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HOKKAIDO UNIVERSITY
Japanese species of *Sargassum* subgenus

*Bactrophycus* (Phaeophyta, Fucales)

Tadao YOSHIDA

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This paper represents a dissertation in partial fulfilment of the degree of Doctor of Science, Hokkaido University (1983).
The genus *Sargassum*, the largest genus in the Phaeophyta with more than 400 described species, is distributed in the tropical to temperate regions of all around the world. Along the Japanese coast, the genus constitutes an important part of the marine flora, forming an extensive vegetation in shallow rocky coasts.

Our present knowledge on the taxonomy of Japanese species is largely dependent on an eminent work of YENDO (1907), entitled “the Fucaceae of Japan”. Since that time, fragmentary works were published from time to time by various authors.

Most of the species common in temperate regions of our coast are included in the subgenus *Bactrophycus* J. AGARDH. I tried to make collections and my own observations in the field, in addition to plenty herbarium specimens mainly collected by the late Prof. Y. YAMADA and housed in the herbarium of Faculty of Science, Hokkaido University (SAP), to bring about a clearer knowledge of the species concerned. Up to present, I recognized 28 species of this subgenus including the *Micracanthae* proposed by YENDO. As has been noticed that the species has its own period of reproduction.
Japanese species of *Sargassum* subgenus *Bactrophycus* restricted to a certain season of the year (Segawa et al. 1959), process of growth and reproduction in several species was followed in Oshoro, Hokkaido (Marui et al. 1981). Culture of eggs to a certain stage of development gave us a clearer understanding of the subgeneric relation in the genus. The *Bactrophycus* is known to have a wide range of diversity in the morphology of basal part of the thallus as to relations of holdfast, stem and branches, as well as reproductive structures. I propose to use these characteristics in discriminating sections and species, resulting in a recognition of 4 sections in the subgenus. Comparison of external morphology of adult thallus as well as knowledges concerning the developmental process is a major base of the present study. Informations from the other fields such as cytology and chemical constituents are obtainable only for a restricted number of species (cf. Kusumi et al. 1981), and therefore at present it is difficult to use these informations in the considerations of general classification. In this study, I did not try to recognize subspecific taxa except in *S. ringgoldianum*. Until more informations from various fields of research are available, subspecific discrimination basing on dried herbarium specimens is not convincing. For the preparation of distribution maps, I consulted only specimens deposited in SAP and SAPA, except a few cases. At the same time, efforts were made to follow a strict type method. Types were located and examined as for the taxa described by Yendo in the herbaria of Tokyo University (TI) and Faculty of Agriculture, Hokkaido University (SAPA) (Yoshida 1980). Types of the taxa described by Okamura and Yamada were examined in either TI or SAP, and I lectotypified some of them. Most of the types of the taxa described by European phycologists were also examined except those of Grunow, Greville and Harvey. By these procedure I made efforts to determine the original application of the name as far as possible.

Abbreviation for herbaria are those in ‘Index Herbariorum’ ed. 7 (1981), except for SAP (Herbarium of Faculty of Science, Hokkaido University) which is in accordance with ed. 2 (1954).

**A brief history of research on *Sargassum* of Japan**

History of taxonomic research on the genus *Sargassum* as a whole was concisely described by Yendo (1907) and Setchell (1931).

