 fathoms. Distributed from Matsumae district as far north as Ishikari Bay, Shiribeshi Province. The so-called "Bon-me" occurring along the coasts of the Sanriku district and Iwaki Province in Honshû is probably identical with the present species. In Hokkaido this *Laminaria* is called "Hosome." It is harvested there in early summer while the frond is not yet fully matured, and is exported to Uetsu districts of middle Honshû to meet the public demand at the Festival of Chûgen or Bon. Hence

it is named "Bon-me". Mature plants harvested in summer are used for food, the broader ones of them being packed in the style of "Hanaori-kombu."¹⁷⁾ The plants produced at the villages of Fukushima, Miyauta, and Yoshioka, all in Matsumae district, are known to be of superior quality. As compared with *L. japonica* and *L. ochotensis*, the present species is so poor in both sugar and salt contents, that it stands far behind those species in the quality needed for giving flavor to food.

Addenda. The present species finds its most closely resembling allies in *L. japonica* and *L. ochotensis*. Their adjacency in distribution range as well as their resemblance in histological characters seems apparently to suggest their specific identity. But the author recognizes the plant in question as a new species, because its characteristic shape of the blade, verticillate hapteres, and sporangial sori formed always on both surfaces of the blade are considered to be sufficient to make the plant deserving specific rank.

7. *Laminaria cichorioides* MIYABE, sp. nov.

(Plates 7 & 8)

Japanese name. Chijimi-kombu.

Arame-kombu (Wakkanai), Tororo-kombu (Shiribeshi, Teshio, Kitami Provinces), Koise (Aino name at Abashiri), Gaggara-kombu or Chijimi-kombu (Nemuro Harbor).

Holdfast composed of delicate filamentous hapteres branching 6-9 times, arising in whorls from the basal part of the stipe, the uppermost whorl being sometimes composed of as many as fifteen hapteres. Stipe solid, smooth on surface, cylindrical or rarely complanato-cylindrical below, compressed above, 3.5-6.5 cm in length, 6.5-8.5 mm in diameter near the base. Blade, while young, lanceolate, tapering toward each end, thin, markedly crispate on the margins, with a row of bullations along both sides of the median fascia; becoming with the advance of growth more or less thicker at the lower or newly-formed portion which is destitute of crispations on the margin and of bullations along the median fascia, and is round or even cordate at the base; on maturity becoming sometimes again finely crispate on the margins; usually 1-2 m in length, 10-20 cm in breadth. Sporangial sori formed on both sur-

17) Cf. MIYABE, 1902, pl. 33, figs. 11-12, pl. 35, fig. 4.

faces, quite irregular in shape, occupying the depressed portions, but not the elevated, of the blade.

This kelp is rich in mucilage, hence it is named "Tororo-kombu" in Japanese.

Mucilage ducts in the stipe very narrow, arranged as a rule in a complete circle, but sometimes in a semi-circle, or rarely occurring sporadically, while those in the blade arranged in a row. Medulla of the blade is rather thick.

Habitat and use. Growing in water between the low tide-mark and the level 1-2 fathoms deep. Distributed from the northern part of Shiribeshi Province northeastward along the coasts of Teshio and Kitami Provinces, as far as the western coast of Kunashiri Island and the interior of Nemuro Bay. The present species is not worth being harvested since its frond is small and inferior in quality.

Addenda. This kind of *Laminaria* is believed to have been unknown to science. So the author proposes here to name it *Laminaria cichorioides* as a new species.

8. *Laminaria angustata* KJELLMAN

(Plate 9)

KJELLMAN, in KJELLMAN and PETERSEN, Om Japans Laminaria, p. 266, 1885.

Japanese name. Mitsuishi-kombu.

Sôpaushi (Aino name at Muroran and Shiraoi), Shiohoshi-kombu (Esan), Urakawa-kombu, Shamani-kombu, Tokachi-kombu, Dashi-kombu (Shiranuka), Mizu-kombu (Hidaka).

Holdfast composed of filamentous hapteres branching 5-7 times, arising in several, up to 5-7 whorls, from the lower part of the stipe. Stipe smooth on surface, solid, cylindrical or complanato-cylindrical, nearly of the same diameter at both ends, somewhat flattened at the portion adjacent to the blade, 3.5-8 cm, rarely up to 10 cm in length, 6.5-8.5 mm in diameter. Blade entire, linear, cuneate at the base, attaining the maximum breadth at a distance of nearly 1/4 of the overall length of the blade from the base, slightly undulate on the marginal portions, coriaceous in substance, dark brown in color; median fascia only 1/6 as wide as the entire breadth of the blade; up to 1.6-6.5 m in length, up to 5-15 cm in breadth. Sporangial sori formed on the marginal portions of the

upper surface¹⁸⁾ of the blade but usually not on the median fascia nor on the under surface,¹⁹⁾ developing from the lower portion upwards as a continuous patch, becoming discontinuous and scattered in the upper portion. In the specimens collected at Moyoro Village, Biroo district, Tokachi Province, and in the vicinity of Cape Erimo, Hidaka Province, the sporangial sori were found not only on the marginal portions of the upper surface but also on the median fascia of the under surface. The sori begin to develop from the middle of July and come to maturity in August and September. In the period between the early autumn and the beginning of the winter, old fronds are detached from the substratum and new ones begin their growth. Owing to the damage caused by drifting ice or to other reasons, new plants sometimes happen to appear first in the following spring. Such plants, commonly called "Mizu-kombu", are of very narrow blade. They produce sporangial sori towards the end of October or at the beginning of November.

KJELLMAN described the present species as having no mucilage duct in either stipe or blade. In the abundant specimens at hand from Hidaka and Iburi Provinces, however, the author could rarely find an individual bearing a row of mucilage ducts in the stipe. On the other hand, the stipe of the specimens collected at Shiranuka, Esan, and Biroo was found to be entirely destitute of mucilage ducts. Thus variable was the existence of the ducts in the stipe, while their presence in the blade was ascertained to be constant. The present species differs from others in the fact that the arrangement of the ducts is quite irregular. The ducts would be entirely lacking under both surfaces in a part of a blade, while in other parts of the same blade they would be present in the tissue under one surface but absent from the tissue under the other. This species is characterized by having mucilage ducts not in the form of an extensive continuous net-work but in the form of small broken fragments of a net-work. (Plate 29, Fig. 5). The medulla of the blade is composed of filamentous cells running in every direction, just the same as that of the stipe, and when immersed in fresh water it swells up remarkably to occupy $1/3$ of the thickness of the blade in cross section. (Plate 29, Fig. 2).

Habitat. Growing on rocks between the low-tide-mark and the

18) 19) Cf. Foot-note no. 6 on page 5.

level at about seven fathoms depth, along projecting coasts washed by a strong cold current mingled somewhat with a warm current. Distributed along the coasts from Shiranuka, Kushiro Province, southwestwards as far as Muroran, and occurring at Cape Esan, Oshima Province. Growing most luxuriantly along the coasts of Hidaka Province.

Use. The species in question is used in the western provinces of Honshû for the manufacture of shredded kombu ("Kizami-kombu"), and is also exported to China in considerable amount. It is known to be rich in iodine content. The plants produced at the localities west of Samani and Urakawa are more rich in sugar content as compared with those from Biroo and Horoizumi.

Natural enemies. On flat reefs in Hidaka Province, *Phyllospadix* is a tremendous menace to the growth of this *Laminaria* while the plants on uneven rocky bottoms along projecting coasts at Esan, Muroran and Erimo are exposed to the menace of *Costaria*, *Sargassum*, *Alaria yezoensis* and *A. crassifolia*.

Addenda. The present species resembles *Laminaria longissima* of Nemuro and Kushiro Provinces in some respects, but differs from the latter in the position of the sporangial sori, in the possession of discontinuous mucilage ducts, and in general appearance of the frond.²⁰⁾ Accordingly it can easily be distinguished at a glance from that species. The scientific name for this species was given by KJELLMAN.

9. *Laminaria longissima* MIYABE sp. nov.

(Plate 10)

Illustration. WADA & NOZAWA, Report on the Preliminary Survey of Fishery in Hokkaido, Plate V, 1892.

Japanese name. Naga-kombu.

Ma-kombu (Kushiro, Nemuro), Nimotsu-kombu (Kushiro), Gimberikombu (Kushiro, Nemuro), Kimberikombu (ditto), Mizukombu (ditto), Hosome (ditto), Shimakombu (ditto).

Holdfast composed of filamentous hapteres branching 4-8 times, arising from the lower part of the stipe, in 4 to 7 quite irregular

20) OKAMURA (1936, pp. 252-253) holds the view that the present species and the next are one and the same species. MIYABE (*in* OKAMURA, 1936, p. 287) reduced the next described species to a variety of the present as var. *longissima* (MIYABE) MIYABE.

whorls. Stipe smooth on surface, solid, complanato-cylindrical below, compressed above, up to 5-8 cm in length, 6-8 × 5-7 mm in cross section near the base. Blade entire, narrow linear, attaining the maximum breadth at the portion a little above the middle of the overall length or at a distance of 2/3 of the overall length from the base, gradually tapering towards each end, broadly cuneate at the base, coriaceous, dark brown in color, sometimes with a tinge of green; median fascia 1/5 as wide as the entire breadth of the blade; marginal portions thin, slightly undulate, but thick and plane in the lower portion; usually 5-7 fathoms, rarely up to 12 fathoms, in length, usually 13-16 cm in breadth. Sporangial sori developing from the lower portion of the blade upwards, covering both surfaces except only along the margins, becoming discontinuous in the upper portion, disappearing first from the median fascia and forming scattered patches only on the marginal portions.

Mucilage ducts absent from stipe, arranged in one row in blade, forming a continuous net-work. Some of the specimens collected at Kushiro were found to lack mucilage ducts in the median fascia on the under surface.²¹⁾ Medulla in the blade is rather thin as compared with that of *L. angustata*, and its filamentous cells run in all directions as in the previously described species.

Habitat. Distributed in the cold current, along the coasts of the Kurile Island, Nemuro and Kushiro Provinces. Protected localities are not inhabited by the present species. Though it was impossible to see the sea bottom from a boat through the usually turbid water of the cold current, the present species is supposed to inhabit the bottom extending as far as the depth of 4-5 fathoms. However, the individuals growing in 3-4 fathoms of water are said to be of longer frond and of superior quality. The southern limit of this alga's distribution range does not seem to extend beyond Kushiro Harbor. As for its northward distribution, it reaches as far north as Shikotan Island and the eastern coast of Etorofu Island, but it is unknown at present whether it invades northern regions further.²²⁾ It grows most luxuriantly in the area lying between the eastern coast of the Nemuro Peninsula and the adjacent islets.

21) Cf. Foot-note no. 6 on page 5.

22) This alga has not been known from the northern Kuriles beyond Etorofu Isl. (Cf. NAGAI, 1940, pp. 75-77).

Matured plants become detached from the substratum one after another during winter from November to the next spring. Germination of new individuals takes place on rocks in winter from about the winter solstice to the middle of January, and they attain their maturity in summer. In late winter from the middle of February to March, numerous blocks of drift-ice sometimes happen to touch coastal sea bottoms and wash away young individuals. The plants which may afterwards germinate from spores there would be only 3-6 dm long even in the height of summer, and are named "Wakaoui," which means "young growth." They would first attain their maturity in summer the following year.

Use. This species holds the first place in amount among the Japanese fishery products exportable to China. It is poor in sugar content but rich in salt content.

Natural enemies. The growing ground of the present species is under the threat of invasion by *Alaria yezoensis* and species of Sargassaceae.

Addenda. The plants which are commonly called "Kimberi" or "Gimberi" are matured individuals of *Laminaria longissima* which bear well developed sporangial sori on almost the entire surface of the blade except only along the margins. The sterile margins thus assume a color different from that of other fertile parts of the blade; they are yellowish in color in some individuals which are hence called "Kimberi", that means a *Laminaria* with golden margins, or they have a whitish tinge in other individuals which are hence called "Gimberi", meaning a *Laminaria* with silvery margins. "Kimberi" is said to be abundant at Echashi of Hattaushi in the village of Atoshizu, and at Takinoshita in the village of Chirippu, both in Akkeshi-koshima, while the "Gimberi" is said to be abundant at the village of Kiritappu and at Tochirippu in the village of Chirippu. Besides the foregoing there are also other individuals which are called "Hosome". They are of a narrow blade, only 2-5 cm in breadth, and up to 5 fathoms in length, so they appear at a glance to be referable to a distinct species. Such a peculiar blade-shape is probably due to mutual hindrance of normal growth of several dozens of fasciculate individuals growing densely on a single mass of holdfasts. "Hosome" in Nemuro Province is said to thrive in a year when damage by drift-ice has occurred. It produces sporangial sori on both surfaces of the blade

in autumn. In the shape of sori and in the nature of mucilage ducts and other tissues, it does not differ at all from "Naga-kombu."

Since this alga is believed to be unknown to science, the author proposes here to name it *Laminaria longissima* as a new species.

10. *Laminaria coriacea* MIYABE, sp. nov.

(Plate 11)

Japanese name. Gaggara-kombu.

Gaggara-kombu (Akkeshi & Kiritappu), Oni-kombu (Kushiro & Kombumori), Tachi-kombu (Kiritappu).

Holdfast composed of filamentous hapteres branching 6-9 times, arising from the lower portion of the stipe in whorls, the uppermost of which is composed of 8-10 hapteres. Stipe short, solid, sometimes becoming furnished with numerous minute protuberances on surface with the approach of maturity, cylindrical below, becoming subterete but showing no marked difference in diameter above, 5-8.5 cm in length, 8-10 mm in diameter. Blade linear, round at the base; median fascia $2/3-3/5$ as wide as the entire breadth of the blade, 2.5 mm in thickness; marginal portion thick, with no undulation; substance coriaceous and coarse, suggesting that the blade may be biennial or perennial; 2.5-5 m in length, 8.5-20.0 cm in breadth. Sporangial sori formed on both surfaces of median fascia, in a continuous patch in lower portion of the blade, divided into two rows in the upper portion. The blade is sometimes found to be crowned at the apex with a piece of an old frayed blade, which is the remnant of the blade that has grown in the previous year and bears evident traces of the sporangial sori.

Mucilage ducts absent from stipe, but present and arranged in one row in blade. Medulla of the blade is thick.

Habitat and use. Growing in company with *Laminaria yezoensis* and *Arthrothamnus bifidus* at about 3-4 fathoms depth, and distributed along the coasts of the cold current regions from Kushiro northeastwards. This species is poor in salt content. Though it contains a little sugar, it tastes poor and is not highly regarded in the market. Sometimes people would mix this alga with *L. longissima* when they tie the latter's fronds in bundles for marketing. However, a skilled inspector is said to be able to distinguish with

ease between the two by feeling them with his fingers.

None of the known species is identical with the alga in question, so the author proposes here to name it *Laminaria coriacea* as a new species.

11. *Laminaria yezoensis* MIYABE, sp. nov.

(Plates 12 & 13)

Japanese name. Gohei-kombu.

Gohei-kombu (Kushiro, Nemuro), Heisoku-kombu (ditto).

Holdfast composed of a scutate disc, round or elliptical at the base, with entire margin and smooth surface while young, becoming irregularly divided along the margin and warty on the surface when matured, sometimes united with one or more other discs. Stipe solid, rigid, cylindrical, thick in the lower portion, tapering upwards, abruptly compressed at the place of connection with the blade, often furnished with annual rings in cross section thus showing the perennial nature of the plant, forming warty outgrowths on surface when old just as in the holdfast, variable in length according to the age of the plant, up to 85 cm in length, 26–30 mm in diameter. Blade entire while very young, becoming divided palmately with the advance of growth, long elliptical or broad elliptical in entire shape, round at the base, up to 0.7–1.3 m in length, 20–30 cm in breadth; divided segments of the blade 3–5, up to as many as 15 in number, sword-shaped, 3 cm in breadth, thick near the base, thin in the upper portion; light brown in color; sporangial sori unknown.²³⁾

Mucilage ducts absent from stipe but present in blade, arranged in one row under each surface near the medulla. Medulla in blade thick, composed mainly of vertically arranged filamentous cells.

Habitat and use. Growing in water 3–4 fathoms in depth, distributed along the coasts in the cold current region from Kushiro as far northeast as the Kurile Islands. This species is not worth harvesting for the market. Its stipe is sometimes utilized of late years for making a tobacco-pipe.

Addenda. About eleven of the known species of the genus *Laminaria* are known to have a palmately divided blade. They

23) According to KANDA (1938, p. 97), this species becomes soriferous in winter and the zoosporangia are formed on both surfaces of the blades.

are all provided with a filamentous holdfast; a species provided with a discoid holdfast like the present has not been known to science. So the author proposes here to name it *Laminaria yezoensis* as a new species.

12. *Laminaria Ruprechtii* (ARESCH.) DE TONI

(Plate 14)

DE TONI, Syll. Alg., III, p. 339, 1895.

Syn. *Hafugyia Ruprechtii* ARESCHOUG, Observ. Phyc., IV, p. 4, 1833.

