Hedophyllum spirale, sp. nov., and its relation to Thalassiophyllum and Arthrothamnus.

By

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With Plate VI.

Hedophyllum spirale, sp. nov.

Frons junior lamina simplici abovato-cuneata, stipite brevi subcylindraceo solido; adultior marginibus laminae exterioribus crassissimis ad basin, intus spiraliter involutis, stipite crassiore subcompresso brevissimo solido ramosissimo. Pars media laminae sensim extra et deorsum ad usque ad basin, sinum inter duo volumines relinquuens, obliterator; volumen laminam in pluris lacinias longitudinaliter fissam emittens. Medulla in sectione transversali stipitis ellipsoidae. Sori in maculas basi laminae ambitibus irregularibus.

Habit. ad insulam Shimushu.

f. kamtschatkensis, f. nov.

Frons major, stipite 20-30 cm longo, basi subtereti, sursum compresso expanso marginibus involutis.

Habit. ad oras Yavinam, Kamtschatkae.

During the three months stay at Shimushu, the island at the northern extremity of the Kurile Isles, I could satisfactorily study the marine vegetation in its vicinity. The present species is one of the common Laminaireaeous algae found covering the extensive reefs in front of Kataoka Bay, at low tide hours.

The earliest stage of the plant begins to appear late in July or at the beginning of August. The lamina is oblong obovate with a short and subcylindrical stem. The mucilage canals are found in lamina traversing beneath the both epidermal layers. In the stipe as well as the ramuli of the holdfast there are glandular cavities¹ in the form of ring close by the peripheral margin (fig. 5).

When the plant has grown about 7-10 inches long, the lamina expands

¹. In the cross sections of a stem, these cavities have similar appearance to the primary stage of the mucilage ducts. But they do not develop further, remaining as elliptical cavities elongated tangentially. Hence it would be advisable to treat them under different name to avoid the confusion with the true mucilage canals.
more, especially at the upper portion. Two longitudinal rows of the transverse foldings begin to appear along the margins of the lamina. The stipe gains larger diameter and evidently becomes compressed near at the transitional region. But there occurs little addition in the length. The upper portion of the lamina is torn away as the plant grows larger.

It seems to me that the plants remain in a little advanced stage over the winter.

As the plant becomes older the lamina enormously broadens without considerable increase in its length. The foldings become remarkable and the upper portion of the lamina splits into several longitudinal segments. In this stage they are hardly distinguishable from a form of *Hedophyllum subsessile*, Setch., at the same time much applicable to the description of *Hafnygia Bongardiana f. furcata*, Aresch.) Sooner or later the both margins of the lamina begin to roll inside at the transitional region, the middle portion of the lamina wearing away till clear to the base.

The wearing of the lamina extends downward until a narrow portion is left at the transition region which has much increased in its thickness. Hence the plant has now two arms at the top of the short stem, each arm bearing a wide bullated lamina. The external margin of each lamina rolls toward the inner side, and has considerable thickness at the basal region. The cross section at this region, therefore, shows $\sim$-shape (fig. 3). The upper portion of the external margin is thin and fimbriated.

The rolling takes place only at the restricted portion near the base of each arm, and not along the whole part of the external margin. The consequence is a loose spirality. I could not find any plant with the rolling more than $2\frac{1}{2}$ turns (fig. 6.).

Not seldom I have met with those specimens which had incomplete rhizoidal processes around the both arms; and often a plant had one arm with its middle segment torn away to the base, apparently resembling the second order of dichotomy. In the latter case the external segment (the inner portion at the earlier stage) showed no indication of further development.

The sori were found in the armed plants. They cover the basal portions of the laminae at the both arms in large patches with irregular outlines (fig. 1).

The mucilage canals in the adult plants are found, as in the younger ones, in the lamina traversing beneath the both surfaces. The glandular

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cavities in the stipe and holdfast remain unaltered, but more or less becoming insignificant when compared with the younger stage.

The medulla is ellipsoid in a transverse section of the young stems but soon becomes compressed accompanying the development of the stem. In the armed specimens we find the primary medulla much compressed into linear form and another ring around it; the arms have simple incomplete ring, a part of which has travelled into the torn off portion of the lamina (figs. 2.4).

*f. Kamtschatkensis* differs from the type by having very long stipe. It measures 1.5-2.0 cm in diameter and 20-30 cm in length. The upper portion of the stipe becomes complanated and much broader, and the margins turning inward at this region. In other respects similar to the type.

There is no doubt that the present species has close similarity with *Hedophyllum subsessile*. The former is easily separable by the spiral rolling of the both margins at the transition region. This character had not been found in the latter though minute investigations have been done upon the plant by the American algologists. But in *Hedophyllum subsessile* the basal margins have a tendency of folding inside while in *Hedophyllum sessile* no such indication could be found. The wearing of the primary lamina is also limited to *Hedophyllum subsessile* and none of the circumstance had been noticed in the allied species.