As for the Japanese species of this genus, Thunberg was the first botanist who collected specimens during his stay in Japan in 1775 and published later a short note on 3 species under the genus name *Fucus* in 1815. As the first contribution to the knowledge of Japanese *Sargassum* in a Linnean system of classification, a publication of the species of Thunberg
collection was made by Roth, who received the specimens through Mertens in Bremen, and named it as *Fucus thunbergii* Roth (1806, p. 104). Scientists in a Russian Mission, Tilesius, Langsdorff and Horner, collected many specimens from Japanese coast during a circumnavigation under the command of Captain Krusenstern on board a ship 'Nadeschda' (cf. Yoshida 1978). The collections were made mainly in Nagasaki Port in a period of about 6 months from 1804 to 1805. Those specimens were passed over to Mertens, who sent them with his provisional names to Turner and to C. Agardh. In his 'Historia Fucorum', Turner (1808-1819) gave descriptions and figures of many taxa relating to *Sargassum*, among which 16 taxa were based on the specimens of Japan and adjacent seas. Of these 16 taxa, *Fucus thunbergii* was already published by Roth, and *F. sisymbrioides, F. myagroides* and *F. langsdorfi* were the species now attributed to genera other than *Sargassum*. Types and their duplicates of Turner's taxa are now deposited in the British Museum of Natural History (BM). Certain of them were formerly kept in the Hooker herbarium in Kew Garden (K). As for *F. acinaria* $\beta$ pycnocystus, specimen was not located in BM. Although Setchell (1933 a, p. 191) supposed that the specimens not located in K at that time were lost after they were returned to Mertens, they are preserved in BM. C. Agardh also published 12 taxa in several times during 1812 to 1824, based on the specimens of Tilesius and others collected in Japan and sent from Mertens. Among the taxa of C. Agardh, 2 belong to genus other than *Sargassum*. He gave figures only for *F. swartzii* and *F. pinnatifolius*. All specimens studied by him are housed in the Botaniska Museum, University of Lund (LD, Herbarium Agardh). C. Agardh established the genus *Sargassum* in 1820, and included 62 species in the genus. Thunberg (1815) gave descriptions of 3 species of *Fucus* from Japan, but they were synonymized with the taxa of Turner. Kützing also studied the specimens from Japan constituting a part of Mertens collection which he obtained through Henschel in Breslau after the death of Mertens, and described in 1843 9 new taxa under several genera. Later he gave figures of most of them in his 'Tabulae Phycologicae' vols 10 and 11 (1860, 1861).

More than a decad later, Harvey studied the specimens collected by members of the United States North Pacific Exploring Expedition and sent by Asa Gray to him. He (1859) published 8 species of Fucales with many other new taxa. Figures to be accompanied his descriptions were recently discovered by Dawson, who published them in 1959.

Von Martens (1866) reported the botanical collection of 'Thetis' expedition. Among many new species described by him, *Anthophycus japonicus* and *Halochloa heterophylla* credited to Asian coasts have some concern
Japanese species of *Sargassum* subgenus *Bactrophyccus* 103

here. Without an accompanying figure, however, these 2 taxa were variously treated by later workers.

J. Agardh (1889, 1896) added 5 species of *Sargassum* from Japan, based on the specimens sent from Kjellman. A system of subdivision of the genus into 5 subgenera was proposed by him (1889), and this system was followed by most of recent phycologists with or without slight modification. Grunow, in his posthumous monograph (1915), treated all species in a world wide scale including also Japanese species. His collection was until now not inspected by other students of the group.

First intensive studies on the genus by Japanese phycologist were made by Yendo (1905, 1907, 1909). In his excellent work, Yendo (1907) described 7 new species along with a revision of the species of earlier phycologists, based on the specimens of his own collection (TI) and those in Miyabe herbarium (SAPA). This work was made before he visited European herbaria, and regrettably he did not publish his comments on important specimens of the group concerned, although he made annotations on herbarium sheets.

In his 'Icones of Japanese Algae', Okamura (1923-1925) gave excellent illustrations for many species of the genus. Setchell (1931-1936), in his treatment of Hong Kong Seaweeds, presented many discussions which are relevant to the species distributing also in Japan. More recent works of Yamada (1942, 1944), though centered his chief attention to the subgenus *Sargassum* (=Eusargassum), added 2 taxa of the *Bactrophyccus*, along with 8 new species and new records belonging to other subgenera. He described with Segi (1948) a new species *S. racemosum* (=S. segii), and later *S. sagamianum* var. *yezoense* from Hokkaido (in Yamada & Kinoshita 1950). He visited many European herbaria and inspected important collections, but did not publish the results except a fragmentary note on the herbarium of Thunberg (1955).

Sawada (1955, 1956), Kawashima (1963) and Ogawa (1977) added new knowledges to a certain species. Yoshida (1978 a) made clear a synonymous relation of *S. kjellmanianum* and *S. miyabei*. He (1980) designated the types of the taxa described by Yendo and settled the application of names. Recently, 3 new species of the *Bactrophyccus* were proposed by himself and Konno (Konno & Yoshida 1982, Yoshida & Konno 1983).