Japanese name. Chishima-gohei-kombu.

Chishima-heisoku-kombu.

Holdfst composed of filamentous hapteres branching 5-6 times, arising in whorls, the uppermost one of which is composed of ca. 14 hapteres. Stipe very long, solid, smooth on surface, rigid, cylindrical for a short distance at the basal portion but more or less complanated in the remaining portion which expands at its top into the blade, perennial and provided with annual rings, up to 0.7-1.5 m in length, 2.5-2.8 cm in diameter below, 3.0×0.6 cm in the middle portion. Blade broad-elliptical as a whole, split palmately into segments, round and thick at the base; segments thin and sword-shaped; ca. 80 cm in length, 40 cm in total breadth; segments 2-3 cm in breadth; light brown in color; sporangial sori unknown.

Stipe has a row of large mucilage ducts closely set. Blade also has a row of the ducts.

Habitat and distribution. The specimens collected by YANAGAWA, technician of the Hokkaido Prefectural Government, at Iriribushi, Naiho Village, on the eastern coast of Etorofu Island, Kuriles, in September 1893, are the only material now at hand. So the range of distribution of this species in our region is not clear yet, though it probably is to be found throughout the Kurile Island. It is to be regretted that the matter could not be fully studied on account of the scantiness of the material. The present plant coincides most closely with *Laminaria Ruprechtii* that grows on the coasts of Sitka Island, Alaska. So it is referred to that species.²³⁾

23) MIYABE (1928, pp. 955-956) states: "A digitate *Laminaria*, collected on the eastern coast of Etorofu, and erroneously identified by the author as *Laminaria Ruprechtii* is most likely a remarkably well developed form of the species under consideration (*Laminaria dentigera* KJELLM.)." However, MIYABE and NAGAI (1932, p. 201) identify MIYABE's *Laminaria Ruprechtii* from Etorofu Island with *Laminaria platymeris* DE LA PYL. (Cf. also, MIYABE, in OKAMURA, 1936, pp. 239-290).

2. *Kjellmaniella* gen. nov.

Plants of this genus have a blade furnished all over the marginal portions with closely set gyrate puckerings, of which the depressed portions are so identical with the protuberant ones in shape, that the pattern of the puckerings on the upper and on the lower surfaces show no marked difference between each other. The median fascia is plane and clearly defined from the marginal portions being elevated to one surface. The mucilage ducts are present in both stipe and blade. The holdfast consists of filamentous hapteres.

There are two species from the region under study which should be placed in the present genus; one is *K. gyrata* from Kushiro and Nemuro and the other is *K. crassifolia* from Oshima. While the latter is new to science, the former is the plant which KJELLMAN (1892) studied with the specimens collected in Hokkaido and preserved in the herbarium of the Academy of St. Petersburg. He recognized it as a new species of the genus *Laminaria* and named it *Laminaria gyrata*. Since the specimens he examined were dried incomplete ones, he could not observe depressed and protuberant gyrate puckerings on the blade surface but merely sporangial sori forming irregular gyrate markings, after which the species was named *Laminaria gyrata*. The sporangial sori in this species are always formed only in the depressed portions and thus naturally produce the beautiful gyrate pattern. These characteristics are considered to be enough to warrant the establishment of a new genus separate from the genus *Laminaria*. Here the author proposes to name it *Kjellmaniella* in honor of KJELLMAN whose contributions to the knowledge of our Laminariaceous plants deserve our high appreciation.

1. *Kjellmaniella gyrata* (KJELLM.) MIYABE, comb. nov.

(Plates 15 & 16)

Syn. *Laminaria gyrata* KJELLMAN, Organisationstyp inom slägt. *Laminaria*, p. 16, Taf. I, 1892.

Illustration. KJELLMAN, *loc. cit.*, Taf. I; OKAMURA, *in* Bot. Mag., Tokyo, Vol. 10, Pl. 7, Figs. 6-10, 1896.

Japanese name. Tororo-kombu.

Tororo-kombu (Kushiro & Nemuro), Chijimi-kombu (ditto).

Holdfast composed of filamentous hapteres branching several times, arising verticillately at the base of the stipe. Stipe solid, smooth on surface, cylindrical or complanato-cylindrical below, compressed above, 3-4 cm in length, ca. 4 mm in diameter near the base. Blade linear or lanceolate; median fascia very narrow and distinct but not differing from the marginal portion in thickness; gyrate puckerings closely set, arranged pinnately along both sides of the median fascia meeting the latter at right angles; plane or crispate on the margins depending upon the conditions of the habitat: thin and coriaceous in substance, very rich in mucilage; usually 1 m, up to 4.5 m in length, only 7.5-12 cm in breadth at the broadest portion. Sporangial sori formed exclusively in the depressed portions on both surfaces of the blade.

The stipe has a row of quite irregular and obscure mucilage ducts. KJELLMAN who described the present species as lacking mucilage ducts in stipe seems to have missed seeing them because of their small size. The blade has also a row of ducts, which are large and distinct. The medulla of the blade is thick.

Habitat and use. Growing together with *Laminaria longissima* in the cold current region extending from Kushiro as far north as the North Kuriles. As this alga is rich in mucilage, one can readily get a mucous substance resembling grated yam by stirring chopped pieces of its dried blade in hot water. After removing refuse and seasoning with soy, it can be served as soup. To store dried blades of this alga, people usually braid them tightly.

Addenda. The present species varies markedly in the shape of blade according to the habitat. At projecting localities exposed to rapid tides, it has a narrowly linear blade which is not crispate but smooth on the margins (Plate 15), whereas in calm water within an arm of the sea it has a broadly lanceolate or elliptical blade which is remarkably crispate on the margins. The latter should be treated as a variety of the species and the author proposes to name it var. *crispata* MIYABE. (Plate 16).

2. *Kjellmaniella crassifolia* MIYABE, sp. nov. (Plate 17)

Japanese name. Gagome.

Gagome (Kameda and Kayabe).

Holdfast composed of filamentous hapteres arising verticillately and branching 6-8 times. Stipe solid, smooth on surface, sub-cylindrical below, compressed above, 4.5-6.5 cm in length, 11.5 mm in diameter. Blade lanceolate or linear lanceolate, attaining the maximum breadth at a distance of ca. 1/4 of the overall length from the base, round at the base; median fascia 1/3-1/4 as wide as the entire breadth of the blade, ca. 3 mm in thickness; marginal portion adjacent to the median fascia provided along both sides of the latter with one narrow longitudinal furrow depressed on one surface but protuberant on the other; gyrate puckerings more or less identical in shape with those of *Kjellmaniella gyrata* but more rough and large, becoming obscure on drying; thick and coriaceous in substance, rich in mucilage; 1-2.3 m in length, about 15 cm in breadth. Sporangial sori unknown as yet.²⁵⁾

The matured stipe has two rows of mucilage ducts, the outer one of which consists of narrow ducts and the inner of broad ones. The median fascia of the blade has likewise two rows of mucilage ducts, one beneath the epidermis and one just outside the medulla. In the latter, the ducts are surrounded by a group of very minute cells. The medulla is remarkably thick in the blade.

Habitat and use. The present species is of quite a limited range of distribution. It grows together with *Laminaria japonica* at a depth of 2-5 fathoms, along the coasts extending from Shiokubi point, Kameda Gun, to Kayabe Gun in Oshima Province. Fishermen harvest this plant and make "Nagakiri-kombu"²⁶⁾ to be marketed at Hakodate. The amount of production is not large. The superior quality product among those made of this species can compare in market price with the middle quality one among those made of *Laminaria angustata*.

None of the known species of Laminariaceae is identical with the present plant, so the author proposes to name it *Kjellmaniella crassifolia* as a species new to science.

25) KANDA (1933, pp. 101-102) reports that the zoosporangia of the present species are produced, at first, on one side of the blade, covering the greater part of it, later on both sides."

26) Cf. MIYABE, 1902, pl. 39.

3. *Arthrothamnus* RUPRECHT

RUPRECHT, Bemerkungen, p. 67, 1848.

To this genus belong two species: one, *Arthrothamnus bifidus*, is distributed from Kushiro northeastwards along the coasts of the Kuriles and Kamtschatka as far as Behring Island, and the other, *A. kurilensis*, is known only from the Kuriles north of Etorofu Island. The blade, in both species, is linear in shape, and comes with the approach of maturity to produce an auriculate outgrowth on both sides of its base. The overwintered old blade is shed in spring leaving a scar extending from the broadened top of the stipe to the base of each outgrowth. The auriculate outgrowth develops into a new stipe and blade.²⁷⁾ In *A. bifidus*, the stipe is flattened and gives rise along both its sides to hapteres which keep the decumbent thallus firmly attached to the rocks. *A. kurilensis* is characterized by having an erect, but never repent, thallus. In both species, the age of the thallus can easily be ascertained from the number of ramifications of the stipe.

1. *Arthrothamnus bifidus* (GMEL.) RUPR.

(Plate 18)

RUPRECHT, Bemerkungen, p. 68, 1848.

Syn. *Fucus bifidus* GMELIN, Hist. Fuc., p. 201, pl. 29, fig. 2, 1768.

Illustration. GMELIN, *loc. cit.*, pl. 29, fig. 2, 1768; POSTELS et RUPRECHT, *Illustrationes Algarum*. Tab. XV. 1840.

Japanese name. Nekoashi-kombu.

Mimi-kombu, Shita-kombu.

Matured frond attaching to the rocks by means of filiform hapteres formed along both sides of the complanate stipe. Blade 1.3-5.0 m in length, 4.3-6.5 cm in width, somewhat broadened toward the base; base rounded and with no outgrowth while young, but provided with auriculate outgrowths when matured; median fascia a shallow depression, as thick as the marginal portions; coriaceous in substance.

Specimens collected in June 1893 at Shinshiru Island, Kuriles, are found to have on one surface of the blade two rows of sporangial sori.

27) Cf. YAMADA, 1934, *in* Jour. Jap. Bot., 10 (11): 732-736, figs. 1-2; *Idem.*, 1935, *ibid.*, 11 (5): 318-320, figs. 1-6; TOKIDA, *in* Trans. Sapp. Nat. Hist. Soc., 15 (2): 60-66, figs. 1-5.

A row of mucilage ducts is present in both stipe and blade.

Habitat and use. The present species is found growing only on substrata exposed to a rapid current and at a depth of more than four fathoms, so that it is not possible to collect with ease any specimens of the plant other than drifting ones cast ashore by waves. At Kushiro it grows together with *Laminaria yezoensis*. It contains a considerable amount of iodine and is rich in sugar content too. It can be marketed and used for giving flavor to food.

Addenda. In 1768, GMELIN gave a description of the present kelp based on the specimens collected by STELLER on the coast of Kamtschatka. GMELIN named it *Fucus bifidus*. This was the first introduction of the present alga to science. In 1848, RUPRECHT established a new genus, *Arthrothamnus*, and placed this species in it.

2. *Arthrothamnus kurilensis* RUPRECHT

(Plate 19)

RUPRECHT, Bemerkungen, p. 67, Taf. VI, 1848.

Illustration. RUPRECHT, *loc. cit.*, Taf. VI, 1848; KITAHARA, Rakko Ryôba Chôsa Hôkoku, Fig. 2, 1895.

Japanese name. Chishima-nekoashi-kombu.

Kidachi-mimi-kombu (named by Dr. OKAMURA).

Holdfast composed of filiform hapteres branching several times. Stipe, as a characteristic of the species, erect, branching up to 6-7 times. Branches of the stipe, formed by the development of the auriculate outgrowths, twisted once or twice according to their length. Sporangial sori formed in one or two rows on the surface of the median fascia and the marginal portions. Other characters similar to those of the preceding described species.

Habitat and use. Growing abundantly in the waters around Etorofu Island and Uruppu Island. Mr. Shigetada GUNJI says that a majority of kelps growing around Shimushu Island belong to this species.²⁸⁾ This kelp is rich in sugar content and can be used as food.

Addenda. This species has been known to science only through RUPRECHT's report in 1848 on incomplete specimens collected at Uruppu Island. The result of the author's studies on this and the preceding species is planned to be published in another paper.²⁹⁾

28) However, NAGAI (1940, pp. 100-103) reports that *A. bifidus*, but not *A. kurilensis*, is occurring in Shimushu Island and other North Kurile islands.

29) No other paper was published by the author on these species.

4. *Costaria* GREVILLE

GREVILLE, *Algae Britannicae*, p. xxxix, 1830.

The genus *Costaria* is characterized by having a blade traversed by five longitudinal ribs, of which the central and two outermost ones are all projecting on the same surface of the blade but are depressed on the other while the remaining two intermediate ones are projecting on the opposite surface as compared with the other three. The numerous small perforations are scattered all over the blade. The surface of the blade is adorned with gyrate puckerings, and also, while young, with cryptostomata. Mucilage ducts are absent from both stipe and blade. Sporangial sori are formed from the basal part of the blade upward, mostly within the depressed portions of both upper and under surfaces of the blade, sometimes spreading over the elevated portions. Stipe is provided on the surface with more than ten longitudinal projecting striations.

DE TONI, in his *Sylloge Algarum* (Vol. III, 1895), placed four species in the present genus. However, judging from the fact that *Costaria Turneri* in Hokkaido is variable in the morphology of the thallus according to the topography of the habitat, *Costaria Mertensii* J. AG. and *C. quadrinervia* RUPR. are considered to be nothing but varietal forms or malformed individuals of *C. Turneri* GREV. The remaining *Costaria reticulata* SAUND. is not to be placed in this genus.³⁰⁾ Then the genus *Costaria* would be regarded as consisting of a single species.

Costaria Turneri GREVILLE

(Plate 20)

GREVILLE, *Algae Britannicae*, p. xxxix, 1830.

Illustration. TURNER, *Historia Fucorum*, Vol. IV, Tab. 226, 1819; POSTELS et RUPRECHT, *Illustrationes Algarum*, Tab. XXIV, 1840.

Japanese name. **Zarame.**

Zarame (Kushiro, Etorofu), Zarume (Osatsube & Todohokke), Sujime (named by Dr. OKAMURA), Jarame (Hakodate), Aname (Rikuchû Province in Honshû), Kagome (Kiritappu & Nemuro), Arame-kombu (Kitami-mombetsu).

30) *Costaria reticulata*? SAUNDERS (1895, p. 58, tab. VII) is known to be a young stage of *Dictyonereis californicum* RUPR. (Cf. SETCHELL and GARDNER, 1925, p. 610).

Holdfast composed of filiform hapteres arising verticillately, branching several times. Stipe circular or elliptical in cross section at the lower portion, somewhat compressed upward, variable in length, from only 2.3 cm up to more than 15 cm; a short-stiped individual, in general, bears a broad blade and a long-stiped one a narrow blade. Blade variable in shape too, elliptical or linear oblanceolate, or linear, broad in individuals growing in mild tide, but narrow in those growing in rapid tide, in shorter individuals up to 33-66 cm in length, but in longer individuals up to 2-3 m or more. Reproductive organs maturing in summer season, from June to September.

Habitat and use. Ubiquitous in Hokkaido. Very widely distributed in the North Pacific, being distributed on the one hand southward as far as Mutsu and Rikuchû in the main island of Japan, and on the other northward from the Kurile Islands as far as the northwest coast of North America. This kelp grows in company with *Laminaria* spp., and so it often becomes one of the competitors of the latter, proving a hindrance to their propagation. Juvenile individuals are sometimes utilized as food by people.

Addenda. In 1819, TURNER first published an illustration of the present alga based on specimens from the western coast of North America and named it *Fucus costatus*. GREVILLE, in 1824, established the genus *Costaria* for the species concerned, and changed its name to *Costaria Turneri*. This name is still generally accepted as valid today.³¹⁾ In 1857, the government of the United States despatched Admiral Rodgers to engag  in an exploratory expedition to the northern part of the Pacific Ocean. The specimens of marine algae brought back by this expedition were sent to HARVEY for identification. Among them were some specimens of *Costaria Turneri* collected at Hakodate Harbor. According to HARVEY's description, they differ from the American plant in having four ribs instead of five and small perforations on the blade, and are therefore to be treated as var. *pertusa*. However, the author has never met with an individual bearing a four-ribbed blade among the specimens examined. HARVEY's specimens might have been malformed individuals. To make special mention of the perforations which

31) SETCHELL and GARDNER (1925, pp. 610-611) adopted *Costaria costata* (TURN.) SAUNDERS in place of *Costaria Turneri* GREV., and since then that name has generally been used in the literature.

HARVEY recognized as the characteristic of the Japanese variety, they are not uncommonly present even in the American specimens.³²⁾ Consequently our Hokkaido plant is not worth recognizing as a variety.

5. *Alaria* GREVILLE

GREVILLE, *Algae Briatannicae*, Synopsis, p. xxxix and p. 25, 1830.

The upper portion of the stipe is flattened, and along its two sides numerous leaflets stand oppositely side by side. The lower leaflets are older in growth. They are shed successively from the undermost to the upper ones. New leaflets sprout at the uppermost place above those already existing. Sporangial sori are formed on both surfaces of these leaflets, hence they are called sporophylls. The flattened part of the stipe from which the sporophylls arise is called the rhachis. The blade is terminal, entire, with a longitudinal percurrent midrib located at the center, usually provided with cryptostomata, and destitute of mucilage ducts.