Among the multitudinous forms of Laminareaceous plants, *Eisenia, Arthrothamnus, Thalassiophyllum*, and *Hedophyllum* have their primary lamina to be worn away in the adult stage. Only one species among the members, *Hedophyllum sessile*, is the exception. If all the members of *Ecklonia* have been transferred to *Eisenia*, which is highly probable, we shall have more of the case. The first of the above mentioned four genera has no visible rolling in the lamina, as the corresponding position is assumed by a number of the ligules. But it is clear that the both arms tend to turn inside, especially when they are not in a great length: cf. Illustr. d'Alg. d. Japon. Pl. XIX–XX. Besides, we have a species of *Agarum* with its lamina scrolled at the base.

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1. Ruprecht mentions several forms of *Laminaria digitata* to occur in the Ochotsk sea. One of the form had the basal region rolled inside at the margin (Tange, p. 352); and he mentions *Laminaria dermatodea* in the list of algae collected by Wesnesenski at Yavina, where the present writer has collected this plant. These remarks shall be discussed in future in connection with the present form.

2. Suringar: Musée Botan. d. Leide. T. II.
*Thalassiothamnus* and *Arthrothamnus* have hitherto been incompletely studied. The author could happily trace the stages of the development in the both genera during the stay. On returning home from the trip, I was struck with curious coincidence upon reading the excellent work newly published by Setchell and Gardner. They gave precise description on the development of *Thalassiothamnus,* which I expected to write, and reformed the previous knowledge relating the plant. Nothing might be added to their description about the transformation of the external character through the development of the plant. A few words, however, shall be necessary to describe about the development of *Arthrothamnus,* on which, as far as I could refer to, no one seems to have touched yet.

At the first stage of development the lamina is linear, 8-12 cm. long and 2.5-3.0 cm. wide, attenuated toward the base which ends in a cylindrical stipe. The stipe measures 1.5-2.0 cm. in its length and has a simple holdfast.

The lamina expands into a thin wide blade in the next stage, the upper portion gradually wearing away. The stipe increases in its thickness and number of thick rhizomes are given rise at the upper portion of the primary holdfast. The length of the stipe is thus greatly diminished. (fig. 10).

A limited portion of the margins close at the transition region is scrolled inside for one turn. The scroll is not loose spiral roll but rather a sort of hemming without any descriminable space inside. The apical portion of the inner edge of the scroll develops into a short cylindrical stem which gently expands into a narrow lamina (fig. 10).

The primary lamina disappears in this stage leaving the wide sinus between the new stems. The scar of the worn lamina traverses along the sinus and turns from the outerside to the innerside around the base of each new stem. (fig. 11).

The newly formed or the secondary lamina is almost always unsymmetrical, especially at the beginning of its growth. This is due to the greater rapidity of the growth at one—in majority of cases, external—side of the lamina. As the plant grows larger the stems begin to increase their thickness and the rhizomes begin to appear as the stout processes around their basal parts. (fig. 11).

The secondary lamina develops further until it retained the proper

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1. Algae of N.W. America.
2. p. 267.
form which was satisfactorily reported by the previous authors. The rhizomes around the secondary stem grow more and more, issuing dendritic ramules, each of which ending in a small hapter. The primary stem grows larger adding considerable length and thickness; and bending suddenly downward at the base. The scar of the primary lamina faces against the substratum as a rule. (fig. 11).

When the secondary lamina grew to its full size, the margins at the transition region begin to expand so as the characteristic auricle now appears. At the same time bullation takes place in the lamina at the upper part of each auricle. The scrolls are formed at the margins of the auricles, the tertiary laminae are sprung out from them and the secondary lamina gradually wears away leaving its scar as before.

At this stage the secondary stems begin to grow larger, adding their thickness and gently expanding upward. When the secondary laminae have wholly disappeared the secondary stems become wedge-shaped having their narrow ends connected with the primary stem, and provided with the tertiary frond at each corner of the broadened ends.

The tertiary rhizomes appear at the bases of the tertiary stems. The wedge-shaped secondary stems bend downward so that the tertiary rhizomes are thus greatly helped to easily access the substratum, just as the primary stem has done before.

The successive growth takes place once in a year repeating the similar process at each growth. The branching mode is, as readily be understood from the above given description, a regular dichotomy. But after several years the old stems wear away and some of the branches are detached off in the heavy storms during winter. The final result is an irregularly dichotomous, highly complicated stolon, with stripe-form lamina at each ultimate point. This form has been fully described\(^1\) and familiar to us.

The above relates the development of *Arthrothamnus bifidus*. In *Arthrothamnus Kurilenensis* the entire plant is erect, not as De Toni has doubted.\(^2\) Consequently the dorsi-ventrality of the stems are not clearly manifested. The primary stem and holdfast are persistent and the successive holdfasts or the rhizomes are not normally found. In other respects as the former species.

Had the new species been legitimately reckoned under the genus

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1. Among the descriptions of Arth. bifidus, the one by Mertens, Linnea. 1829, p. 55. under the name of Fucus cornucopiae shall be recommended.
Hedophyllum we find a remarkable parallelism between Hedophyllum, Thalassiozyllum and Arthrothamnus in the mode of branching.