On the other hand, Tahara (1909-1941) and Inoh (1930-1947) made morphological studies on many species giving us a clearer understanding of the group concerned. Process of development of conceptacle gives us a clue to consider the relationship among the subgenera, and among other characters, division mode of rhizoid cell and embryonal development have some
meanings at generic level in the Fucales. Observations on the development of eggs to mature plants were made by Terawaki et al. (1982, 1983). Apical organization of the stem was studied by Yoshida et al. (1983). Cytological informations on chromosome numbers were obtained in several species (Ogawa et al. 1969).

**General discussion on the subgenus Bactrophycus**

*The subgenus Bactrophycus and its relation to the other subgenera*

An early development of the thallus is summarized as follows. Liberated eggs are fertilized and begin to develop while they are retained in the mucilaginous substance surrounding the receptacle. Young germlings develop 8 or 16 primary rhizoids according to the species. After attaching to the substratum, the germling elongates to become an upright terete body. At this stage, cryptostomata begin to differentiate in some species. The upper part flattened as they grow longer. This flattened part can be called as

![Diagram of thallus construction](image-url)

**Fig. 1.** Schematic representation showing types of thallus construction. A, section *Spongocarpus*. B, sections *Halochloa* and *Teretia*. C, section *Repentia*. b, lateral branch; h, holdfast; l, leaf; m, main branch; r, receptacle; v, vesicle.
Japanese species of *Sargassum* subgenus *Bactrophycus*

first "cauline leaf" or "primary leaf" (Terawaki et al. 1982). In case of *Cystoseira*, this is called primary frond by Fritsch (1945). The elongation of the first cauline leaf is caused by the differentiation of an apical cell. But this apical cell soon ceases to grow further. Another apical cell differentiates laterally some distance from the base. This newly formed one establishes the growing point of a "stem" (Fig. 1, s) or a "main axis" (Jensen 1974), and continues to be active in whole life of the shoot. The apical cell situates in the bottom of an apical depression, and is always triangular in cross section and lenticular in longitudinal section (Yoshida et al. 1983). Those of lateral formation are differentiated while they are inside the apical depression. The cauline leaf becomes obliquely directed as the apex of the stem differentiates. The second cauline leaf is formed nearly opposite direction to the first. As the stem grows, successive cauline leaves are formed with a divergence of phyllotaxis converging to 2/5, spreading always horizontally. The first cauline leaf is simple with entire margin in the species observed up to date. Later formed ones show a morphology characteristic to the species as to the serration on the margin or presence of midrib. The cauline leaves are always simple in the species of the *Bactrophycus* so far observed. While in other subgenera, they often become pinnatilobed (Terawaki et al. 1982, 1983). Up to this stage of development, there is a close similarity between the species of *Sargassum* and those of *Cystoseira* (Oltmanns 1922). Differences according to the group or species become apparent in later stages. After a period of formation of cauline leaves, lateral formations on the stem change their morphology to those called here "main branches" (Fig. 1, m). The main branch is defined as a lateral formation from the stem without a subtending leaf and gives rise to leaves, lateral branches, vesicles and receptacles. In this respect, the main branch differs from other lateral formations in that they arise from the axil of subtending leaves. Once the main branches appear, no cauline leaf is formed any more. In perennial species, the stem continues to grow slowly, may or may not branch, issuing annually several main branches which fall off after maturation period and leave knotty appearance on the stem. The main branch grows much longer than the stem (Fig. 1, B, C). In this respect, *S. horneri* and *S. filicinum* are quite different from all other species of the genus. In these 2 species, the stem continues to elongate and lateral formations always arise in axils of leaves (Fig. 1 A). So it can be said that these 2 species have no main branch, as defined here, and produce cauline leaves until the apex changes into receptacle. Differentiation at subgeneric level becomes apparent from a stage when leaves are formed on the main branch.