The genus *Alaria* is known at present to comprise twenty-two species, of which many are distributed in the Arctic Ocean and the North Pacific; five occur in the vicinity of Japan.

1. *Alaria fistulosa* POSTELS et RUPRECHT

(Plate 21)

POSTELS et RUPRECHT. *Illustrationes Algarum*, p. 11, Tab. XVI, 1840.

Illustration. POSTELS and RUPRECHT, *loc. cit.*, Tab. XVI, 1840.

Japanese name. Oni-wakame.

Kerupu (among hunters of marine mammals in the Kuriles), Kairoppa or Kairoppu (among the natives of the Kuriles), Karafuto-wakame (Kitami Province).

Holdfast composed of filiform hapteres branching several times, complicated, forming a turbinate compact mass of very hard quality. Stipe somewhat complanated, solid, bearing numerous, crowded, obovate or oblong sporophylls. Sporophylls shortly petiolate, completely covered by the sporangial sori excepting only a narrow margin, 9–10.5 cm in length, 2–3 cm in width. Blade very long, claimed by someone to be sometimes up to 40–50 fathoms in length,

³²⁾ In the diagnosis of the genus *Costaria* given by SETCHELL and GARDNER (1925, p. 609) it is stated that "blade...not rarely perforate."

but revealed by KJELLMAN's description of the Behring specimens to be 20 m at the maximum, up to 86-89 cm in width, attaining the maximum breadth at or slightly above the middle of the overall length, thin and tender in substance; midrib composed of a row of numerous hollow cavities separated at irregular intervals by septa, serving as a buoy because of the air contained in the cavities, often making long blades to float in so much abundance on the sea surface that a boat sometimes finds difficulty in sailing through them and sea mammals often live on them by choice.

Habitat. Growing abundantly in the region extending from Etorofu Island as far north as the Behring Sea, and along the North American coasts between Alaska and California; also on the western coast of Saghalien, from where drifting fronds are sometimes carried by a current to the coast of Kitami Province in Hokkaido and are cast ashore there. Hence the plant is called "Karafuto-wakame" in that province.

Addenda. In 1840, POSTELS and RUPRECHT illustrated the Kamtschatka specimens of the present species, and gave it a new scientific name. The sporophylls are illustrated by them to be linear in shape, rounded at the apex, tapering gradually toward the base, and sessile. Comparing them with the same organ of our Kurile specimens, the author finds a great difference in the morphology between the Kamtschatka specimens and the Kurile ones.

2. *Alaria crassifolia* KJELLMAN

(Plate 22)

KJELLMAN, in KJELLMAN och PETERSEN, Om Japans Laminariaceer, p. 267, Taf. X, Figs. 9-12, 1885.

Illustration. KJELLMAN och PETERSEN, *loc. cit.*, Taf. X, Figs. 9-12, 1885; OKAMURA, in Bulletin of the Japan Fishery Association, No. 106, Pl. 1, 1891; *Id.*, in Bot. Mag., Tokyo, Vol. X, Pl. 7, Fig. 15, 1896.

Japanese name. Ezo-wakame.

Sarumen or Sarume (Oshima), Ezo-wakame (ditto), Chikaiso (Rikuzen & Rikuchû in Honshû), Chigaisome (Rikuchû), Jikkaisome (Rikuzen & Rikuchû), Jikkaiso (Rikuchû).

Stipe cylindrical, 6.6-16.5 cm in length. Sporophylls linear-lanceolate, sword-shaped, crowded, with a short petiole, obtuse at apex, rounded at base, coriaceous and thick in substance, with fine serrations along the margins and a thin sterile piece of leaflet

at the apex while immature but at maturity both serrations and sterile piece of leaflet disappear. Sporangial sori, according to OKAMURA, forming at first ovate or elliptical small patches near the base of the sporophylls. Blade lanceolate, tapering gradually to the base, somewhat undulate on the margins, with long transverse corrugations along both sides of the midrib, usually 0.5 m in length and 10–23 cm in breadth, somewhat thicker in substance as compared with other species; midrib 10.8 mm in width, oblong in cross section.

Habitat. Distributed along the coasts from Muroran as far south as Hakodate and Sanriku district in Northern Honshû, and often menacing the luxuriant growth of *Laminaria* species by invading their substrata.

3. *Alaria yezoensis* MIYABE, sp. nov.

(Plate 23)

Japanese name. Ainu-wakame.

Jikkaiso (Nemuro), Kaioppa (Suishô Island off Nemuro Peninsula).

Stipe 3–6 cm in length, subcylindrical below, compressed above; rhachis flattened, a part of which bearing sporophylls measures only 2.5–3.0 cm in length, while the remaining lower part which has shed its sporophylls measures variously according to the age of the plant, sometimes attaining to 10–13 cm in length. Sporophylls 16–24.7 cm in length, 2.3–3.0 cm in width, not crowded, long linear, rounded and spatulate at the apex, coriaceous, not very thick, sori covering the entire surface except along the margin. Blade linear oblanceolate, gradually tapering at the base, ca. 2 m in length, ca. 15 cm in width, slightly undulate on the margins, thin and coriaceous in substance; midrib 1.0–1.3 cm in width, oblong or linear-elliptical in cross section.

Habitat and use. Distributed along the coasts from Hidaka north-eastward as far as Nemuro, and often menacing the growth of *Laminaria* species. Fishing-villagers in Nemuro Province are said sometimes to eat sporophylls of this species raw.

Addenda. None of the known species coincides with the present species, so the author proposes here to name it *Alaria yezoensis* as a new species.

4. *Alaria corrugata* MIYABE, sp. nov.

(Plate 24)

Japanese name. Chishima-wakame.

Stipe cylindrical, ca. 7.5 cm in length; rhachis ca. 4.5 cm in length. Sporophylls linear or linear-oblong, slightly curved in the shape of a sword, with short petioles, covered completely by sori except the apical and marginal portions, 20–30 cm in length, ca. 3 cm in width. Blade linear-lanceolate, rounded at the base, passing abruptly into the rhachis, markedly undulate on the margins, with fine transverse corrugations on the surface, rigid, up to 4.6 m in length, 30–33 cm in breadth; midrib solid, oblong in cross section, 9.9–10.8 mm in width.

Habitat. Growing along the coasts of Etorofu and Uruppu in the Kurile Islands. This species can easily be distinguished from the known species by its characteristic shape of the blade base and by its possession of fine corrugations on the blade surface. So the author describes it here as a new species naming it *Alaria corrugata*.³³⁾

5. *Alaria macrophylla* MIYABE, sp. nov.

(Plate 25)

Japanese name. Kunashiri-wakame.

Stipe cylindrical, ca. 13 cm in length, a part of the rhachis which bears sporophylls measuring only 2.5–3.0 cm in length. Sporophylls remarkably larger in comparison with those of other species, 23–33 cm in length, 6.6–10.0 cm in width, oblong or oblanceolate or linear-oblanceolate, rounded at the apex, somewhat narrowed and obliquely rounded at the base, slightly curved on one side, with short pedicels, completely covered by sori except along the margin, pliant and thin in substance. Blade in the author's specimen too incomplete to make it possible to figure its whole shape, tapering gradually at the base, markedly undulate on the margins, with

33) YENDO (1919) relegated *Alaria corrugata* MIYABE to a synonym of *Alaria macroptera* (RUPR.) YENDO, stating as follows (p. 82): "A glance at the original specimen of *Phasganon 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". Dr. MIYABE agreed with YENDO's views. (Cf. MIYABE and NAGAI, 1933, p. 99; MIYABE in OKAMURA, 1936, p. 297).

fine transverse corrugations on the surface which are not so conspicuous as in the preceding species, 33 cm in breadth at the widest portion; midrib solid, linear-oblong in cross section, up to 1.5 cm in width.

Habitat. Only a single specimen from the eastern coast of Kunashiri Island, Kuriles, is at hand. But none of the known species has ever been described to have so large sporophylls in company with a corrugate blade as this specimen does. So the author assumes it provisionally as new to science and proposes to name it *Alaria macrophylla*.³⁴⁾

6. *Undaria* SURINGAR

SURINGAR, *Illustr. Alg. du Jap.*, p. 77, 1873.

Stipe is flattened and bears an undulate wing along both sides. With the advance of the maturity of the plant, a part of the wing develops and changes into a markedly wrinkled sporophyll, which produces sporangial sori on its entire surface. The sori are sometimes found to spread over the base of the blade. Blade has a midrib, and is divided pinnately in the marginal portions. The blade lacks mucilage canals, but is provided with cryptostomata. In the genus *Undaria* are included two species viz., *U. pinnatifida* and *U. distans*.³⁵⁾

Undaria distans MIYABE et OKAMURA, sp. nov.

(Plate 26)

Illustration. KJELLMAN och PETERSEN, *Om Japans Laminariaceer*, Taf. XI, 1885; OKAMURA, *in Bot. Mag.*, Tokyo, Vol. IV, Pl. 2, 1890.

Japanese name. Nambu-wakame (*in* SUYAMA's *Yûyô-sôfu*, 1900).
Wakame (Hokkaido).

Holdfast composed of filiform hapteres branching several times. Stipe longer in comparison with that of *U. pinnatifida*, sometimes up to more than 66 cm in length. Sporophyll produced just above

34) YENDO (1919, p. 79) placed *Alaria macrophylla* MIYABE in the list of synonyms of *Alaria macroptera* (RUPR.) YENDO without giving any remarks. Dr. MIYABE is in agreement with YENDO's views. (*Cf.* MIYABE and NAGAI, 1933, p. 99; MIYABE, *in* OKAMURA, 1936, p. 297).

35) MIYABE (*in* OKAMURA, 1936, p. 300) is of opinion that *U. distans* is a distinct species, but OKAMURA (1902, p. 128, 1916, p. 166, 1926, p. 118, 1936, p. 232) reduces it to a local and ecological form of *U. pinnatifida*, as f. *distans* MIYABE et OKAMURA.

the holdfast, forming a large mass of wrinkles. Marginal portions of the blade divided in a pinnate manner deeply toward the midrib into narrow and considerably long segments. In an immature individual, the segments at the basal part of the blade are crowded in a pectinate manner.

Habitat and use. Distributed in Hokkaido along the coast of the Japan Sea from Rumoi in Teshio Province southward, and along the eastern coast from Muroran southwestward but not northeastward; in Honshû, along the coast of Sanriku district and of the Gotô archipelago in Higo Province, Kyûshû. The *Undaria* plants distributed along the Japan Sea coast of Honshû are all perhaps referable to the present species. This assumption awaits the proof of future studies.³⁶⁾ The blade of this species can be used as food like that of the ordinary "Wakame", and the sporophylls as a substitute for grated yam because they are rich in mucilage.

Addenda. The present plant has been confused with *Undaria pinnatifida* (HARV.) SURINGAR, as it bears a close resemblance to the latter. It was not until the spring of 1901, when the author could observe matured specimens of *U. pinnatifida* from Bôshû in Chiba Prefecture, that he thought it reasonable to regard this plant as a distinct species. Principal characters in which the two species differ from each other are as follows. In *U. pinnatifida*, the sporophylls are formed on the upper portion of the stipe and keep a direct contact with the blade. So the sporangial sori are rarely found invading the basal portion of the blade. The sporophylls are not in the form of a corpulant spindle as in *U. distans*, but are narrow in breadth, keeping nearly the same diameter through the entire length, and wrinkled rather loosely. The blade is divided not very deeply, and its segments are short and broad. Young segments at the base of the blade just above the stipe are not pectinate.

The plant which was named *Alaria pinnatifida* by HARVEY is from Shimoda in Izu Province, and is referable to *U. pinnatifida*. The fertile specimen collected by KJELLMAN at Gotô in Hizen Province is known from his illustration, to be identical with *U. distans* from Hokkaido, but not with HARVEY'S *Alaria pinnatifida*.

36) ÔSHIMA (1950) published in Fig. 41 (1) of his work a photograph of a specimen of *Undaria pinnatifida*-type collected in Toyama Bay, on the Japan Sea side of middle Honshû.

7. *Agarum* (BORY) POST. et RUPR.

POSTELS et RUPRECHT, *Illustrationes Algarum*, p. 11, 1840.

Blade is provided at the center with a flattened percurrent midrib, with numerous perforations scattered all over the surface, lacking cryptostomata and mucilage canals, and slightly crisped in the basal portion.

In the present genus are included four species,³⁷⁾ of which only one is known from Japan.

Agarum Turneri POSTELS et RUPRECHT

(Plate 27)

POSTELS et RUPRECHT, *loc. cit.*, p. 12, Tab. XXII, 1840.

Illustration. TURNER, *Fuci*, Tab. LXXV, 1809; POSTELS et RUPRECHT, *loc. cit.*, Tab. XXII, 1840.

Japanese name. Aname.

Zarame.

Holdfast composed of filiform hapteres arising verticillately, branching several times. Stipe flattened, rigid, 2.3–16.5 cm in length. Blade elliptic, only 33–66 cm in length; midrib usually a little broader than, or sometimes as broad as, the stipe; perforations of various sizes scattered promiscuously all over the surface; perforations smooth without dull dentations on the margins; rigid in substance. Sporangial sori in patches scattered over the blade on both surfaces.³⁸⁾

Habitat. Distributed in the northern part of the Pacific Ocean and the northwestern part of the Atlantic. Widely spread all along the coasts of Hokkaido and said to occur also in Aomori Prefecture. Growing in deep water, making it difficult for a person to observe the natural habit of the plant.³⁹⁾

Addenda. Some of the specimens from Hokkaido have some-

37) DE TONI (1895, pp. 334–335) enumerates four species in *Agarum* as follows: *A. Turneri*, *A. Gmelini* MERT., *A. pertusum* (MERT.) POST. et RUPR., and *A. fibratum* HARVEY.

38) SETCHELL and GARDNER (1925, p. 615) adopted *Agarum cribrosum* BORY in place of *Agarum Turneri* POST. et RUPR., and since then that name has generally been used in the literature.

39) TOKIDA (1954, p. 121) reports that he was once able to observe several fronds growing on rocks at 2–3 feet depth beneath the low water mark at Cape Nishinotoro, Saghalien, in April 1937.

what broadened midribs which become nearly twice as broad as the stipe. However, it may be natural to conclude that they should be referred to the present species rather than to *A. Gmelini* MERT. from the fact that their perforations are smooth on the margins and spread all over the blade without any order.

8. *Thalassiophyllum* POST. et RUPR.

POSTELS et RUPRECHT, *Illustrationes Algarum*, p. 11, 1840.

Holdfast is perennial, composed of filiform hapteres. Stipe gives rise to many branches, each of which bears a fan-shaped blade spirally scrolled. The outer part of a scroll is old whereas the inner part is young. Blade is destitute of any midrib, with numerous small perforations; the edge of the perforations are always torn and projecting on one surface; mucilage canals and cryptostomata are absent. Sporangial sori are scattered on the blade surface forming irregular patches.

Thalassiophyllum is a monotypic genus.

Thalassiophyllum Clathrus (GMEL.) POST. et RUPR.

(Plate 28)

POSTELS et RUPRECHT, *loc. cit.*, p. 11, Tab. XVIII-XIX, 1840.

Illustration. GMELIN, *Historia Fucorum*, Tab. 33, 1768; POSTELS et RUPRECHT, *loc. cit.*, Tab. XVIII-XIX, 1840.

Japanese name. Kikuishi-kombu.

Kikumeishi-kombu.

Characters as described for the genus. Frond attaching to the rocks covered by water in flood-tide and exposed to the air in ebb-tide, standing upright or obliquely, from 33-66 cm up to 1.3-1.6 m in height, growing in remarkably dense clusters, which are said to look like bushes from afar when the tide is low.

Habitat. Distributed from Etorofu Island, Kuriles, northward along the coasts of Kamtschatka, and from Alaska to California.⁴⁰⁾

40) The present species is now known to be distributed on one hand in the Kuriles from Uruppu, but not from Etorofu, northward (NAGAI, 1940, pp. 103-104), and on the other along the coast of North America as far south as the Straits of Juan de Fuca (SETCHELL and GARDNER, 1925, p. 613), but not as far south as California as once mentioned by DE TONI (1895, p. 336).

