Mem. Fac. Sci., Shimane Univ.,
15, pp. 75–87 Dec. 20, 1981

Streptophyllopsis a new genus of Laminariaceae, Phaeophyta, from Japan

Mitsuo KAJIMURA
Marine Biological Station, Shimane University, Kamo, Saigo, Oki-gun, 685 Japan
(Received September 5, 1981)

Streptophyllopsis kuroshioensis (SEGAWA) gen. et comb. nov. is described herein on the basis of the detailed observations on the abundant materials collected from deep-waters in the Oki Islands, Shimane Prefecture, in the past seven years since 1974. The frond of the new taxon has a shortly stipitate simple annual blade arising singly from each terminal of the dichotomously branched perennial prostrate branch which has perennial haptera on its ventral surface. Mucilage-canals are present in the blade, stipe and the prostrate branch. Sporangial sori are formed on both surfaces of the blade and the stipe. The paraphysis has a short mucilaginous appendage.

Key Index Words: Streptophyllopsis kuroshioensis; *Laminariaceae*; *Phaeophyta*; *annual simple blade*; *perennial prostrate branch*; *perennial haptera*; *mucilage-canal*; *mucilaginous appendage*.

Introduction

Hedophyllum(?) *kuroshioense* SEGAWA was reported in 1948 (SEGAWA 1948) from deep-waters off Izu Province in Shizuoka Prefecture on the Pacific coast of Honshū, where Kuroshio Warm Current is washing along and has a significant effect upon the algal vegetations there. However, unfortunately he could not collect enough amounts of materials of this alga to make a detailed study possible as he mentioned in his paper that, "Because of an inadequate supply of specimens, the present alga has been not studied in such respect in detail. This is the reason to be marked with a query on the genus name." The present writer was fortunate enough to discover this alga growing in the depth of 50 m off Chiburi Isl. in the Oki Islands, Shimane Prefecture, on September 9, 1974, and he could collect its specimens abundantly which made a detailed study on this alga possible leading to a conclusion that this alga may be considered as belonging to a new genus in Laminariaceae.

Materials and methods

The materials used for this study were collected by a dredge designed by the

Contribution No. 16 from Oki Marine Biological Station, Shimane University

writer from the depth ranging from 20 to 60 m in the Oki Islands all through the year, except August, in the past seven years since 1974, as shown in the following list.

List of materials

No.	Date	Locality	Depth (m)	Habitat
OS9836	Sep. 9, 1974	off Chiburi Isl.	50	on rocky bottom
OS9837	Sep. 18, 1974	off Chiburi Isl.	50	on rocky bottom
OS9838	Nov. 28, 1974	off Koike	40	on rocky bottom
OS9839	May 10, 1978	off Tsuma	30	on rocky bottom
OS9840	May 11, 1978	off Koike	50	on sponge
OS9841	May 11, 1978	off Tsuma	40	on *Cynthia* sp.
OS9842	May 29, 1978	off Tsuma	30	on stone
OS9843	Jun. 2, 1978	off Tsudo	40	on *Lithothamnium* sp.
OS9844	Jul. 12, 1978	off Tsuma	40	on rocky bottom
OS9845	Jul. 12, 1978	off Tsuma	40	on rocky bottom
OS9846	Jul. 16, 1978	off Tsudo	35	on stone
OS9847	Jul. 21, 1978	off Tsuma	60	on rocky bottom
OS9848	Jul. 27, 1978	off Tsudo	40	on rocky bottom
OS9849	Jul. 27, 1978	off Tsudo	40	on *Lithothamnium* sp.
OS9850	Oct. 4, 1978	off Tsuma	20	on rocky bottom
OS9851	Nov. 27, 1978	off Koike	40	on rocky bottom
OS9852	Nov. 27, 1978	off Koike	40	on rocky bottom
OS9853	Jan. 9, 1979	off Koike	40	on stone
OS9854	Feb. 7, 1979	off Koike	40	on *Cynthia* sp.
OS9855	Mar. 20, 1979	off Tsuma	45	on rocky bottom
OS9856	Jul. 13, 1979	off Tsuma	30	on stone
OS9857	Jul. 25, 1979	off Tsuma	20	on rocky bottom
OS9858	Oct. 9, 1979	off Koike	40	on rocky bottom
OS9859	May 19, 1980	off Tsudo	30	on rocky bottom
OS9860	May 29, 1980	off Tsudo	30	on rocky bottom
OS9861	May 30, 1980	off Tsudo	40	on rocky bottom
OS9862	May 30, 1980	off Tsudo	40	on stone
OS9863	Jun. 14, 1980	off Tsudo	40	on *Lithothamnium* sp.
OS9864	Oct. 23, 1980	off Tsudo	40	on rocky bottom
OS9865	Nov. 19, 1980	off Tsudo	38	on rocky bottom
OS9866	May 27, 1981	off Tsudo	30	on stone
OS9867	Jun. 4, 1981	off Tsudo	30	on stone

Zoospore germination was studied as follows. The zoospores discharged from a mature sporophyte which was collected from the depth of 40 m off Koike on No-

vember 28, 1974, and they were cultured in filtered sterilized seawater kept in 20°C and constant 800 lux under a cool-white-fluorescent lamp.

Streptophyllopsis gen. nov.