Agardhian system of subdivision of the genus *Sargassum* into 5 subgenera
must be taken as a starting point of discussion on the grouping at sub-generic levels. J. Agardh (1889) used as a main characteristic for the sub-division of the genus morphogenetic relations of stem and leaf. In the subgenera Phyllotrichia and Schizophycus, main branches emerge as foliar expansions, according to J. Agardh. As a matter of fact, cauline leaves and main branches are distinct structures as shown by Terawaki et al. (1982). Early stages of development of the main branch in the species of the subgenus Sargassum (=Eusargassum) are very similar to those of the Phyllotrichia and the Schizophycus (Terawaki et al. 1982, 1983, 1983a, 1983b). J. Agardh considered that the subgenus Sargassum had “true horizontal leaves”. But observations on some Japanese representatives show that the species belong to the subgenus Sargassum develop their leaves as vertically flattened primordia, and always expand in a plane same as the flattening of the main branch. Whereas the species of the Bactrophycus issue their leaves as a horizontally expanding structure, that is to say at right angles to the branch on which they are borne, at least several leaves first formed on the main branch. In this respect, the Arthrophycus shows the same feature as for the plane of expansion of the lower leaf, though there is few data on the early development of the thallus in this subgenus.

It can be safe to divide the species of Sargassum into 2 groups by the plane of expansion of leaf:

With only vertical leaves—Phyllotrichia, Schizophycus and Sargassum (subgenus, =Eusargassum)
With horizontal leaves (at least lower one)—Bactrophycus and Arthrophycus

Distinction between the Bactrophycus and the Arthrophycus seems to be rather difficult. J. Agardh (1889, p. 33) defined that the Bactrophycus had receptacles “simplicia siliquaeformia et inermia” and the Arthrophycus “plus minus composita, demum in ramulo axillari racemosa aut rarius sub-cymosa, nunc teretiuscula et saepe inermia, nunc angulata et saepe dentibus armata”. As shown in the following enumeration of species, receptacles in Japanese species are not only siliquaeform, but also of rather divergent features. Until much comparative studies are made, I simply place all species with horizontally expanding leaves distributed in the northern hemisphere in the Bactrophycus and those of the southern hemisphere in the Arthrophycus.

Previously, Segi (1948) assumed that his S. racemosum (=S. segii) was a species of the Arthrophycus. I treat it in the Bactrophycus because of the reason stated above. Though Setchell (1933) included his S. macclurei and S. herklotsii in the Arthrophycus, I prefer to include them also in the Bactrophycus.
Japanese species of *Sargassum* subgenus *Bactrophycus*

The subgenus *Sargassum* (=*Eusargassum*) has compound receptacles often with spinal processes and leaves well differentiated than those of the *Phyllotrichia* and the *Schizophycus*. Womersley (1954) discussed that the distinction between the *Phyllotrichia* and the *Schizophycus* could not be maintained at subgeneric level.

**Morphological characters used to distinguish the species in the subgenus Bactrophycus**

**Basal morphology**

Holdfast is at first formed by primary rhizoids issued from the bottom of germinating embryo, then the secondary rhizoids develop to contribute the construction of the holdfast. As the stem grows in length, the holdfast increases in size. In annual species, the holdfast becomes established its full aspect in a few months. In perennial species, characteristic features of the holdfast are completed after one or two years of growth. Morphology of basal part including holdfast and stem vary considerably according to the species especially in the *Bactrophycus*, where the basal morphology falls into several types. The holdfast can be called as “disc shaped” when it is round in outline and is rather flat, elevation is less in comparison with its diameter. A single stem arises from a discoid holdfast. It is “conical” when the elevation is rather high. When it grows bigger by the activity of its meristoderm, lower part of the stem is buried in it, resulting in an appearance that several stems arising from a conical holdfast, because of overgrowth to the branching of the stem. In such species as *S. horneri* and *S. fulvellum*, filamentous or finger-like projections from the lower part of the stem are formed radiately and later they fuse with each other to form a disc, leaving radiating furrows on the surface (Fig. 6 B). This state of holdfast is called as “scutellate”. The filamentous outgrowths are variously developed according to the species. In *S. miyabei*, development of filamentous outgrowths is rather restricted in length (Fig. 36 A, B), while in *S. hemiphyllum* (Fig. 30 B) and *S. nipponicum* (Fig. 33 A), the filaments develop well and no coagulation occurs between them. Thick filamentous outgrowths are formed in *S. ammophilum*. These filaments fuse with each other to form a flat disc (Konno & Yoshida 1982, figs. 2–4). In such species with a prostrate stem as *S. okamurae* (Fig. 86 A) and *S. yezoense* (Fig. 92), secondary attaching discs are formed on the ventral surface of the stem. They grow in size and can fuse with each other forming an irregularly shaped disc.