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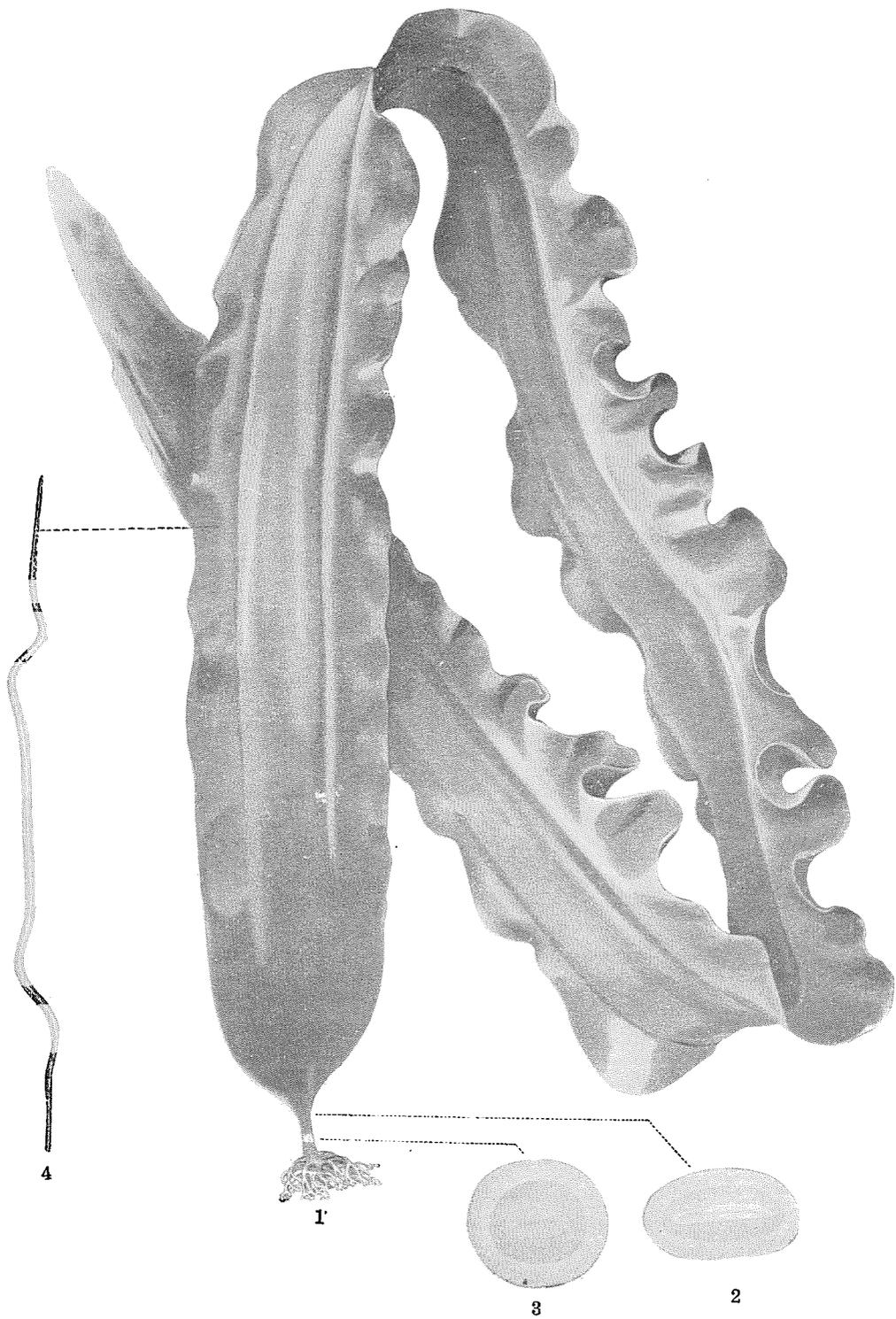
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Rishiri-kombu 8
Sarume 33
Sarumen 33
Shamani-kombu 17
Shima-kombu 19
Shinori-kombu 6
Shio-kombu 8, 11
Shio-hoshi-kombu 17
Shita-kombu 28
Sôpaushi 17
Sujime 30
Tachi-kombu 22
Teshio-kombu 8
Tokachi-kombu 17
Tororo-kombu 16, 17, 25
Uchi-kombu 6
Urakawa-kombu 11, 17
Yayan-kombu 11
Wakame 36
Wakaoi 21
Zarame 30, 38
Zarume 30

EXPLANATION OF PLATES

PLATE I.

Laminaria japonica ARESCH.

- Fig. 1. Habit of a typical plant from Osatsube, Prov. Oshima. $\times 0.1$.
Fig. 2. Cross section through the upper part of the stipe. $\times 1.6$.
Fig. 3. Cross section through the lower part of the stipe. $\times 1.6$.
Fig. 4. Cross section of the blade. $\times 0.4$.



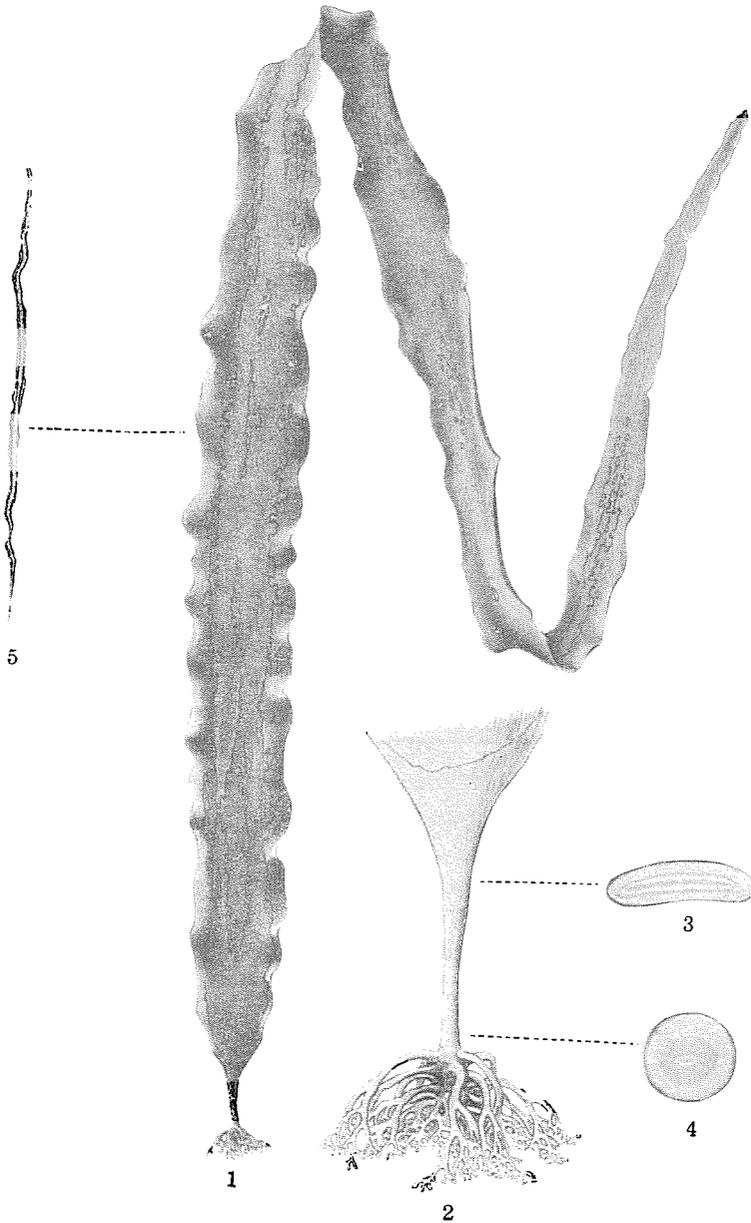
Laminaria japonica ARESCH.

Y. ITO del.

PLATE II.

Laminaria ochotensis n. sp.

- Fig. 1. Habit of a typical plant from Tentokari, Prov. Teshio. $\times 0.1$.
Fig. 2. Basal part of a plant. $\times 0.4$.
Fig. 3. Cross section through the upper part of the stipe. $\times 1.6$.
Fig. 4. Cross section through the lower part of the stipe. $\times 1.6$.
Fig. 5. Cross section of the blade. $\times 0.4$.



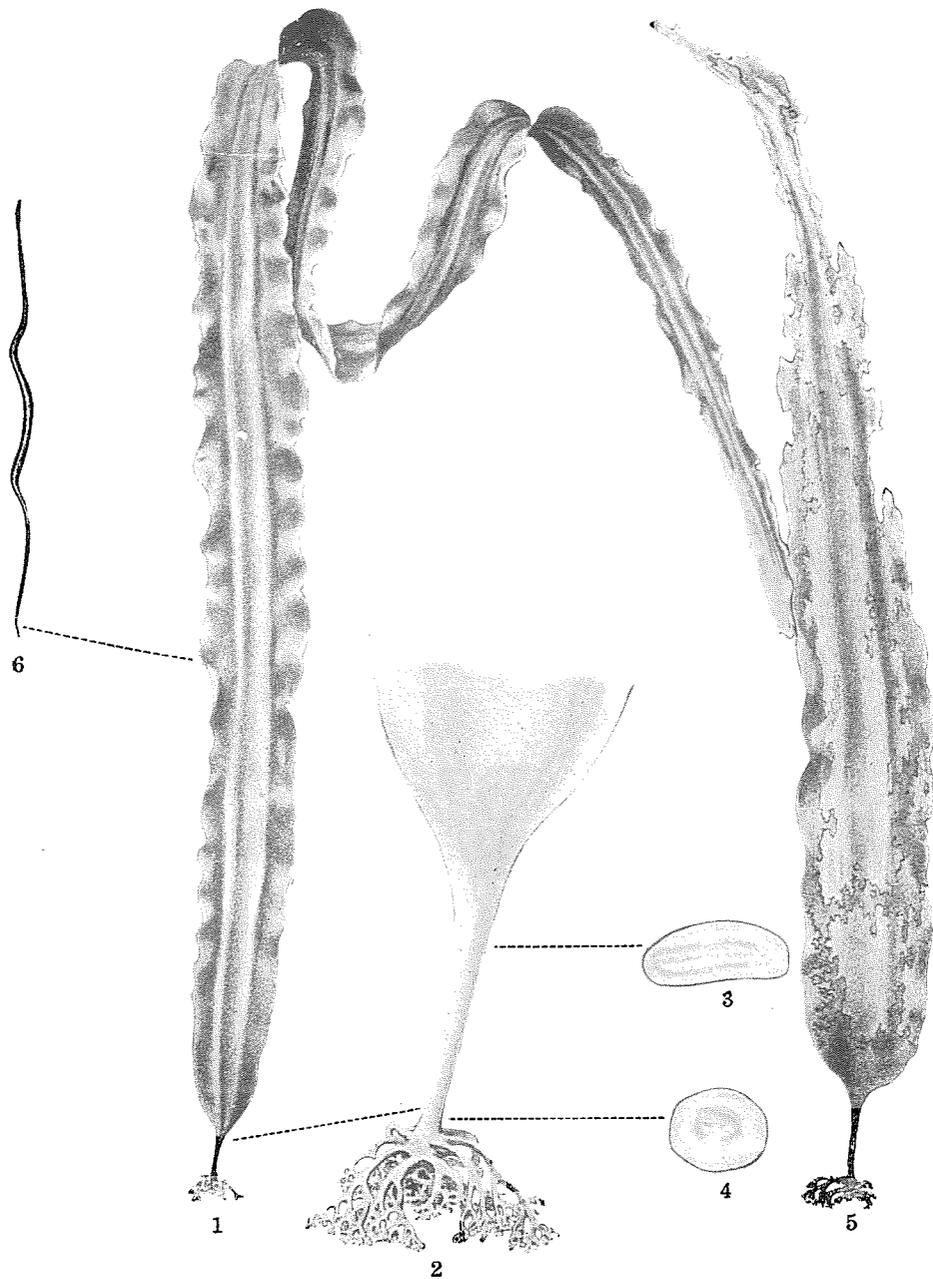
Y. ITO del.

Laminaria ochotensis n. sp.

PLATE III.

Laminaria fragilis n. sp.

- Fig. 1. Habit of a plant from Muroran, Prov. Ihuri. $\times 0.1$.
Fig. 2. Basal part of a frond. $\times 0.4$.
Fig. 3. Cross section through the upper part of the stipe. $\times 1.6$.
Fig. 4. Cross section through the lower part of the stipe. $\times 1.6$.
Fig. 5. Habit of a fertile plant from Hakodate, Prov. Oshima. $\times 0.1$.
Fig. 6. Cross section of the blade. $\times 0.5$.



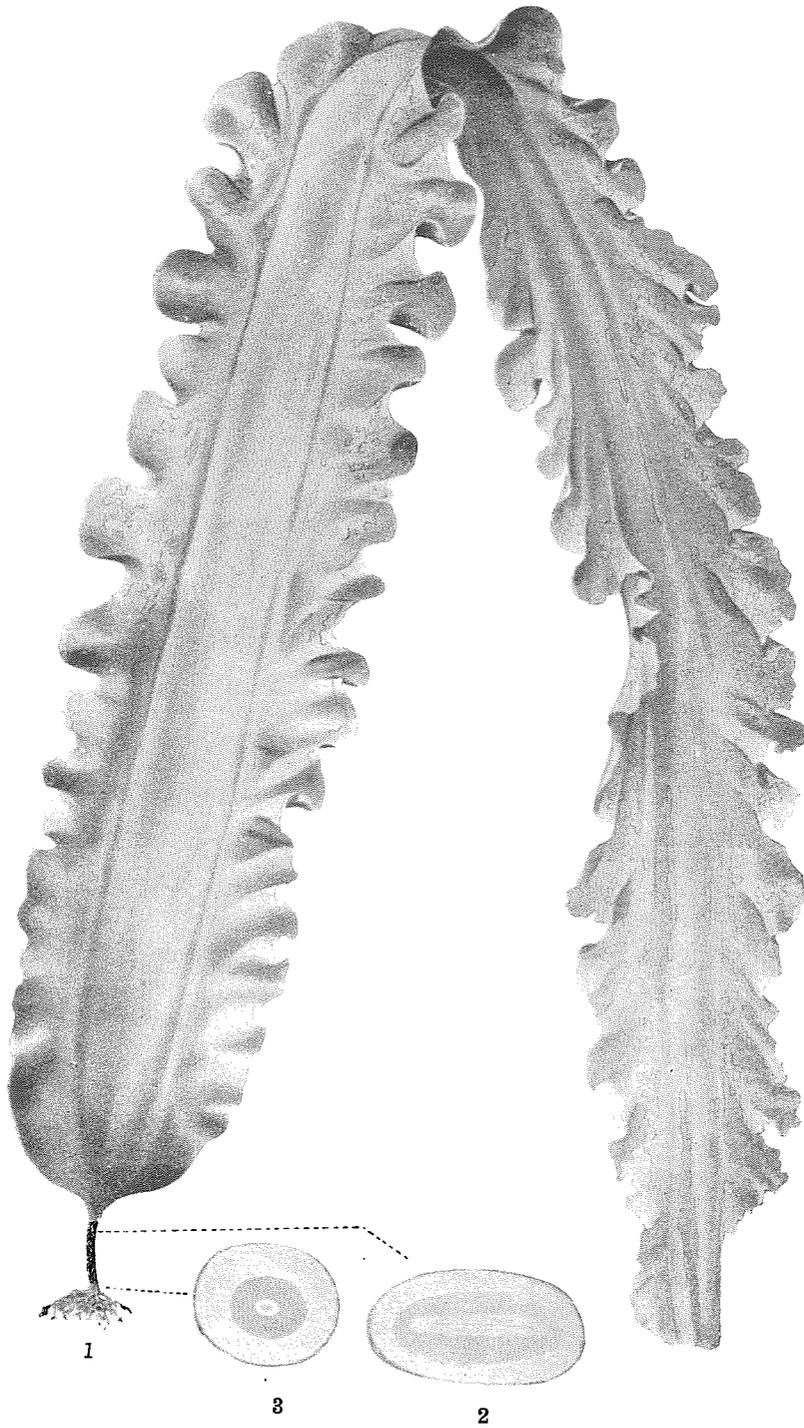
Y. Iro del.

Laminaria fragilis n. sp.

PLATE IV.

Laminaria diabolica n. sp.

- Fig. 1. Habit of a plant from Kiritappu, Prov. Kushiro. × 0.1.
Fig. 2. Cross section through the upper part of the stipe. × 1.6.
Fig. 3. Cross section through the lower part of the stipe. × 1.6.