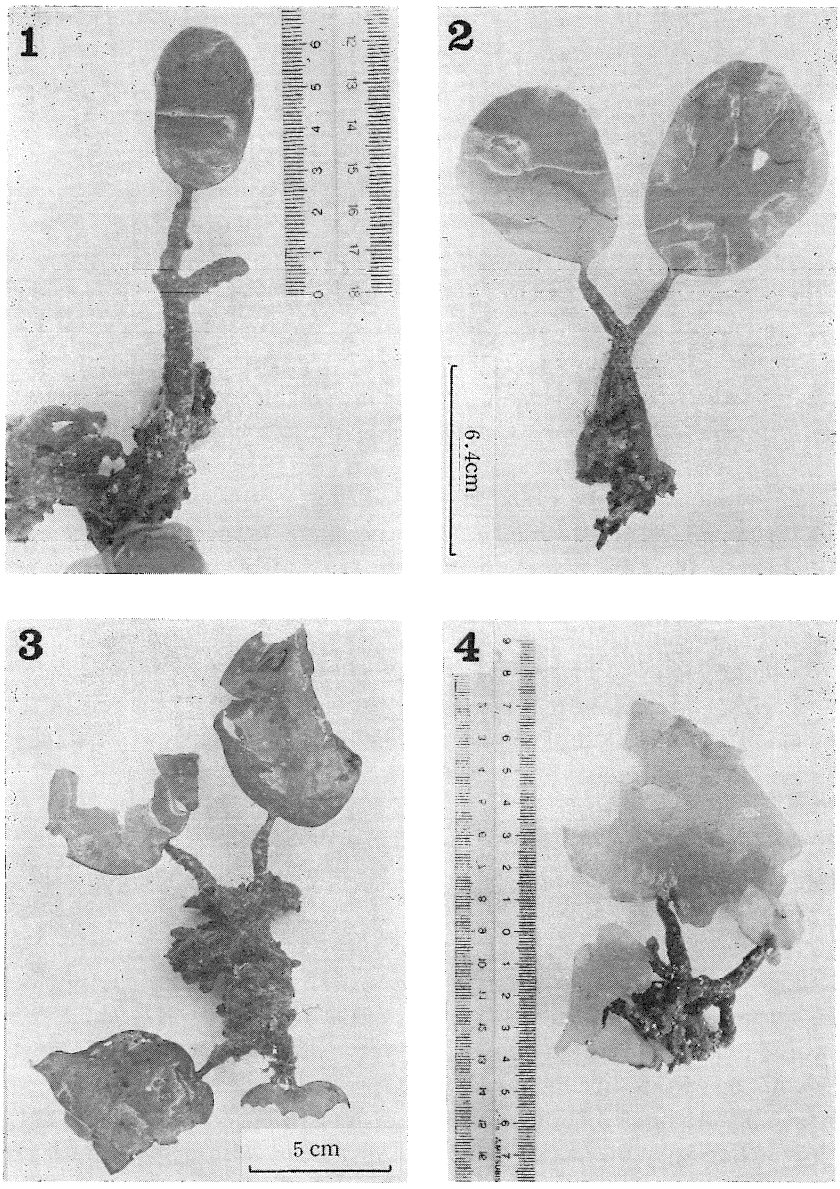
Hapteron e rhizinis perennibus, filiformibus, dichotome ramosis, quae e ramo prostrato ventraliter enascuntur, compositum. Ramus prostratus, perennis, cylindricus, dichotome ramosus. Lamina annua, breviter stipitata. Stipes brevis, crassus, erectus, latere in dorsali concavus, inferme teres. Lamina e parte terminali rami prostrati singulatim enascens, simplex, membranacea, decumbens, obovata ad ellipticam, ad basim cordata, paululum concava convexave, in superficie levis, marginibus integris undulatis, subduplicibus. Canalis mucosus in lamina, stipite et ramo prostrato praesens. Sori sporangiales utraque in superficie laminae stipitisque formati. Paraphysis appendiculam brevem cuneiformem mucosam habens.

Holdfast composed of perennial, filiform, dichotomously branched haptera arising ventrally from the prostrate branch. The prostrate branch perennial, cylindrical, dichotomously branched. Blade annual, shortly stipitate. Stipe short, stout, erect, concave on the dorsal side, terete below. Blade arising singly from the terminal of prostrate branch, simple, membranous, decumbent, obovate to elliptical, cordate at the base, slightly concave or convex, smooth in surface, with entire, wavy, partially double margins. Mucilage-canal present in the blade, stipe and the prostrate branch. Sporangial sori formed on both surfaces of the blade and the stipe. Paraphysis with a short cuneiform mucilaginous appendage.

Streptophyllopsis kuroshioensis (SEGAWA) comb. nov.