Among the 5 subgenera proposed by J. Agardh, the subgenera *Phyllotrichia*, *Schizophycus* and *Sargassum* have similar basal morphology. From a disc shaped holdfast, an upright stem is located in the center, and later
secondary shoots are formed on the surface. The stem is rather short in length and without branching. Several flat main branches are issued spirally at the distal part of the stem. This type of basal part is similar to that encountered in the species of the *Bactrophycus* such as *S. muticum* except that the main branches are angular in the latter. As far as I know from inspection of Agardhian herbarium, the species of the *Arthrophycus* have a type of basal morphology similar to that met with in *S. siliquastrum*, *i.e.*, the abbreviated stem is upright and branches several times.

Maximum length of the thallus is rather variable according to the habitat. A species may be smaller in a habitat of shallow water or exposed to strong wave action, and may become longer in calm subtidal zone with swift tidal current. But a maximum of growth is of some taxonomic value.

In such species as *S. nigrifolium* and *S. okamurae*, the length of thallus always less than 1 m, usually around 0.5 m. Most of the species in this group have thalli 1 to several meters long. *S. horneri* and *S. filicinum* can grow to a length more than 10 m.

**Main Branch**

As defined earlier, the main branch is lateral formations from the stem without a subtending leaf and issues leaves and lateral branches arising in axil of the leaf. The main branches are issued spirally or alternately in one plane, or on dorsal side of the stem if it has dorsiventral tendency to prostrate state. The main branch may be terete or angular with longitudinal furrows, triquetrous with sharp or round edges, or ancipitous with longitudinal costal elevation in the middle part and thinner marginal regions. There are spinal processes on the surface or edges of the main branch as well as on the stem or petiole of some species (Fig. 2). The spinal processes may be

![Fig. 2. Various types of main branch. A, triquetrous with smooth margin. B, ancipitous with obtuse spinal projections. C, ancipitous with acute spines. D, angulate with spines.](image-url)
simple with or without acute apex or may forked. In some cases, the spines are deciduous.

Leaf

Leaves are here defined as filiform or foliose appendages issued on the branch. Some authors prefer a term “phyllode”. Here I use the term “leaf” as an analogy to the higher vascular plant.

The leaf is always simple in the Bactrophycus (Fig. 3). Outlines of the leaf vary from broad elliptical to filiform (Fig. 3F) with an acute or obtuse apex. The leaf has cuneate or abrupt base. It is clearly stipitate or its basal part is decurrent to ancipitous stipe. Retroflexy, that means downward direction of the stipe, is conspicuous in certain species. Size also varies from minute filamentous structure to that 20 cm or more in length and 2 cm or more in width. Leaf margin is entire in several species (Fig. 3 A, G). Various grades of dissection from minute dentation to pinnatissection can be observed even in one individual (Fig. 3 B–E). Irregular incision also encountered rarely. One extreme is those skeletonized to a state with filiform midrib and alter-

nately disposed filiform pinnae as is seen in *S. trichophyllum* (Fig. 3 E). Presence of a midrib has some diagnostic value. Texture of the leaf can be expressed as papyraceous in thinner leaf to coriaceous in other extreme. Cryptostomata are rather common occurrence. In the species with thinner leaves, they are easily recognized even by the naked eye. However, their frequency is variable even in an individual. In the species with thick coriaceous leaves, they are difficult to discern with the naked eye.

Disposition of leaves on the branch is always spiral. Divergence of phyllotaxis varies according to species, in relation to morphology of branch. An ancipitous branch issues leaves alternately, and this is expressed as a phyllotaxis 1/2. A triquetrous branch bears its leaves in 120° divergence, *i.e.*, phyllotaxis 1/3. Phyllotaxis is 2/5, when the branch is terete or angulate. Divergence may change in a branch.

Leaves spread horizontally at least those formed in the basal part of the main branch. In several species, leaves turned to spread vertically in the upper part of the branch.