Y. Iro del.

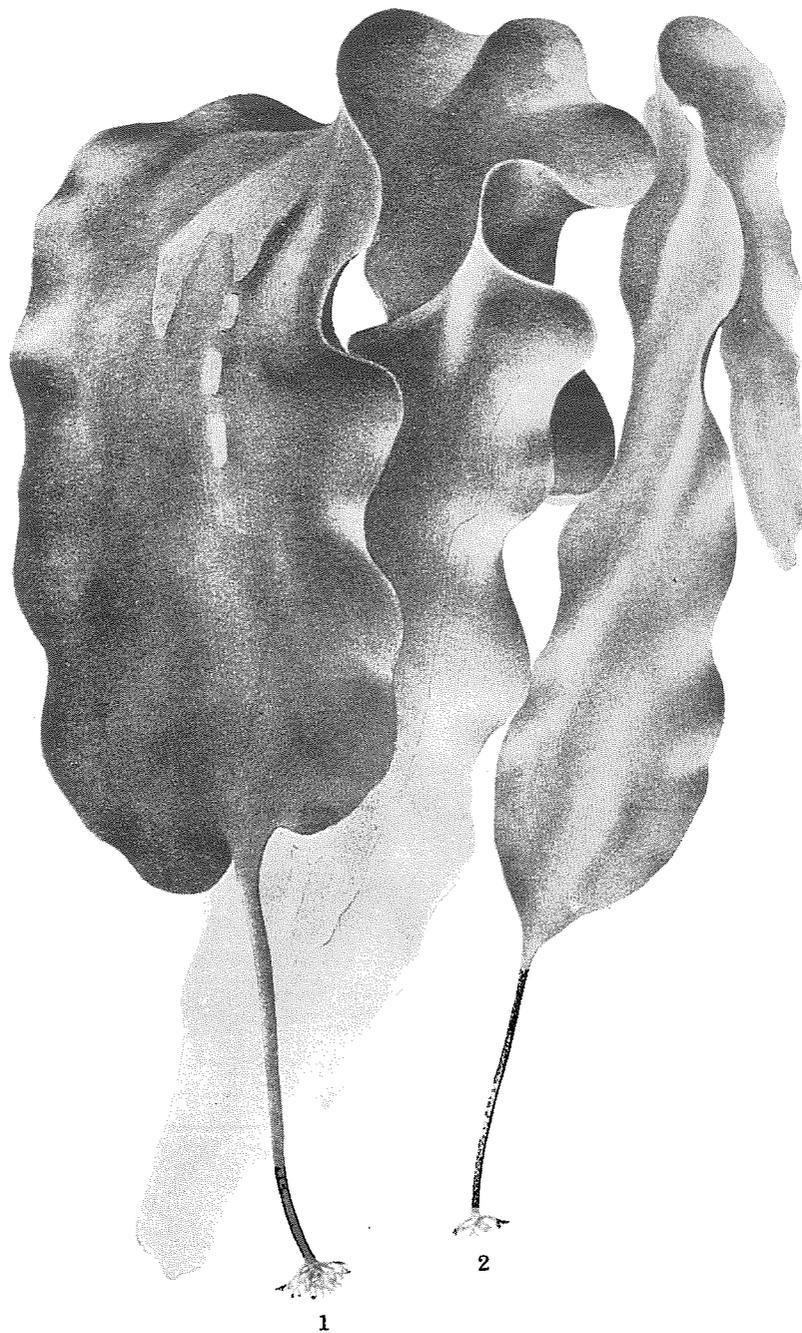
Laminaria diabolica n. sp.

PLATE V.

Laminaria longipedalis OKAM.

Fig. 1. Habit of a mature plant from Akkeshi, Prov. Kushiro. × 0.1.

Fig. 2. Habit of a young plant from the same locality as above. × 0.1.



Y. ITO del.

Laminaria longipedalis OKAM.

PLATE VI.

Laminaria religiosa n. sp.

- Fig. 1. Habit of a plant from Fukuyama, Prov. Oshima. $\times 0.16$.
Fig. 2. Cross section of the stipe. $\times 1.6$.
Fig. 3. Cross section of the blade. $\times 0.8$.



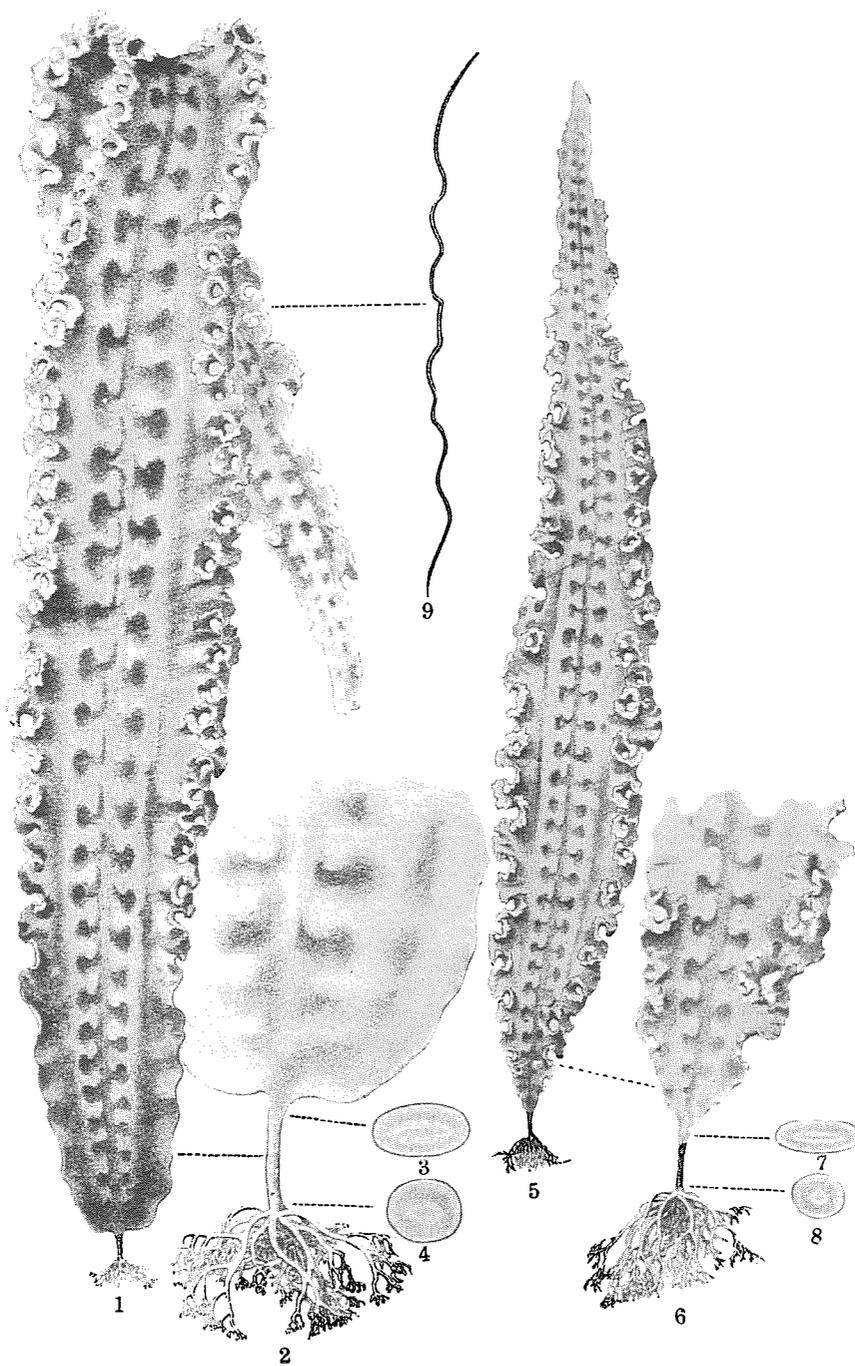
Y. ITO. del.

Laminaria religiosa n. sp.

PLATE VII.

Laminaria cichorioides n. sp.

- Fig. 1. Habit of an immature plant from Nemuro Harbour, Prov. Nemuro. $\times 0.16$.
- Fig. 2. Basal part of the same plant as above. $\times 0.4$.
- Fig. 3. Cross section through the upper part of the stipe. $\times 1.6$.
- Fig. 4. Cross section through the lower part of the stipe. $\times 1.6$.
- Fig. 5. Habit of an immature plant from Otaru Harbour, Prov. Shiribeshi. $\times 0.16$.
- Fig. 6. Basal part of the same plant as Fig. 5. $\times 0.4$.
- Fig. 7. Cross section through the upper part of the stipe. $\times 1.6$.
- Fig. 8. Cross section through the lower part of the stipe. $\times 1.6$.
- Fig. 9. Cross section of the blade. $\times 0.26$.



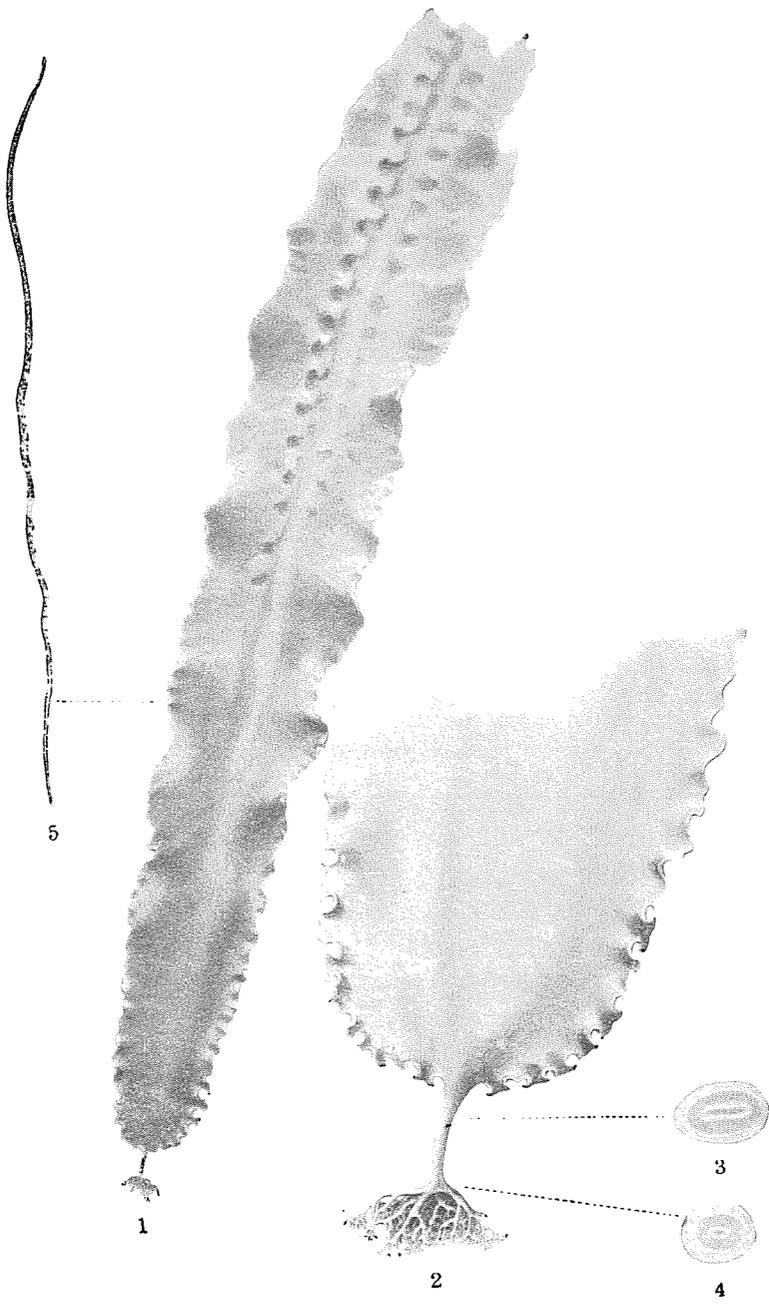
Y. Iro del.

Laminaria cichorioides n. sp.

PLATE VIII.

Laminaria cichorioides n. sp.

- Fig. 1. Habit of a plant from Wakkanai, Prov. Kitami. $\times 0.16$.
Fig. 2. Basal part of the same plant as above. $\times 0.4$.
Fig. 3. Cross section through the upper part of the stipe. $\times 1.6$.
Fig. 4. Cross section through the lower part of the stipe. $\times 1.6$.
Fig. 5. Cross section of the blade. $\times 0.8$.



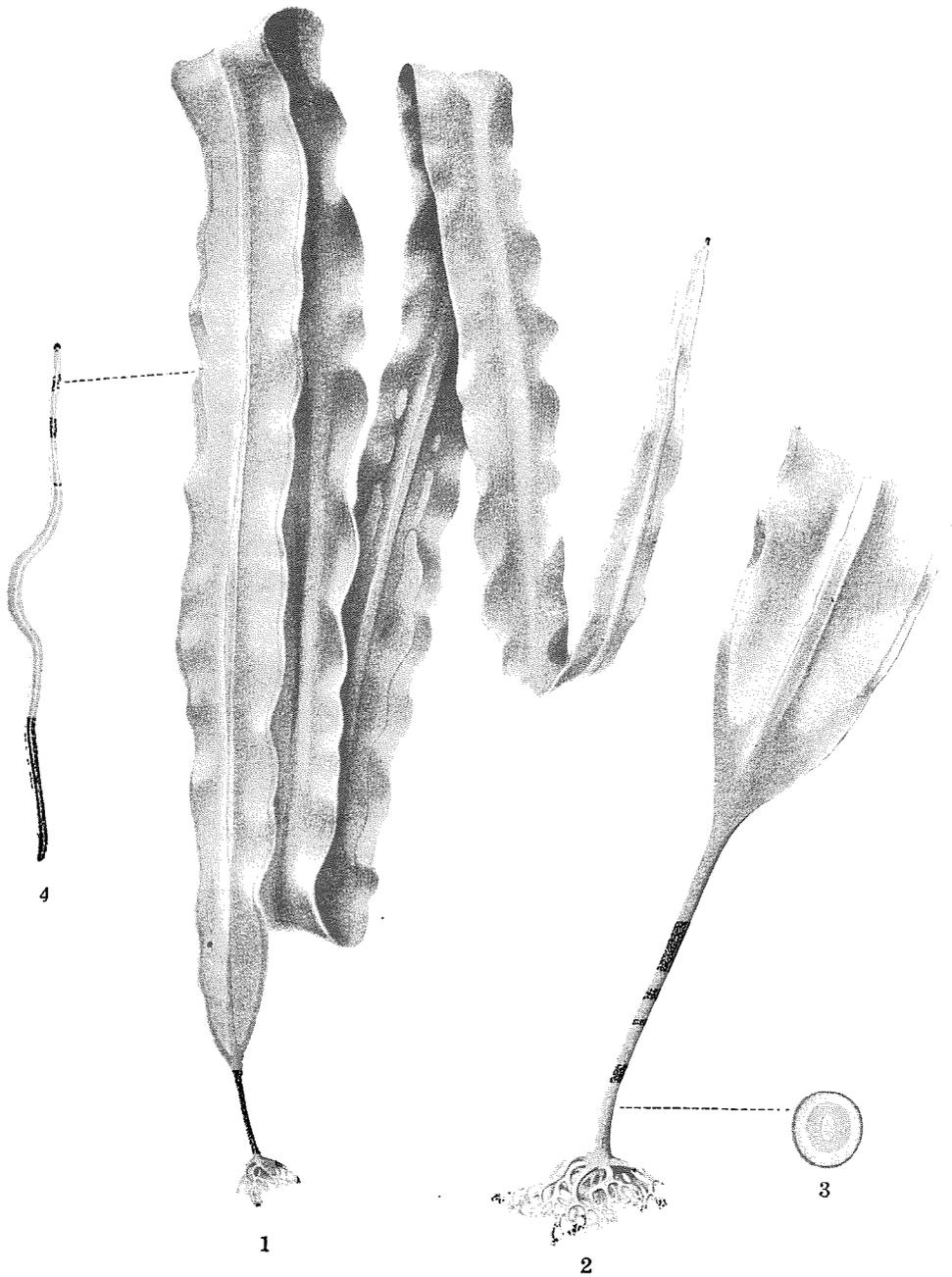
Y. Iro del.

Laminaria cichorioides n. sp.

PLATE IX.

Laminaria angustata KJELLM.

- Fig. 1. Habit of a fertile plant from Shiraoui, Prov. Iburi. $\times 0.16$.
Fig. 2. Basal part of a fertile plant. $\times 0.4$.
Fig. 3. Cross section through the lower part of the stipe. $\times 1.6$.
Fig. 4. Cross section of the blade. $\times 0.8$.