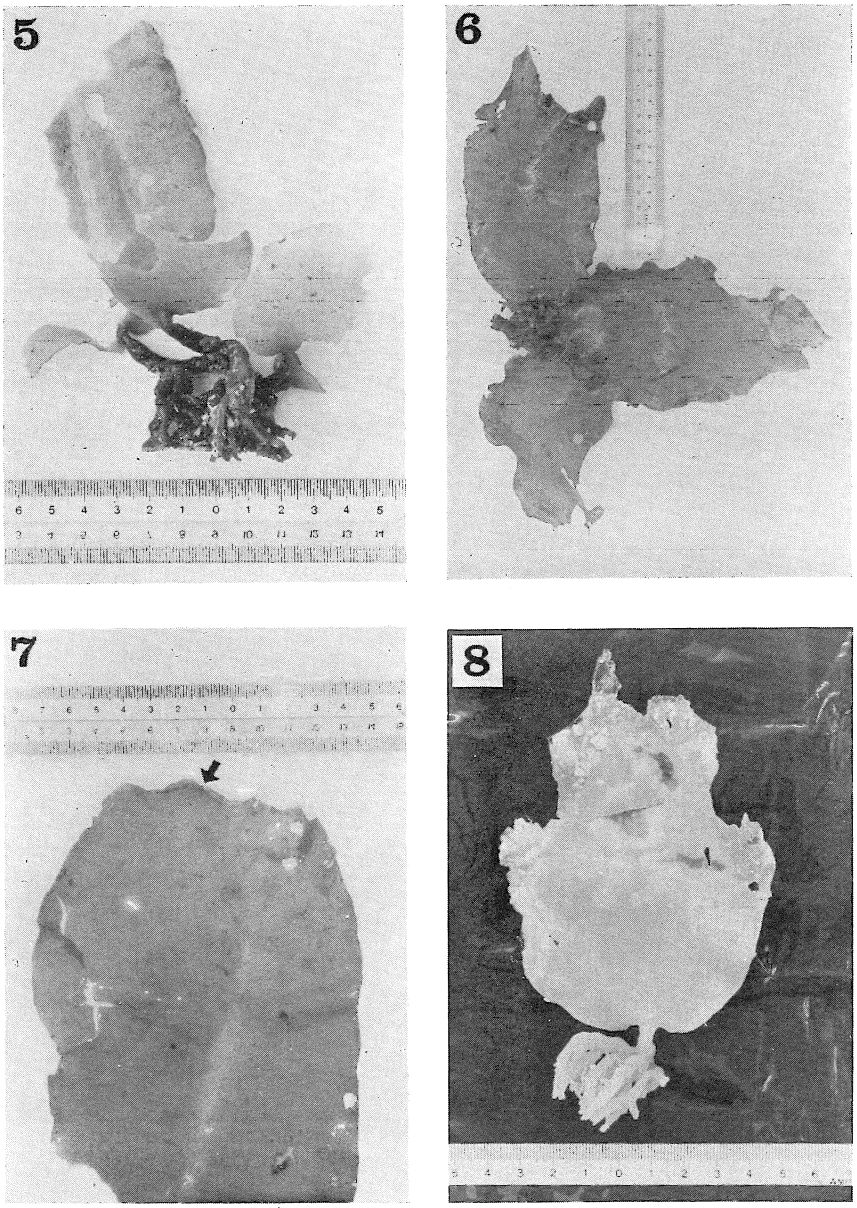
Hedophyllum(?) *kuroshioense* SEGAWA, New Laminariaceous Alg. Found Izu (1948), pp. 59–63, fig. 1.

Holdfast composed of perennial filiform, 2–9 times dichotomously branched, haptera, arising ventrally from the prostrate branch (Fig. 5). Haptera 1–6 cm long, 1–7 mm in diameter, consisting only of parenchymatous tissue with 1–5 growth-rings, but with no epidermis, medulla, nor mucilage-canal. Prostrate branch perennial, cylindrical, dichotomously branched, 1–10 cm long, 3–7 mm in diameter (Figs. 1–5), consisting of three tissues, namely, compressed medulla with hyphae, inner cortex up to ca. 330 μm thick, and outer cortex up to 3 mm in thickness, with 1–5 growth-rings and mucilage-canals in the cortex but with no epidermis. Stipe short, stout, erect, concave on the dorsal side, terete below, 2–4 mm long, 2–5 × 1–3 mm thick (Figs. 1–5, 8), consisting of three tissues, namely, compressed medulla with hyphae (Fig. 16), hyphae up to 330 μm in thickness, inner cortex up to 500 μm in thickness, outer cortex up to 500 μm thick, and epidermis 1-2-cell-layered (Fig. 15), with mucilage-canals in the cortex but lacking growth rings. Blade simple, membranous, decumbent, annual,