Vesicle

As a vesicle is usually formed by a transformation of lower part of a leaf, it has a coronal leaf on its apex and is shortly stipitate (Fig. 4 A–E). Coronal leaves vary from a small mucro to longer one similar to ordinally leaves on the branch. They are often petiolated, while in some species, the coronal leaf extends downwards to form wings along the vesicle (Fig. 4 C). There are several species with muticous vesicles (Fig. 4 F). The vesicle is usually single, although seriate vesicles were reported in certain population of *S. thunbergii*.

![Fig. 4. Variation in vesicle morphology. A, terete with coronal leaf. B, elliptical with coronal leaf. C, elliptical with coronal leaf running down to form wings. D, elliptical with filiform coronal leaf. E, fusiform with mucro. F, spherical without mucro.](image)

Receptacle

Receptacles are terminal portion of a branch, bearing numerous embed-
Japanese species of *Sargassum* subgenus *Bactrophycus*

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ded conceptacles, and are usually simple in external form in this subgenus. They are terete (Fig. 5A, B), or compressed, foliose or triquetrous (Fig. 5C–I). Size varies according to the species. Proliferation of small vesicle and receptacle on the surface of larger receptacle is often encountered on terete receptacles. Degree of flatness also varies. In several species, receptacles have serrulate or denticulate margin (Fig. 5G, I). Forking of receptacle is also of rare occurrence (Fig. 5F).

![Diagram of receptacle morphology](image)

**Fig. 5.** Variation in receptacle morphology. A, B, terete. C-E, compressed. F, forked. G, I, armed with spines. H, triquetrous.

Receptacles are with or without subtending leaf. Those formed on terminal end of the branchlet are often devoid of leaf. Disposition of receptacles in the distal part of the branches is racemose or paniculate in most species. An axis of a raceme or a panicle may elongate or abbreviate.

**Sexuality**

Most of the species of this subgenus are dioecious in sexuality. Male receptacle is usually longer and slenderer than the female one. Monoecious species are few in number, whereas monoecism is often recorded in the subgenus *Sargassum*.

As shown by Sawada (1958), sexual expression is variable in *S. filicinum* where androgynous state is common, but certain individuals have androgynous and male receptacles (andromonoecious). *S. muticum* and *S. tenuifolium* have androgynous receptacles. *S. yezoense* is usually dioecious. Ogawa (1977) reported the presence of monoecious population in this species.

**Maturation period**

Production of receptacles and liberation of reproductive bodies are restricted to a certain season of a year. Table 1 summarizes the data obtained during this study. Difference in maturation period has a certain diagnostic meaning because it implies a sexual isolation. In the species with wide distributional range, maturation is earlier in southern districts and later in northern locality.
Table 1. Maturation period of the species of the *Bactrophycus*

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Japanese species of *Sargassum* subgenus *Bactrophycus*

**Subdivision of the subgenus Bactrophycus**

Species of the *Bactrophycus* can be divided into 3 groups by their basal morphology. One group is those with elongated erect stem. Here the stem grows rapidly and produces leaves until the apex is transformed to receptacle or damaged. Lateral branches always arise in axils of leaves and usually shorter in length than the stem. Therefore there is no main branch as defined above. In this group receptacles are terete. This group is represented by *S. horneri* and called as the section *Spongocarpus*, reviving the genus name of Kützing.

Second group has more or less abbreviated erect stem, which is either unbranched or branched. Main branches arise from the terminal part of the stem. They are acipititous, triquetrous or angulate, issuing leaves and axillary laterals. This group can be subdivided by the shape of receptacles whether they are terete or not. In some species male receptacles are only slightly compressed, although female ones are more conspicuously flattened. Subdivided group with terete receptacle is named here as the section *Teretia*. For the rest with flattened or rarely triquetrous receptacles, the name, section *Halochloa*, can be used.

The species with decumbent or procumbent stem constitute the remainder of the subgenus. In these species, the stem issues on its ventral side secondary attaching discs which in some species fuse to form an irregular shaped holdfast. The name, section *Repentia*, is given for this group.