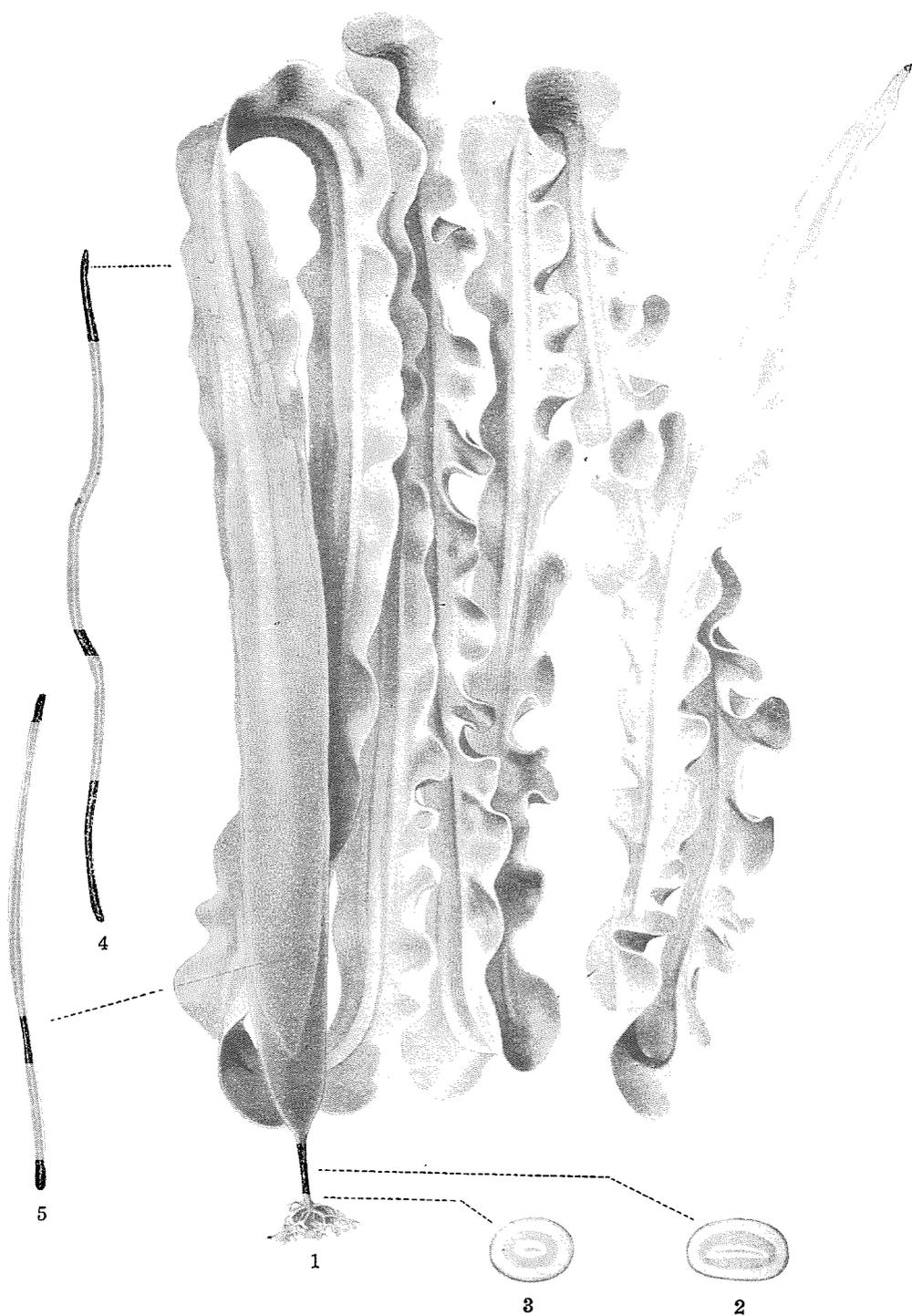
Y. ITO del.

Laminaria angustata KJELLM.

PLATE X.

Laminaria longissima n. sp.

- Fig. 1. Habit of a fertile plant from Kombumori, Prov. Kushiro. × 0.16.
- Fig. 2. Cross section through the upper part of the stipe. × 1.6.
- Fig. 3. Cross section through the lower part of the stipe. × 1.6.
- Fig. 4. Cross section through the upper part of the blade. × 0.8.
- Fig. 5. Cross section through the basal part of the blade. × 0.8.



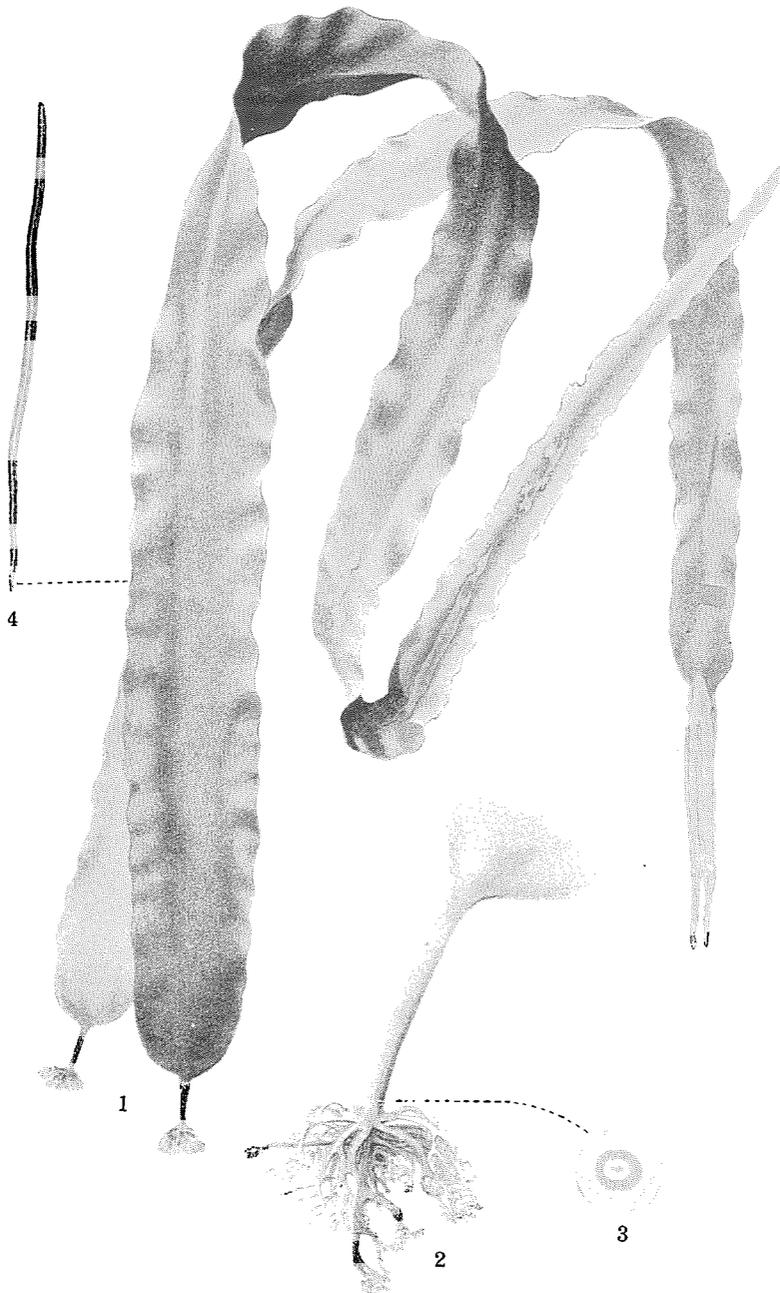
Y. Iro del.

Laminaria longissima n. sp.

PLATE XI.

Laminaria coriacea n. sp.

- Fig. 1. Habit of two plants from Kiritappu, Prov. Kushiro. $\times 0.1$.
Fig. 2. Basal part of a frond. $\times 0.4$.
Fig. 3. Cross section through the lower part of the stipe. $\times 1.6$.
Fig. 4. Cross section of the blade. $\times 0.4$.



Y. ITO del.

Laminaria coriacea n. sp.

PLATE XII.

Laminaria yezoensis n. sp.

Fig. 1. Habit of two plants from Akkeshi, Prov. Kushiro, which are attached to the shell of *Mytilus*. × 0.16.

Fig. 2. Showing the lower part of the stipe and the disc-shaped holdfast seen from the upper side and from the under. × 0.8.



Y. IRO del.

Laminaria yezoensis n. sp.

PLATE XIII.

Laminaria yezoensis n. sp.

Habit of a plant from Etorofu Isl., Kuriles, which bears a young shoot on the holdfast. × 0.16.



Y. ITO del.

Laminaria yezoensis n. sp.

PLATE XIV.

Laminaria Ruprechtii (ARESCH.) DE TONI

Fig. 1. Habit of a plant from Etorofu Isl., Kuriles. × 0.16.

Fig. 2. Showing the holdfast and the basal part of the stipe. × 0.4.



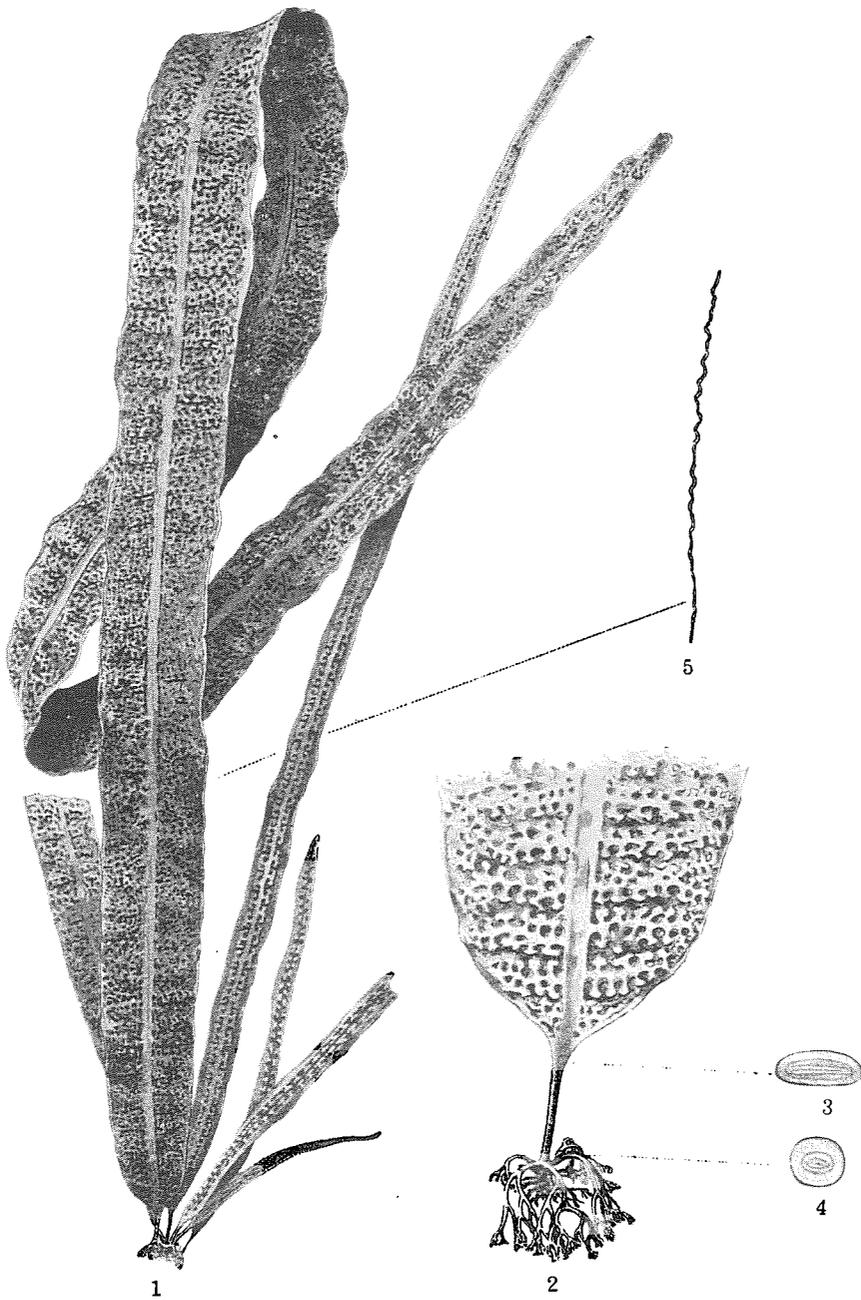
Y. Ito del.

Laminaria Ruprechtii (ARESCH.) DE TONI

PLATE XV.

Kjellmaniella gyrata (KJELLM.) MIYABE

- Fig. 1. Habit of a group of plants from Akkeshi, Prov. Kushiro. $\times 0.16$.
Fig. 2. Basal part of a frond. $\times 0.4$.
Fig. 3. Cross section through the upper part of the stipe. $\times 1.6$.
Fig. 4. Cross section through the lower part of the stipe. $\times 1.6$.
Fig. 5. Cross section of the blade. $\times 0.5$



Y. ITO del.

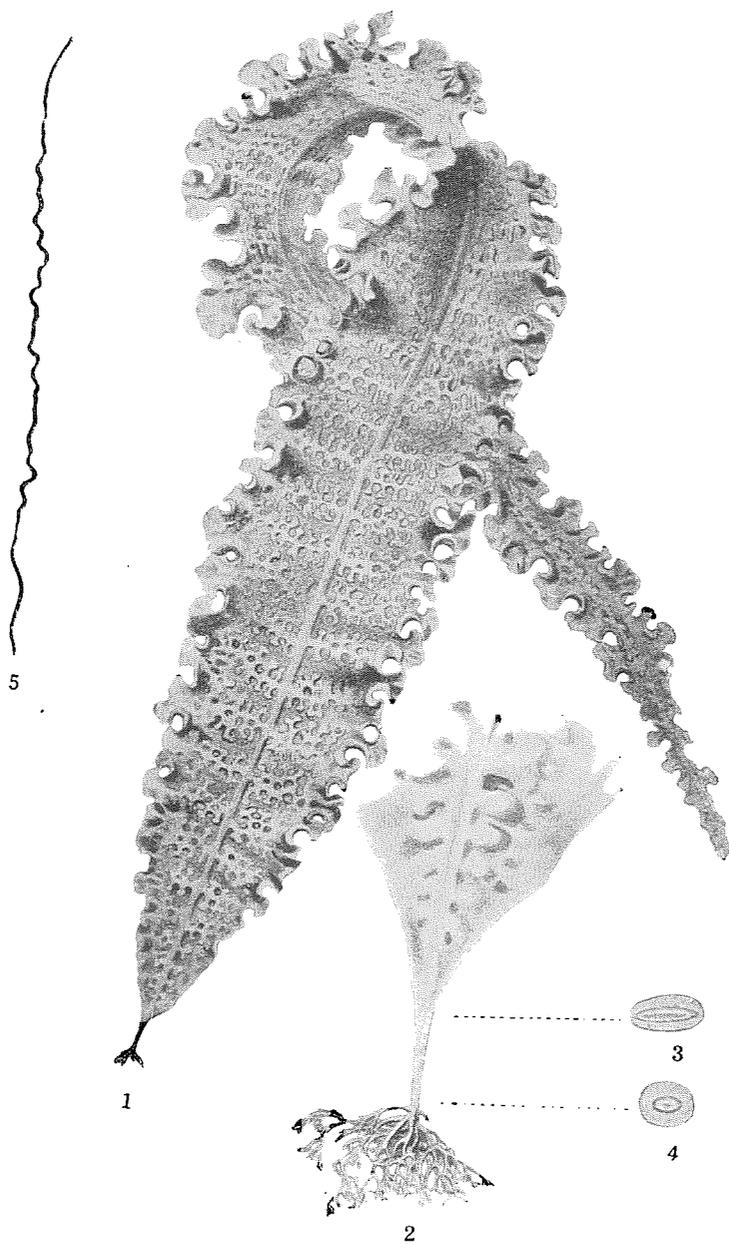
Kjellmaniella gyrata (KJELLM.) MIYABE

PLATE XVI.

Kjellmaniella gyrata (KJELLM.) MIYABE

var. *crispata* MIYABE

- Fig. 1. Habit of a plant from Kiritappu, Prov. Kushiro. $\times 0.16$.
Fig. 2. Basal part of a frond. $\times 0.4$.
Fig. 3. Cross section through the upper part of the stipe. $\times 1.6$.
Fig. 4. Cross section through the lower part of the stipe. $\times 1.6$.
Fig. 5. Cross section of the blade. $\times 0.4$



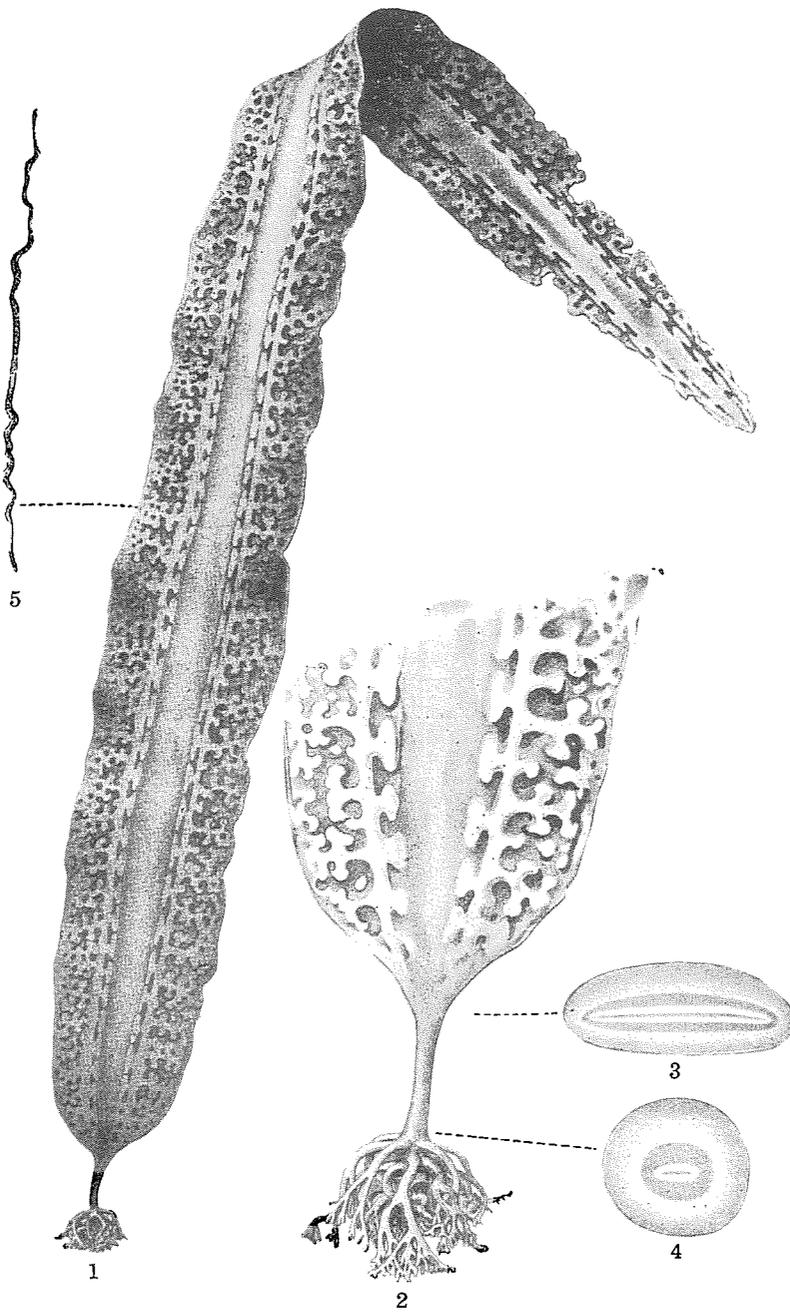
Y. ITO del.