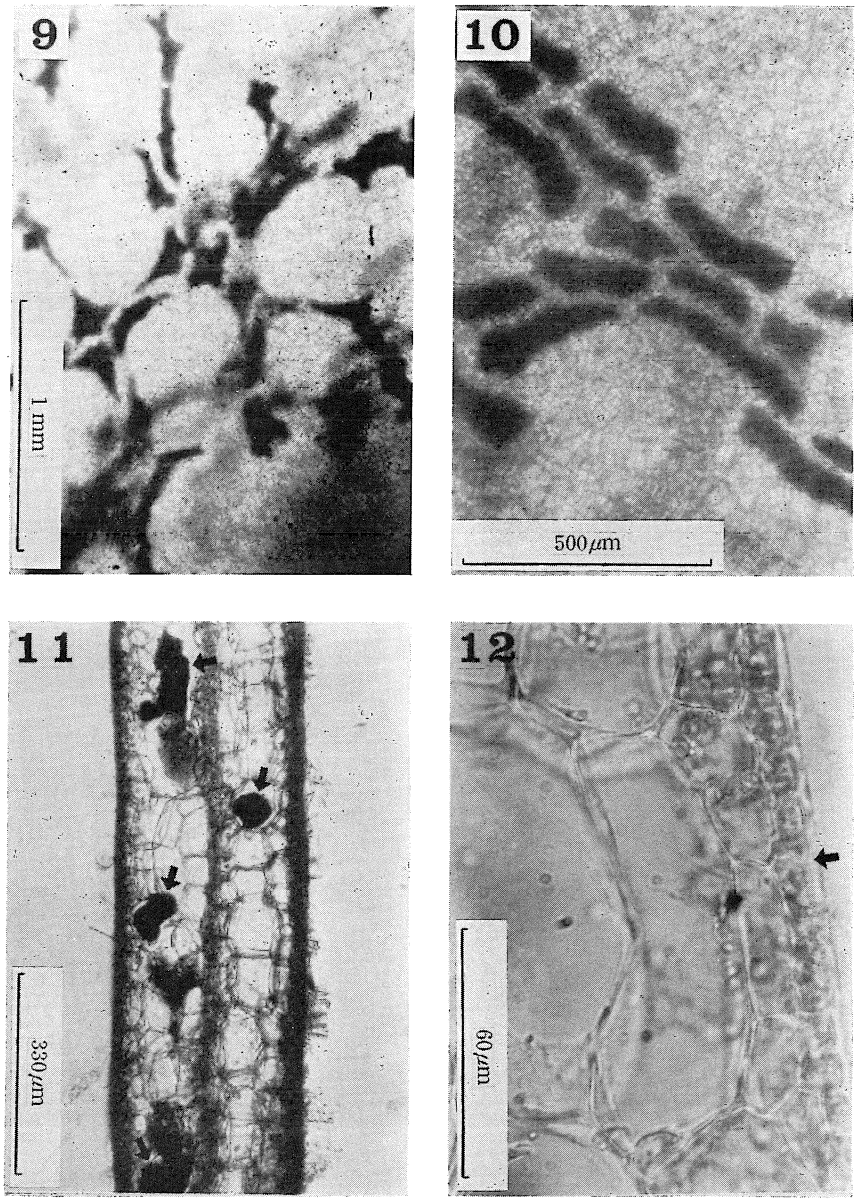
Figs. 1–4. *Streptophyllopsis kuroshioensis* (SEGAWA) comb. nov.

1–2, Fresh specimens collected from the depth of 40 m off Koike on February 7, 1979, showing the young annual blades arising singly from the terminal of the perennial, dichotomously branched prostrate branch in dorsal view; 3, Fresh specimen collected from the depth of 50 m off Chiburi Isl. on September 9, 1974, showing four annual blades arising singly from the terminal of the dichotomous prostrate branch which is covered with *Fosliella* sp. in dorsal view; 4, A sterile specimen collected from the depth of 40 m off Tsuma on July 12, 1978 and preserved in formalin-seawater for three years, showing dichotomously branched perennial prostrate branch which is bearing blades terminally in dorsal view.



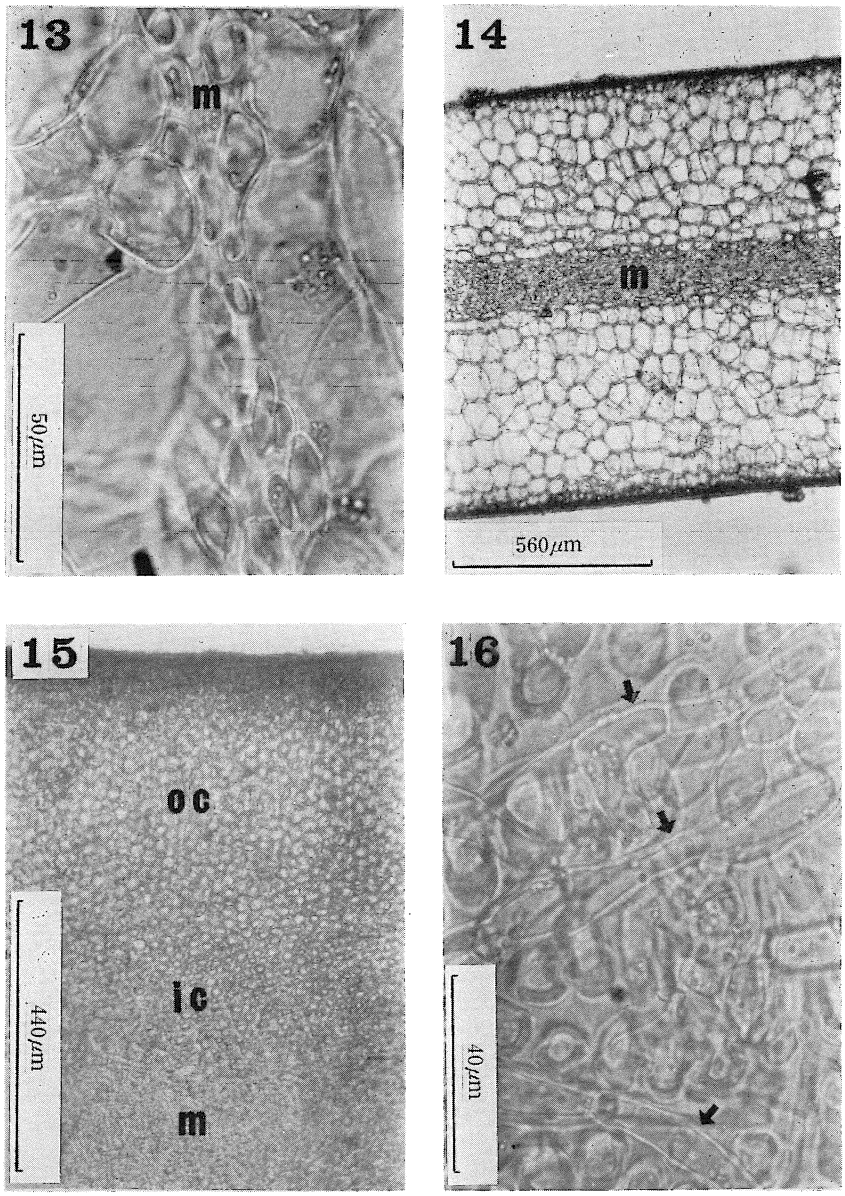
Figs. 5–8. *Streptophyllopsis kuroshioensis* (SEGAWA) comb. nov.