They can be summarized by following key:

1. Stem upright throughout the life .................. 2
2. Stem elongated, no main branch formed. Section *Spongocarpus*
3. Receptacle terete .................. Section *Teretia*
4. Receptacle complanated or triquetrous ....... Section *Halochloa*

**Key to the Japanese species of the subgenus Bactrophycus**

1. Stem elongate, main branch absent, branches always arising in axil of subtending leaf (Section *Spongocarpus*) .................. 2
2. Stem more or less abbreviated, main branches elongated, arising without subtending leaf .................. 3
3. Vesicle cylindrical, dioecious .................. 1. *S. horneri*
4. Vesicle spherical to elliptical, monoecious 2. *S. filicinum*
5. Stem upright, branched or unbranched .................. 4
3. Stem prostrate, branched, forming secondary attaching discs on ventral surface (Section Repentia) .......... 26
4. Receptacle terete (Section Teretia) ................. 5
4. Receptacle compressed, flat or triquetrous (Section Halochloa) 14
5. Stem unbranched, attaining 10 cm or more in several years, main branches issued alternately in one plane ................. 6
5. Stem abbreviated, branched or unbranched, usually less than 3-4 cm, main branches issued spirally in most species .......... 8
6. Leaf filiform throughout the branch .......... 3. S. microceratum
6. Lower leaf broad, elliptical to lanceolate .......... 7
7. Main branch usually armed with spines, leaf coriaceous in texture, vesicle smaller, less than 5 mm in diameter .......... 4. S. confusum
7. Main branch without spines, leaf papyraceous in texture, vesicle larger, up to 10 mm in diameter ................. 5. S. pallidum
8. Holdfast discoid .......... 9
8. Holdfast scutellate or with filamentous outgrowths .......... 10
10. Holdfast with filamentous outgrowths .......... 11
11. Creeping filamentous outgrowths thick, 2 mm in diameter, fused to form a flat disc .......... 9. S. ammophilum
11. Creeping filamentous outgrowths thin, less than 1 mm in diameter, free from each other .......... 12
12. Lower leaf hemiphylous without midrib .......... 10. S. hemiphyllum
12. Lower leaf not hemiphylous .......... 13
13. Creeping filament well developed .......... 11. S. nipponicum
13. Creeping filament short in length, less than 1 cm .......... 12. S. miyabei
14. Stem abbreviated, unbranched, usually less than 1 cm in length 15
14. Stem branched once to several times, usually attaining more than 10 cm long .......... 17
15. Leaf ovate to lanceolate with entire margin, coriaceous in texture .......... 13. S. segii
15. Leaf lanceolate to linear with more or less dentate or incised margin, papyraceous in texture .......... 16
16. Receptacle spatulate with spinal processes on the margin, monoecious .......... 15. S. tenuifolium
17. Leaf lanceolate to linear with entire margin .......... 18
17. Leaf in the middle part of the branch with more or less serrate margin 19
18. Receptacle foliose. 16. S. ringgoldianum subsp. ringgoldianum
18. Receptacle oblanceolate to linear 16 a. S. ringgoldianum subsp. coreanum
19. Receptacle (at least female one) often triquetrous 20
19. Receptacle spatulate to oblanceolate 21
20. Upper leaf skeletonized to filiform midrib and filiform pinnae, receptacle armed with spinal processes 17. S. trichophyllum
20. Leaf with serrate margin, receptacle without spinal process 18. S. sagamianum
21. Receptacle formed in abbreviated panicle 22
21. Receptacle formed as more or less elongated raceme 23
22. Receptacle spatulate, often with dentate margin or apex, leaf pinnatisected 19. S. micracanthum
22. Receptacle linear with smooth margin, leaf larger, with serrate margin 20. S. giganteifolium
23. Main branch armed with obtuse processes on the margin, phyllotaxis 1/2 in the lower part of main branch 21. S. macrocarpum
23. Main branch usually with smooth margin, sometimes with acute spines on the edge 24
24. Lower leaf ovate to lanceolate with entire margin, maturation in spring to early summer 25
24. Leaves narrow lanceolate to linear with serrate margin, maturation in autumn to winter 22. S. autunnale
25. Leaf coriaceous in texture, upper leaf deeply serrate to midrib 23. S. siliquastrum
25. Leaf membraneous to papyraceous in texture, serration not reaching to midrib 24. S. serratifolium
26. Lower leaf ovate or linear, with entire margin 27
26. Lower leaf lanceolate, with serrate or dentate margin 28
27. Leaf linear, receptacle flat clavate, often forked 25. S. okamurae
27. Leaf ovate, receptacle spatulate, often with serrate margin 26. S. nigrifolium
28. Lower leaf not retroflexed, branches triangular with round edges 27. S. yezoense
Description of the species

*Sargassum* C. Agardh, Spec. Alg. 1: 1. 1820, nom. cons.