Kjellmaniella gyrata (KJELLM.) MIYABE
var. *crispata* MIYABE

PLATE XVII.

Kjellmaniella crassifolia n. sp.

- Fig. 1. Habit of a plant from Todohokke, Prov. Oshima. × 0.16.
Fig. 2. Basal part of a frond. × 0.4.
Fig. 3. Cross section through the upper part of the stipe. × 1.6.
Fig. 4. Cross section through the lower part of the stipe. × 1.6.
Fig. 5. Cross section of the blade. × 0.4.



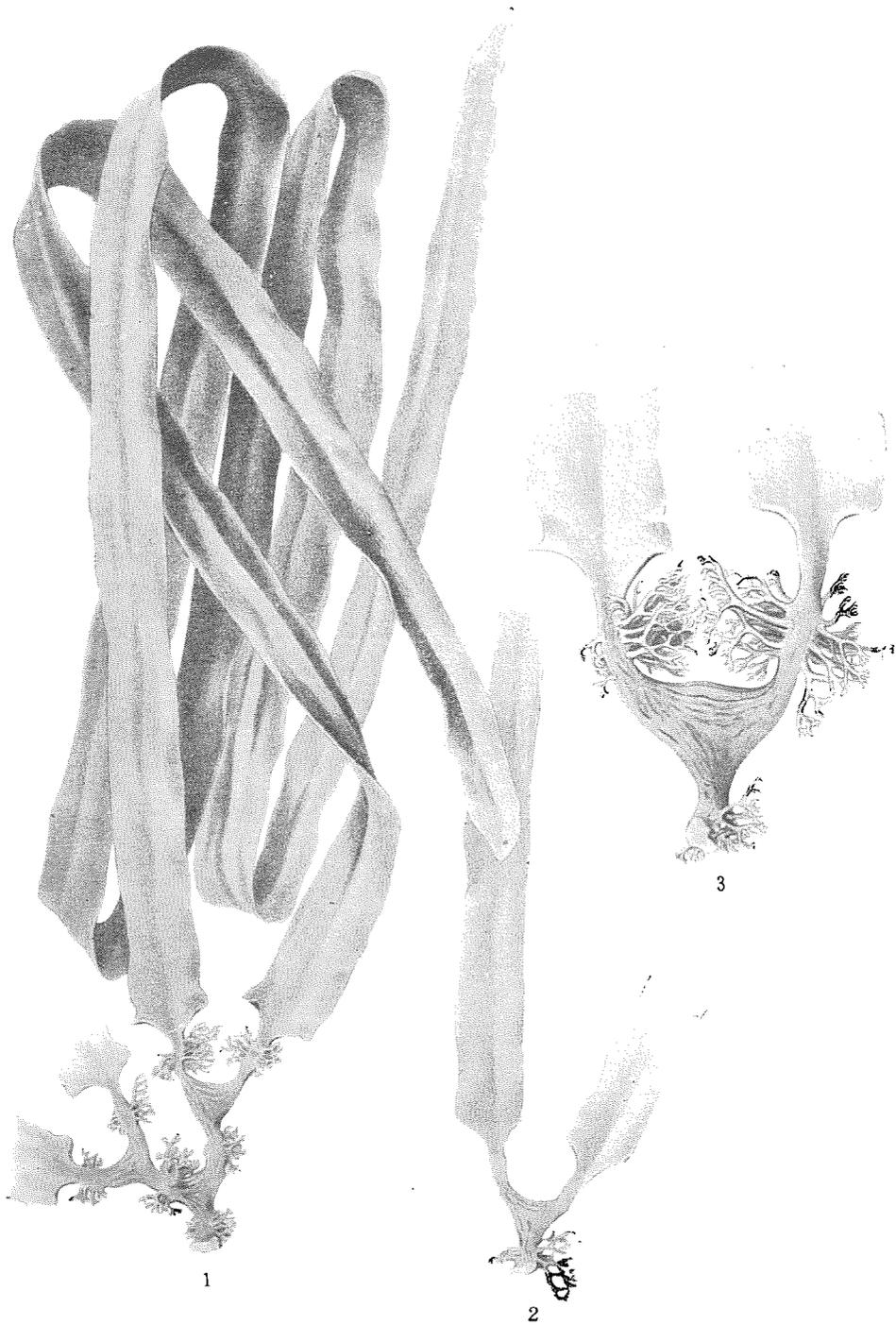
Y. ITO del.

Kjellmaniella crassifolia n. sp.

PLATE XVIII.

Arthrohamnus bifidus (GMEL.) RUPR.

- Fig. 1. Habit of a mature plant from Kiritappu, Prov. Kushiro. × 0.16.
Fig. 2. Part of a young plant from the same locality as above. × 0.16.
Fig. 3. Basal part of the plant shown in Fig. 1. × 0.4.



Y. ITO del.

Arthrohamnus bifidus (GMEL.) RUPR.

PLATE XIX.

Arthrohamnus kurilensis RUPR.

Fig. 1. Habit of a four years old plant wanting the holdfast, from Etorofu Isl., Kuriles. $\times 0.16$.

Fig. 2. Lower part of a two years old plant with the holdfast, and a young plant, from the same locality as above. $\times 0.16$

Fig. 3. Basal part of the plant shown in Fig. 1. $\times 0.4$.



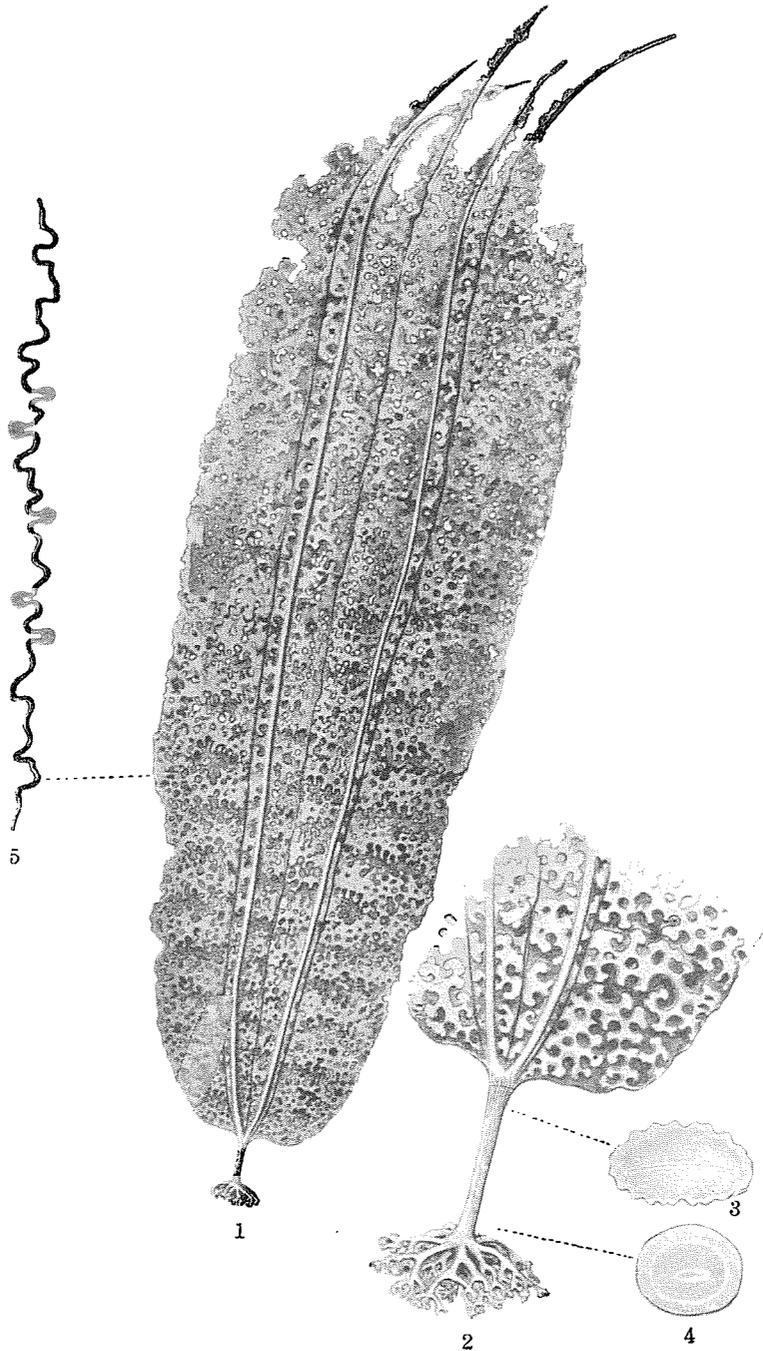
Y. ITO del.

Arthrothamnus kurilensis RUPR.

PLATE XX.

Costaria Turneri GREV.

- Fig. 1. Habit of a plant from Otaru Harbour, Prov. Shiribeshi. $\times 0.16$.
Fig. 2. Basal part of a frond. $\times 0.26$.
Fig. 3. Cross section through the upper part of the stipe. $\times 1.6$.
Fig. 4. Cross section through the lower part of the stipe. $\times 1.6$.
Fig. 5. Cross section of the blade. $\times 0.4$.



Y. ITO del.

Costaria Turneri GREV.

PLATE XXI.

Alaria fistulosa POST. et RUPR.

Fig. 1. Showing the stipe and the holdfast. $\times 0.2$.

Fig. 2. Showing a dense growth of mature sporophylls on the stipe. $\times 0.2$.

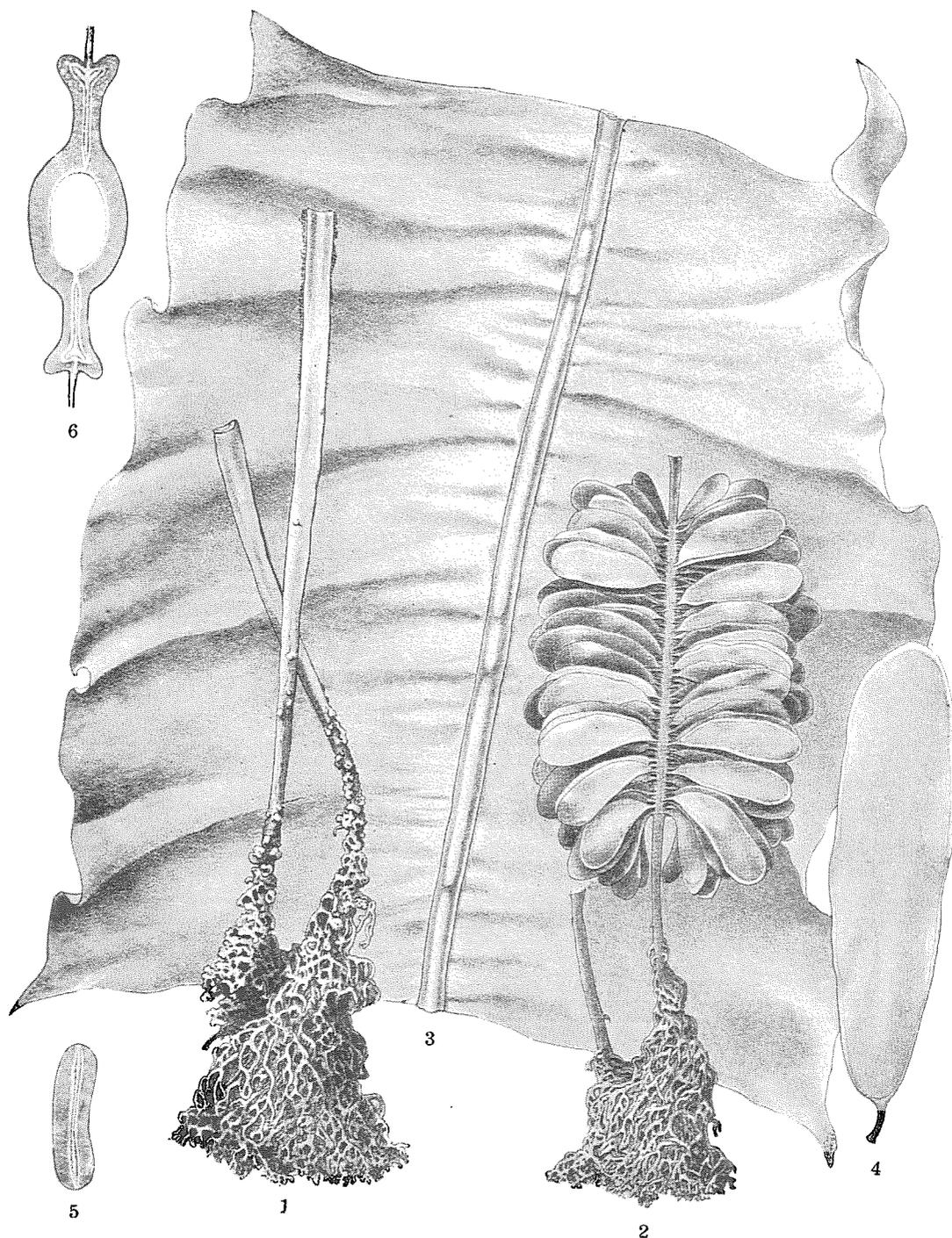
Fig. 3. Part of the blade. $\times 0.16$.

Fig. 4. A mature sporophyll. $\times 0.4$.

Fig. 5. Cross section through the upper portion of a stipe. $\times 1.6$.

Fig. 6. Cross section through the hollow midrib of the blade. $\times 1.6$.

(Pant from Uruppu Isl., Kuriles)



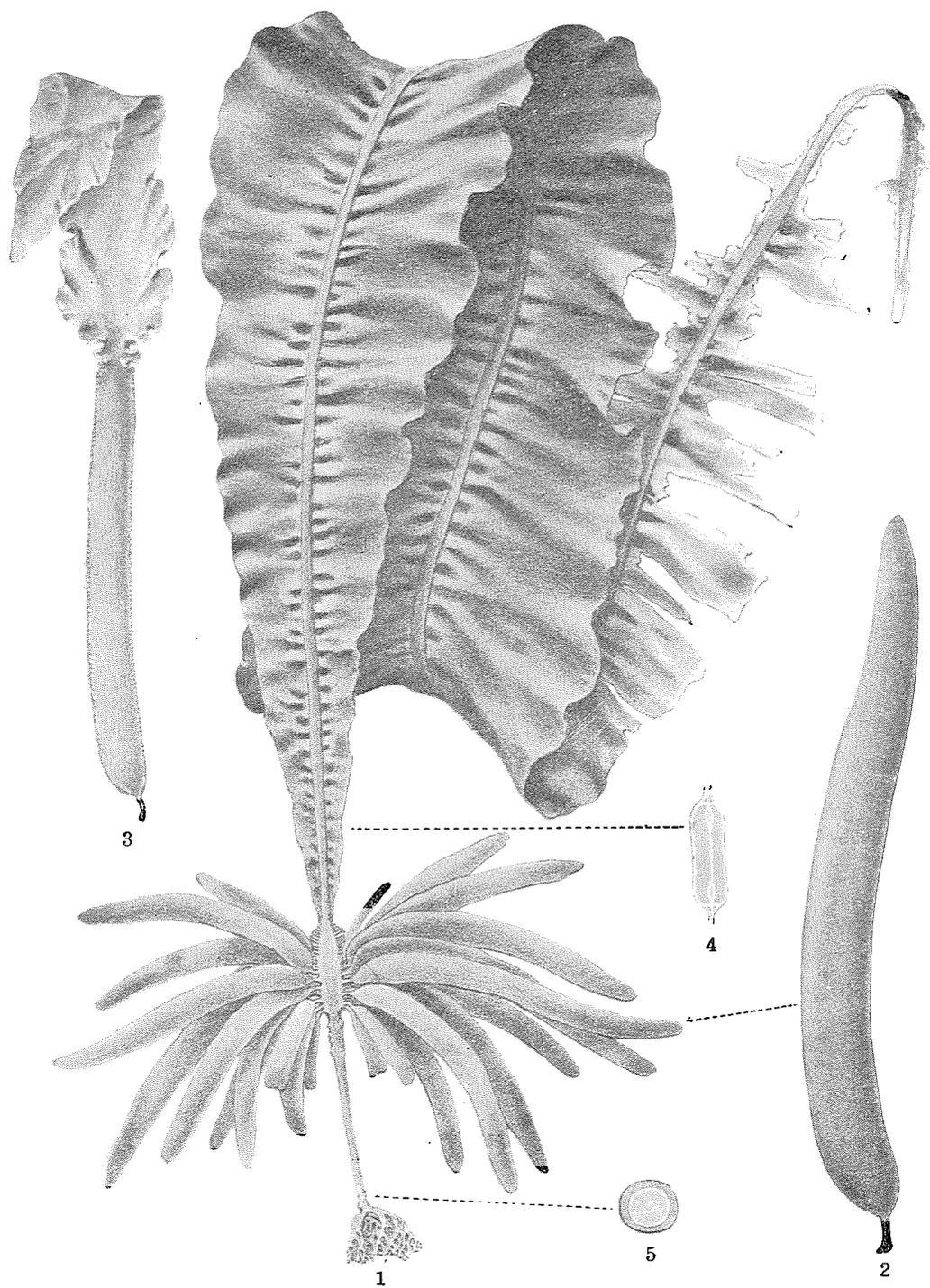
Y. ITO del.