5, The same specimen as the one shown in Fig. 4, showing the dichotomously branched, perennial haptera arising ventrally from the prostrate branch in lateral view; 6, A sterile fresh specimen collected from the depth of 40 m off Tsudo on May 30, 1980, showing moderately developed three blades with the wavy margin in dorsal view; 7, Part of a sterile fresh specimen collected from the depth of 40 m off Tsuma on July 12, 1978, showing the double part of the margin of the blade formed terminally pointed by arrow in surface view; 8, A mature specimen collected from the depth of 40 m off Koike on November 28, 1974, preserved in formalin-seawater for seven years and bearing the sporangial sori on the both surfaces of the blade and the stipe.



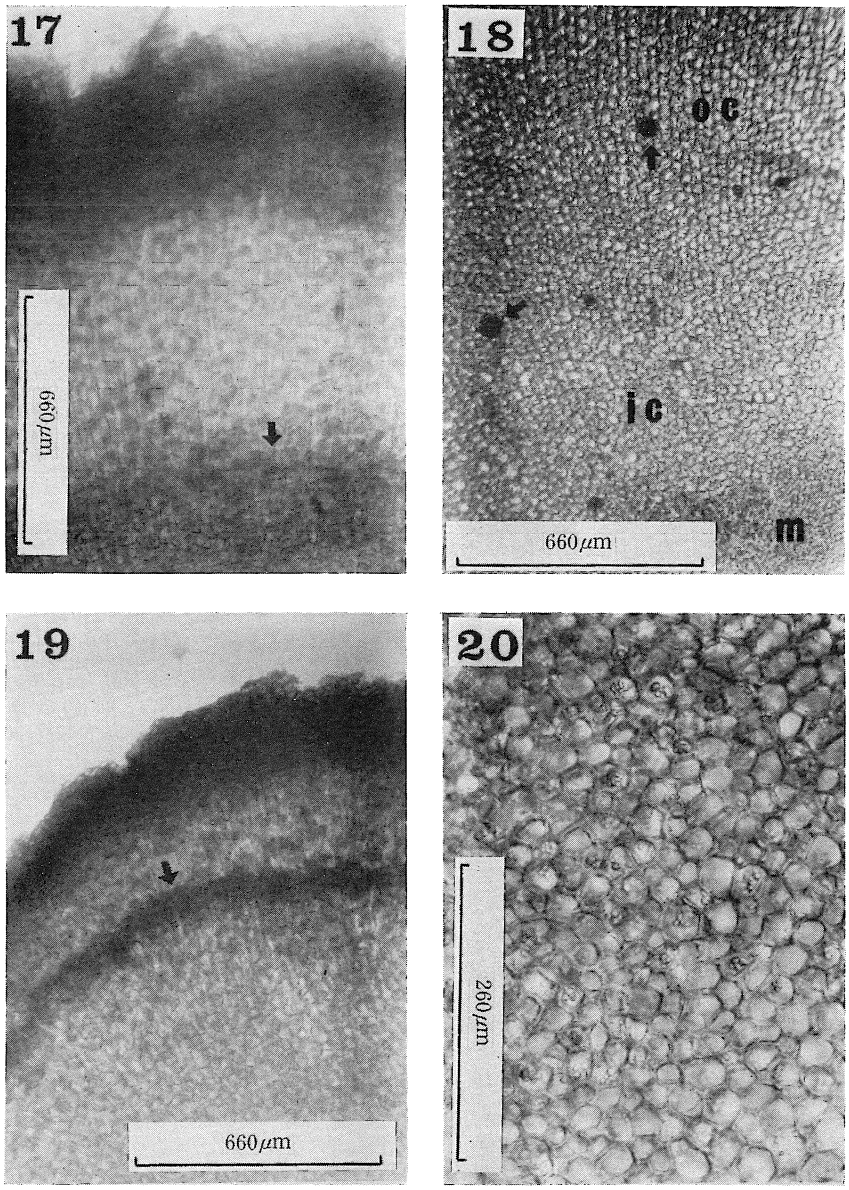
Figs. 9–12. *Streptophyllopsis kuroshioensis* (SEGAWA) comb. nov.