The normal branching of Thalassiozyllum is a simple bifurcation. The lateral branches, which sometimes occur in a considerable number and size, are irregular ones, as has been already remarked by Rosenthal and Setchell.\(^1\) The both arms are the scrolls of perforated laminae constantly unrolling and growing upward.\(^2\) The old portion of the lamina successively wears away leaving spiral scar around the stem. It goes on infinitely. The circumstance is similar in Hedophyllum spirale; the only difference lying essentially on the wanting of the foramen and the limited number of rolling. Compare fig. 7 and 8.

In Arthrothamnus the case is little modified. The turning of the scroll is in the majority restricted to only once. Prof. Miyabe of Sapporo reports\(^2\) that the stems of Arthrothamnus Kurilensis sometimes turn twice. But in the stems of Arthrothamnus bifidus it is exclusively only once as far as I could actually observe. If we trace the outermost branches, from the primary stem upward, we shall find that the terminal lamina has been revolved as many times as the repetition of the dichotomy. It rolls infinitely as it were. (fig. 9.)

The secondary laminae of Thalassiozyllum and Hedophyllum spirale are unsymmetrical, while the adult blades of Arthrothamnus are the contrary. But the young stage of the secondary laminae of the latter species, as has been above remarked, is an unsymmetrical blade. This must not be overlooked in the phylogenetic speculation.

Setchell enumerated Gymnathere, Costaria, Agarum, Thalassiozyllum and Arthrothamnus under the subtribe Agariae in the tribe Laminariideae. And Undaria (Ulopterix), Ecklonia and Eisenia under the subtribe of

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* About the mode of formation of the lateral branches the present writer can not hold in the opinions of Rosenthal and Setchell. The former reported that the lateral branches are originated at the wounded margins of young foraminers, and Setchell seconded this view. If this be the case always the branches must be often found on the lamina, because the young foraminers shall take their places on the lamina as the scroll unrolled. But the lateral branches are always found arisen on the stem without direct continuation with the spiral scar. This can hardly be explained by their view. The present writer found young stages of the branches on a pretty old part of a stem, without any relation with the lamina. Anyhow the lateral branches are not normal ones, but of secondary nature.
Eckloniae in the tribe Lessoniideae. The union of both Costaria and Cymathere to Agaricae is somewhat problematic, as Reinke seems to be inclined to think so. The reason upon which Setchell brought Thalassiophyllum near Agarum was in the similarity of the perforation in the blades of the both genera. This view had been previously announced by Rosenthal. But "nach den Untersuchungen von Rosenthal dürfte die Verwandtschaft von Thalassiophyllum und Agarum keine ganz nahe sein; endgültige Entscheidung wird wohl erst die Beobachtung der Jugendform von Thalassiophyllum bringen." Happily Reinke's desideration has been brought to eyes by Setchell and Gardner; and the grouping of the both genera in Agaricae found another and more legitimate ground.

About the systematic position of Hedophyllum, which was described after the publication of "Classification etc.," Setchell gives nothing. Reinke mentions it under Laminareen which corresponds to Laminariae of Setchell. The erosion of the primary lamina, spiral rolling, and differentiation of the of dorsiventrality in Hedophyllum spirale suggest the close relationship with Arthrothamnus and Thalassiophyllum; and with Agarum when we eliminate the first character.

If the erosion of the primary lamina could be taken as an important character in consideration of the natural order, the genus Eisenia shall be detached from the subtribe Ecklonia, or Ecklonieen of Reinke, and brought close by Arthrothamnus or Hedophyllum.

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EXPLANATION OF PLATE.

1. Hedophyllum spirale. ½ nat. siz. A patch of sori seen on the surface of the left hand lamina. View from the ventral side.
2. Cross section of the primary stem of an adult plant. nat. size.
3. Cross section of lamina at the basal part of the external margin; the thickened portion gradually transforms into lamina. The medulla takes an eccentric position in the thickened portion. Compare with fig. 32. of Rosenthal's paper. (Flora. 1890. Taf. VII. VIII).
4. Cross section of the primary stem, of a frond of young stage, nat. size.

5. A part of cross section of stem, $\times 40$. The glandular cavities are seen near the periphery.

6. A portion of stem, turned twice and half, nat. size. $p$ primary stem, $s$ scar of the worn primary lamina. $G$, the thick basal portion of the external margin of the lamina.

7. Diagramatic figure showing the spiral turning of the secondary stem of Hedophyllum spirale. $p$ primary stem, $s$ scar of the worn primary lamina.

8. ditto of Thalassiophyllum crathrus.

9. Diagramatic figure of a part of branch of Arthrothamnus bifidus. $p$ primary stem. $S_1, S_2, S_3$ indicating the scars of the primary, secondary, tertiary lamina respectively; $S_{1}', S_{2}', S_{3}'$, the scars of the corresponding laminae turned inward and travelling upward along the inner margin of the stems.

10. A young stage of Arthrothamnus bifidus; view from the dorsal side. ca. $\frac{1}{2}$ nat. size. The primary lamina is almost worn away.

11. A more advanced stage of the same, view from the lateral side. The secondary rhizomes are in issue. The scar of the primary lamina facing against substratum. ca $\frac{1}{2}$ nat. size.