Alaria fistulosa POST. et RUPR.

PLATE XXII.

Alaria crassifolia KJELLM.

- Fig. 1. Habit of a plant from Osatsube, Prov. Oshima. $\times 0.26$.
Fig. 2. A mature sporophyll. $\times 0.5$
Fig. 3. An immature sporophyll with dentate margins and an apical leaflet. $\times 0.4$.
Fig. 4. Cross section through the midrib of the blade. $\times 0.5$.
Fig. 5. Cross section through the lower part of the stipe. $\times 1.6$.



Y. ITO del.

Alaria crassifolia KJELLM.

PLATE XXIII.

Alaria yezoensis n. sp.

- Fig. 1. Habit of a plant from Kushiro, Prov. Kushiro. $\times 0.26$.
- Fig. 2. Lower part of a frond. $\times 0.26$.
- Fig. 3. Cross section through the upper part of the stipe. $\times 1.6$.
- Fig. 4. Cross section through the lower part of the stipe. $\times 1.6$.
- Fig. 5. A mature sporophyll. $\times 0.8$.
- Fig. 6. Cross section through the midrib of the blade. $\times 1.6$.



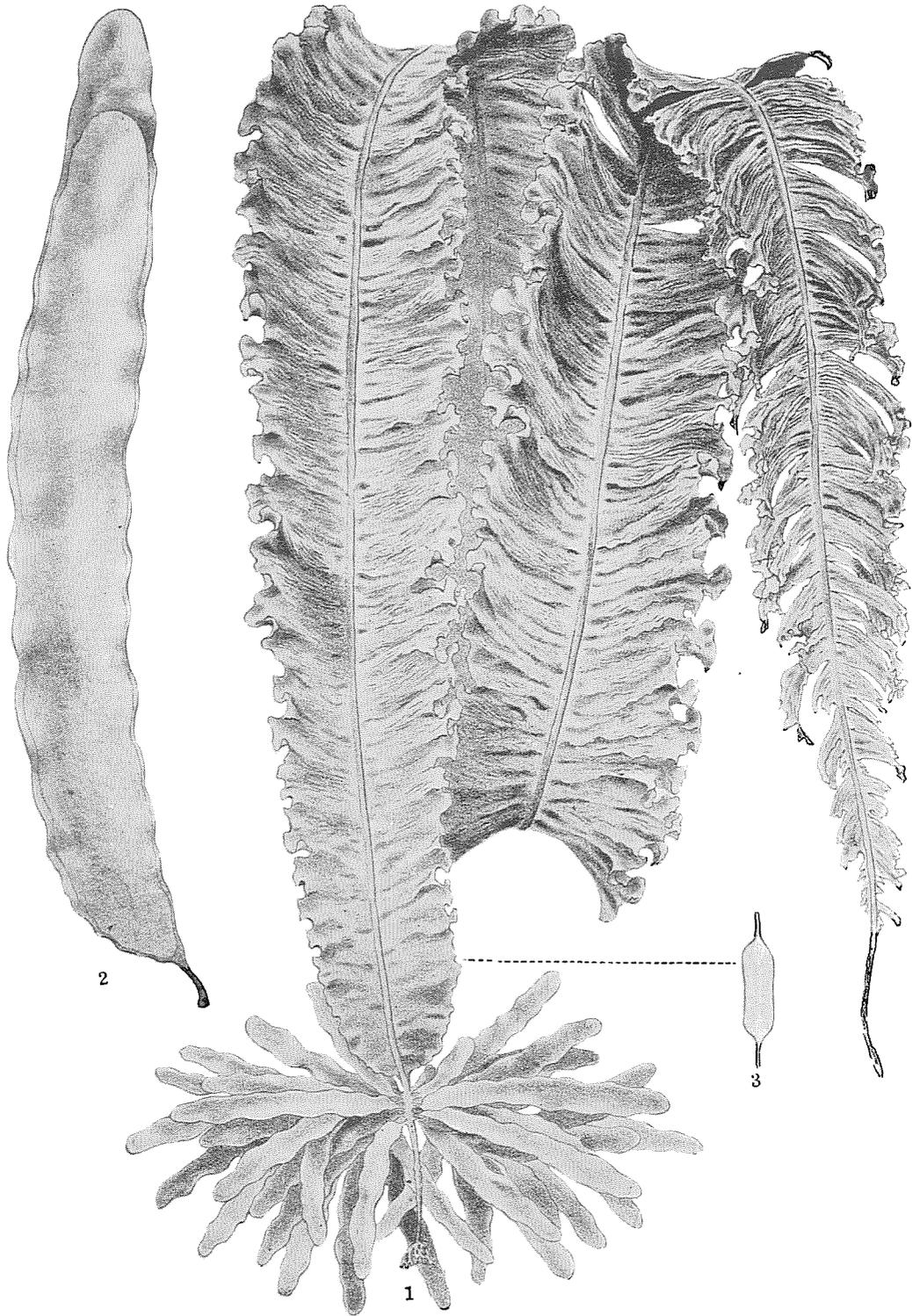
Y. ITO del.

Alaria yezoensis n. sp.

PLATE XXIV.

Alaria corrugata n. sp.

- Fig. 1. Habit of a plant from Shana Gun, Etorofu Isl., Kuriles. $\times 0.13$.
Fig. 2. A mature sporophyll. $\times 0.8$.
Fig. 3. Cross section through the midrib of the blade. $\times 1.6$.



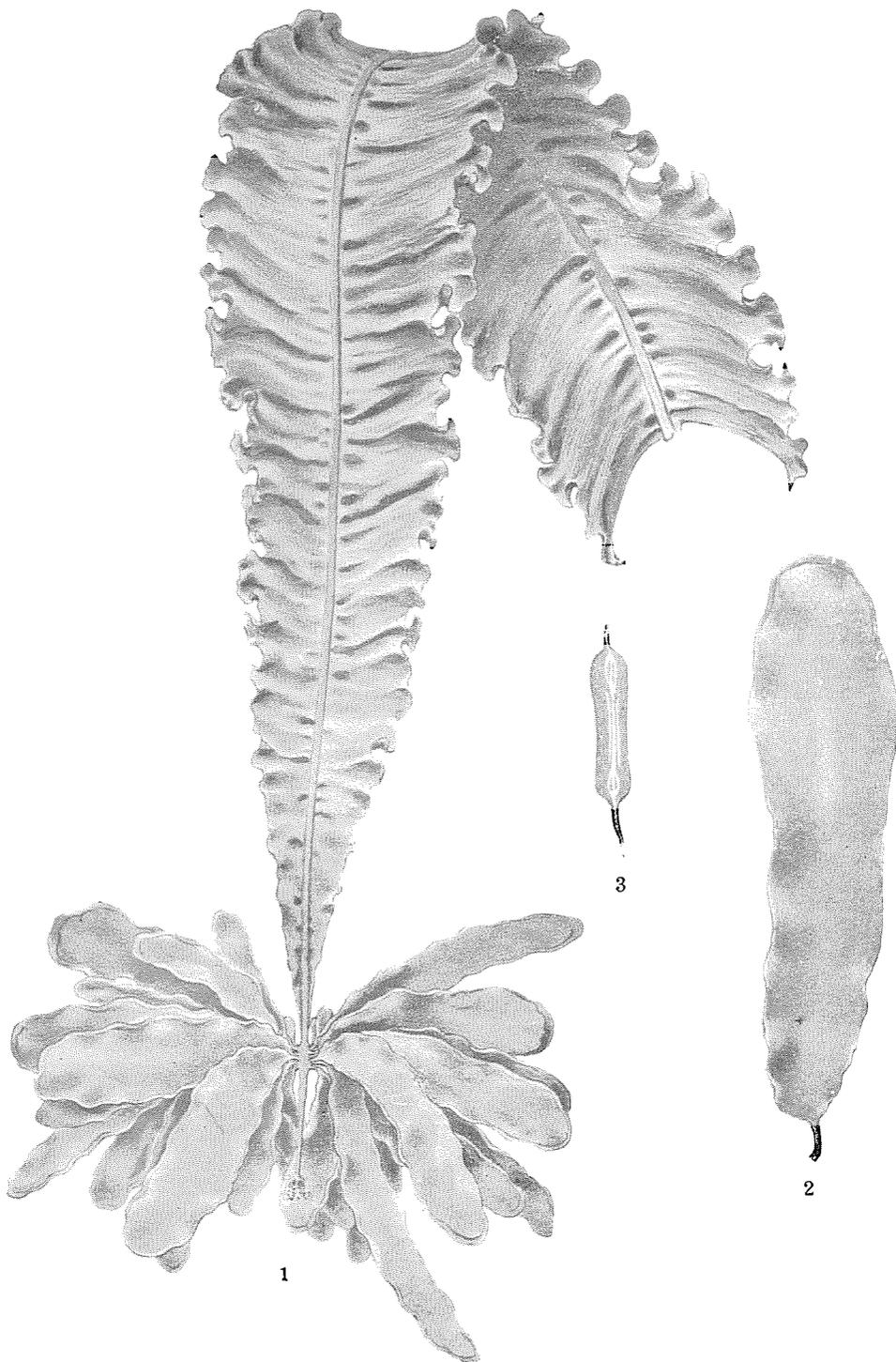
Alaria corrugata n. sp.

Y. IRO del.

PLATE XXV.

Alaria macrophylla n. sp.

- Fig. 1. Habit of a plant from Higashiura, Kunashiri Isl., Kuriles. $\times 0.13$.
Fig. 2. A mature sporophyll. $\times 0.26$.
Fig. 3. Cross section through the midrib of the blade. $\times 1.6$.



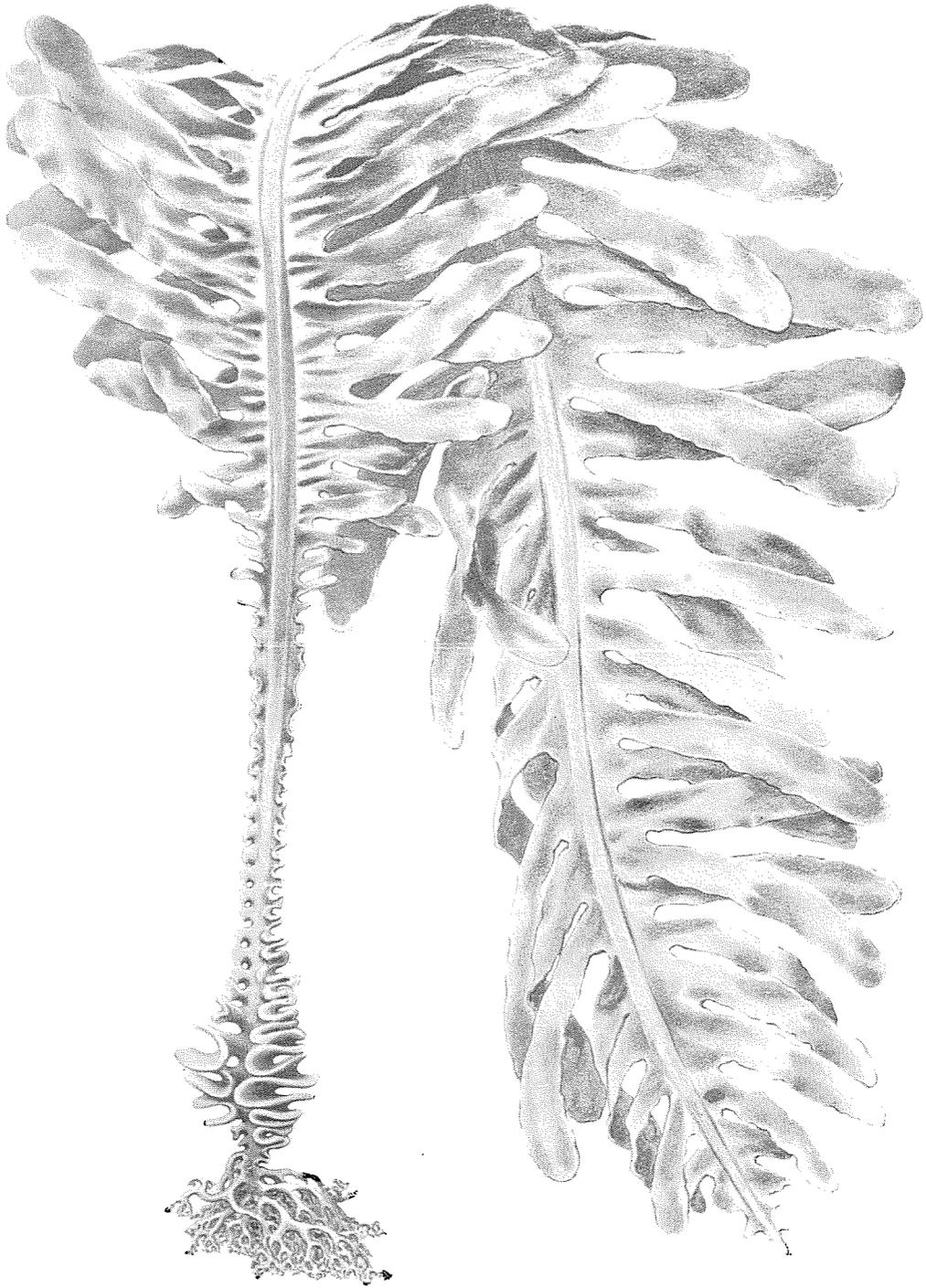
Alaria macrophylla n. sp.

Y. ITO del.

PLATE XXVI.

Undaria distans MIYABE et OKAMURA, n. sp.

Habit of a plant from Osatsube, Prov. Oshima. × 0.16.



Y. ITO del.

Undaria distans MIYABE et OKAM., n. sp.

PLATE XXVII.

Agarum Turneri POST. et RUPR.

Habit of a plant from Rebus Isl., Prov. Kitami. × 0.4.



Y. ITO del.

Agarum Turneri POST. et RUPR.

PLATE XXVIII.

Thalassiophyllum Clathrus (GMEL.) POST. et RUPR.

Habit of a plant from Uruppu Isl., Kuriles. × 0.4.



Y. ITO del.

Thalassiophyllum Clathrus (GMEL.) POST. et RUPR.

PLATE XXIX

Laminaria japonica ARESCH.

Fig. 1. Part of a cross section through the median fascia of a blade. $\times 90$. a. epidermis; b. outer cortex; c. inner cortex; d. medulla; e. cross sections of mucilage canals, two of which are partly or entirely surrounded by small mucilage-secreting cells; f. cross section through a trumpet-shaped cell; g. cross sections through filamentous cells.

Laminaria angustata KJELLM.

Fig. 2. Cross section through the medullary tissue of a frond, showing entangled filamentous cells and two trumpet-shaped cells. $\times 90$.

Fig. 5. Surface view of a part of a blade showing the net-works of mucilage canals stained with anilin blue; the net-works on the right side of the figure are situated in the median fascia area of the blade and those on the left side in the marginal area. $\times 9.7$.

Fig. 7. Showing four zoosporangia (a) and four paraphyses (b). $\times 300$.

Laminaria longissima MIYABE

Fig. 3. Surface view of a part of the median fascia of a blade showing the net-work of the mucilage canals stained with anilin blue; the portions stained in deep blue are occupied by the secreting cells. $\times 9.7$.

Fig. 4. Surface view of a part of the marginal portion of a blade, showing the same structure as in Fig. 3. $\times 9.7$.

Laminaria cichorioides MIYABE

Fig. 6. Part of a cross section through a blade, showing three mucilage canals, of which two are provided with an outwardly developed branch canal reaching the inner wall of the epidermis. $\times 67.5$.

Chorda Filum (L.) LAMOUR.

Fig. 8. Zoospores (after REINKE). $\times 900$.