9–10, Parts of the sterile fresh blade, showing the mucilage-canals in surface view; 11, Transverse section of the sterile fresh blade, showing the mucilage-canals in the cortex pointed by arrow; 12, Transverse section of the upper part of the sterile fresh blade, showing a single layer of the epidermis pointed by arrow.



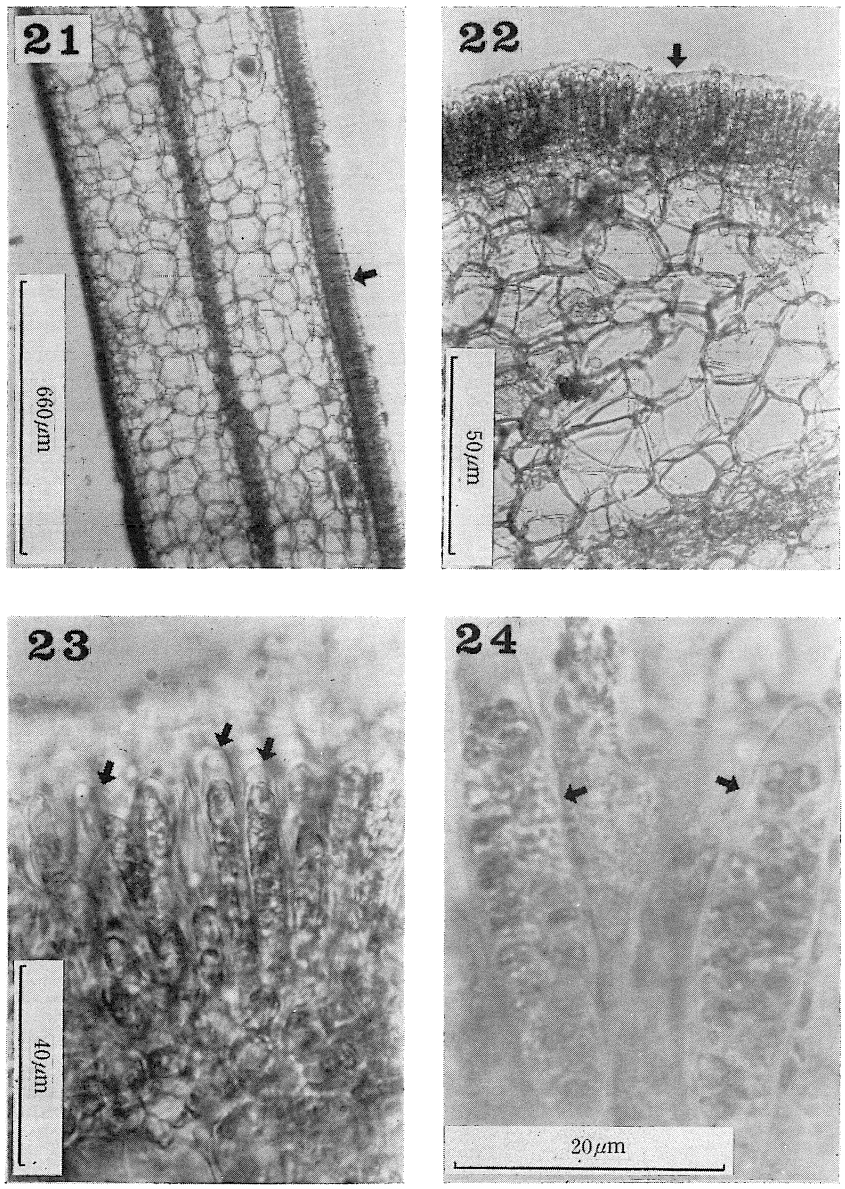
Figs. 13–16. *Streptophyllopsis kuroshioensis* (SEGAWA) comb. nov.

13, Transverse section of the upper part of a sterile fresh blade, showing the thin medulla (m); 14, Transverse section of the lower part of a sterile fresh blade, showing the thicker medulla (m) and the cortex than the ones in the upper part of it; 15, Transverse section of the sterile fresh stipe, showing the differentiation of the thick outer cortex (oc), the inner cortex (ic) and the medulla (m); 16, Transverse section of the medulla of the sterile fresh stipe, showing the hyphae pointed by arrow.



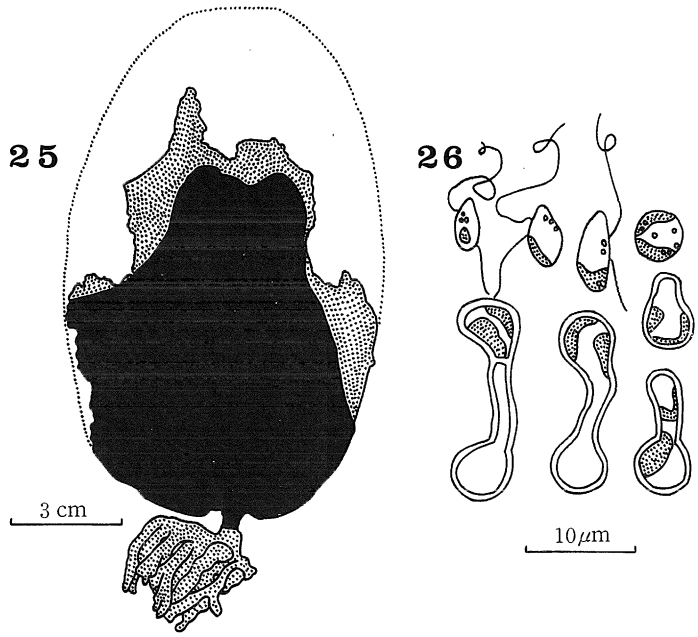
Figs. 17–20. *Streptophyllopsis kuroshioensis* (SEGAWA) comb. nov.

17, Transverse section of the prostrate branch preserved in formalin-seawater for three years, showing a growth-ring pointed by arrow; 18, Transverse section of the prostrate branch, showing the differentiation of the thick outer cortex (oc), the inner cortex (ic) and the medulla (m) as well as the mucilage-canals pointed by arrow; 19, Transverse section of the older haptera preserved in formalin-seawater for three years, showing a growth-ring pointed by arrow; 20, Transverse section of the central part of the haptera, showing the parenchymatous structure without the medulla.



Figs. 21–24. *Streptophyllopsis kuroshioensis* (SEGAWA) comb. nov.

21–22, Transverse sections of the middle part of the mature blade, showing the sporangial sorus formed on one surface of it pointed by arrow; 23–24, Transverse sections of the sporangial sorus, showing the zoosporangia pointed by arrow.



Figs. 25–26. *Streptophyllopsis kuroshioensis* (SEGAWA) comb. nov.
25, The same specimen as the one shown in Fig. 8, showing the sporangial sorus formed on the surface of the blade and the stipe by blackening; 26, Showing the three zoospores just after discharge and the four germlings at the early stage of the development exhibiting so called "mediate filamentous type".

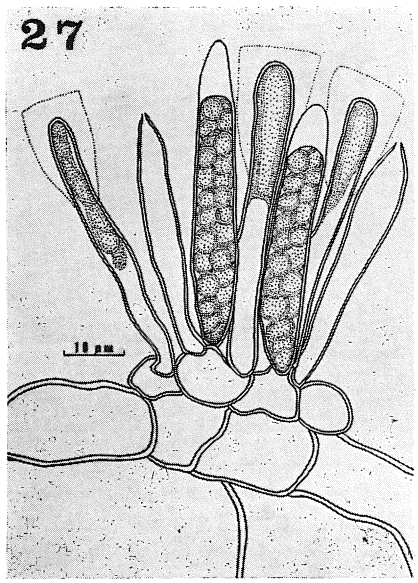


Fig. 27. *Streptophyllopsis kuroshioensis* (SEGAWA) comb. nov.
Transverse section of the sporangial sorus, showing the three paraphyses with a short mucilaginous appendage and the two zoosporangia arising from the basal layer of the sorus.

shortly stipitate, arising singly from the terminal of the prostrate branch, obovate to elliptical in shape, cordate at the base, 4–22 cm long, 3–15 cm wide (Figs. 1–6, 8), 160 μm–1.5 mm thick, slightly concave or convex, smooth in surface, with entire, wavy partially doubled (Figs. 6–7) margins. Blade gradually becomes thinner from the lower part to the terminal. Upper part of the blade consisting of three tissues, namely, epidermis single cell-layered (Fig. 12), medulla up to 13 μm thick (Fig. 13), and cortex up to 90 μm thick, with mucilage-canals (Figs. 9–11), but with no differentiation of inner cortex. Lower part of the blade consisting of three tissues, namely, epidermis 1-2-cell-layered, medulla up to 330 μm thick, and cortex up to 500 μm thick (Fig. 14), with mucilage-canals in the cortex, but with no differentiation of inner cortex. Epidermal cells of blade containing many discoid chloroplasts. Sporangial sori (Figs. 21–22, 25) formed on both surfaces of blade and stipe, composed of zoosporangia and paraphyses differentiated from epidermal cells (Fig. 27). Mature zoosporangia 40–50 × 6–10 μm (Figs. 23–24, 27). Paraphysis 5–8 × 50–55 μm with a short cuneiform mucilaginous appendage covering ca. one-thirds of the cell (Fig. 27). Discharged zoospores 3–6 × 1.5–3 μm, containing a single plastid (Fig. 26). Zoospore germination mediate filamentous type (Fig. 26). Sporophyte fruiting in late autumn, rejuvenating in winter to early spring.

Japanese name: Kuroshio-me.

Type locality: Tōji, Izu Province, Shizuoka Prefecture.

Holotype: Herbarium of Agricultural Department, Kyūshyū University.

Distribution: Izu Province, Shizuoka Prefecture and the Oki Islands, Shimane Prefecture.

Discussion

In 1948, SEGAWA described a curious Laminariaceous alga as a result of his observations on four sterile specimens collected from deep-waters off Izu Province on the Pacific coast of middle Honshū. He considered it as a possible new member of *Hedophyllum*, *H.*(?) *kuroshioense* SEGAWA. A part of SEGAWA's description is cited below to make it a basis for discussion. "In the critical examinations of the 4 specimens it seems probable that they represent the successive stages of development in this species of alga. ..... The successive stages of development were achieved as follows: the form of specimen No. 2 is believed to be an advanced stage from No. 1. The simple blade becomes broader, a slit appearing at the center, and the erosion is seen in the upper margin; from this stage the form of specimen No. 3 is derived. The two armed plant bearing secondary blades seems to be formed as the result of the activity of the transition region of the blade. At this stage two bifurcate arms are arranged almost diametrically opposite in a row. Each arm characteristically develops into two differentiated parts, the stipe of the secondary blade and its successive globular protuberance. ..... specimen No. 4 shows a part of the further developed stage of the

third. The secondary blade seems to produce two tertiary ones by the same course as in the formation of secondary blade. In the present specimen, however, the differentiation of the newly produced arm mentioned above is not shown, and two blades are arranged in bifurcation at almost right angles to each other. ..... The reason to place provisionally the present new alga under the genus *Hedophyllum* is that it has some resemblance to *H. subsessile* in the advanced stage bearing the bifurcate arms. The present plant, however, differs distinctly from the latter by having the bifurcate arms characteristically metamorphosed as shown above. Namely, *H. subsessile* has the arms which are decumbent, somewhat long, much concave. In *H. kuroshioense* such portion is very compact, metamorphosed into two parts, a short, compressed stipe and a globular protuberance. Moreover, the secondary blades of *H. subsessile* split into many segments and are much concave near the base, while in *H. kuroshioense* they are undivided and slightly concave. Though there are such distinct differences existing between these species, it seems that the general appearance of such advanced form bearing secondary arms is the same between these species."

At the beginning of the description cited above, SEGAWA gave a comment that, "In the critical examinations of the 4 specimens it seems probable that they represent the successive stages of development in this species of alga." However, that comment of him is considered apparently not practical from the data observed by the present author.

"Split" or "erosion" mentioned in SEGAWA's description could not be observed in the blade of the present author's specimens at any stage of their frond development. "Split" or "erosion" by SEGAWA is considered to be a damage of the blade given when the specimens of the present species which is characterized to have very fragile blades, are collected with a dredge.

SEGAWA described that, "The two armed plant bearing secondary blades seems to be formed as the result of the activity of the transition region of the blade." But such is also considered as non-practical because the shortly stipitate annual blade of this alga arises singly from the terminal of the dichotomously branched perennial prostrate branch, and also because no longitudinal fission was observed to be formed in "the transition region" of the present specimens.

SEGAWA described that, "two bifurcate arms are arranged almost diametrically opposite in a row." Such is considered to be identical with the straight unbranched short young prostrate branch.

SEGAWA described that, "the stipe of the secondary blade and its successive globular protuberance.". Such is considered to be identical with the stipe of the annual blade and the terminal of the prostrate branch.

SEGAWA described that, "specimen No. 4 shows a part of the further developed stage of the third. The secondary blade seems to produce two tertiary ones by the same course as in the formation of secondary blade." Such is considered also not to be practical in meaning from the same reason mentioned above.

SEGAWA remarked that, "The reason to place provisionally the present new alga under the genus *Hedophyllum* is that it has some resemblance to *H. subsessile* in the advanced stage bearing the bifurcate arms. The present plant, however, differs distinctly from the latter by having the bifurcate arms characteristically metamorphosed as shown above. Namely, *H. subsessile* has the arms which are decumbent, somewhat long, much concave. In *H. kuroshioense* such portion is very compact, metamorphosed into two parts, a short, compressed stipe and a globular protuberance. Moreover, the secondary blades of *H. subsessile* split into many segments and are much concave near the base, while in *H. kuroshioense* they are undivided and slightly concave. Though there are such distinct differences existing between these species, it seems that the general appearance of such advanced form bearing secondary arms is the same between these species." That remark of SEGAWA is also considered to be unreasonable because this alga is fundamentally different from *Hedophyllum* (SETCHELL 1901) not only in having no longitudinal fission in the blade and the transition zone between the stipe and the blade, but also in having both perennial prostrate branch with perennial haptera and annual blade.

The present alga is also considered to be different from such allied genera as *Streptophyllum* (NAGAI 1940), *Ecklonia* (in OKAMURA 1951), and *Laminaria* (LAMOUROUX 1813), at least in having both perennial prostrate branch with perennial haptera and annual blade. On the other hand, this alga has a resemblance to *Streptophyllum spirale* (YENDO) MIYABE et NAGAI in decumbent condition of its stipitate blade, so its new generic name is proposed as "*Streptophyllopsis*".

Acknowledgements

The present writer wishes to acknowledge his great indebtedness to Professor Emeritus Jun TOKIDA of Hokkaido University, for his helpful suggestions and critical reading of the manuscript, and to Dr. Hannah CROASDALE, Dartmouth College, for her kindness in critical reading and preparation of the Latin diagnosis.

References

LAMOUROUX, J. V. 1813. Essai sur les geners de la famille des thallassiophytes non articulées. Ann. du Mus. d'Hist. Naturelle par les profesesurs de cet etablissement, **20**: 21–47, 115–139, 267–293, pls. 7–13.

NAGAI, M. 1940. Marine algae of the Kurile Islands. I. Jour. Fac. Agr., Hokkaido Imp. Univ., Sapporo, **46** (1): 1–137, pls. I–III.

OKAMURA, K. 1951. Icones of Japanese Algae Vol. **III**. Kazama Shobō, Tokyo: 1–218.

SEGAWA, S. 1948. A new Laminariaceous alga found in Izu. Jour. Fac. Agr., Kyūshū Univ., **9** (1): 59–63.

SETCHELL, W. A. 1901. Notes on algae. I. Zoe, **5** (6–8): 121–129.