LT: *S. bacciferum* (Turner) C. Agardh, typ. cons. (*=Fucus bacciferus* Turner)

Subgenus *Bactrophycus* J. Agardh, 1889: 33, 57.

LT: *S. horneri* (Turner) C. Agardh (*=F. horneri* Turner)

Leaves on the lower part of a main branch spreading horizontally. Receptacles usually simple. Distribution in the Northern Hemisphere.

The type species had not been designated to the *Bactrophycus* by J. Agardh. His original characterization of this subgenus includes the possession of siliquaeform unarmed simple receptacles. This fits best to the receptacle of *S. horneri* (Fig. 5 A). In almost all enumeration of the species, *S. horneri* is treated in the first place. By these reasons, it is appropriate to designate this species as the lectotype of the subgenus *Bactrophycus*.

Section *Spongocarpus* (Kützing) Yoshida, stat. nov.

Basionym: *Spongocarpus* Kützing 1843: 55.

LT: *S. horneri* (Turner) C. Agardh.

Stem erect, elongated, branches always arising in axils of leaves and shorter in length than the stem, receptacle terete, siliquaeform.

1. *Sargassum horneri* (Turner) C. Agardh 1820: 38. (Figs. 6–8)


Fucus horneri Turner 1808: 34, pl. 17. C. Agardh 1815: 48. Lectotype: BM (K) “In the straits of Corea, Dr. Horner” (Fig. 7 A).


*Sargassum spatulatum* J. Agardh 1889: 58; 1896: 50. Lectotype: LD (Herb. Agardh No. 2877 “Japan, C. Wright”) (Fig. 7 D).


*Sargassum polyodonthum* J. Agardh 1896: 50. Lectotype: LD (Herb. Agardh No. 2880 “Goto, Japan, Januari 1883, Petersen”) (Fig. 7 C).

Fucus horneri var. denseramosus C. Agardh 1815: 48.

*Sargassum horneri* var. *densum* C. Agardh 1830: 38. Lectotype: LD (Herb. Agardh No. 2867 “e mari japoniae, Tilesius”) (Fig. 7 E).


S. bacciferum (Turner) C. Agardh, nom. cons.

S. horneri (Turner) C. Agardh, typo cons. (*=Fucus horneri* Turner)
Japanese species of *Sargassum* subgenus *Bactrophycus*

Fig. 6. *Sargassum horneri* (TURNER) C. AGARDH. A, terminal part of female plant with receptacle. B, basal part with scutellate holdfast and a stem. C, terminal part of male plant with receptacle.

*Sargassum horneri* f. *minus-dentatum* GRUNOW 1915: 341. Type not located “ad oras orientales Japoniae”.

Japanese name: Aka-moku.

Thallus often reaching several meters high. Holdfast scutellate disks up to 3 cm in diameter, constructed by radiating protuberances from the basal part of the stem (Fig. 6 B). A single stem arising on top of the holdfast, unbranched, angulate with longitudinal furrows, 3-5 mm wide. Many spinal processes, simple or forked, 1-2 mm long, ornamenting the stem surface and petiole of lower leaf. Spines torn off later. Branches always formed in axil of subtending leaf which soon dropped off. Lower leaf lanceolate to linear in shape with obtuse apex, 7 cm long and 1.5 cm wide, more or less conspicuously pinnatisected with rounded sini. The sini often reaching the
percurent midrib. Segments of pinnatisected leaf directed slightly upward, truncated or dentate at the apices, or sometimes narrow segments once or twice digitately or dichotomously divided. The lower leaf weakly retroversed at the insertion to the stem, with petiole slightly dilate to stipule-like expansion at the base. Leaf on the upper part of the branch becoming narrower, often deeply alternato-pinnatisected and the segments almost filiform and ascending. Leaves delicate membranaceous in substance. Cryptostome absent. Vesicle terete, 1-1.5 cm long and 2-3 mm in diameter, ending downward to a short stipe and upward to a sessile or petiolated simple serrated or pinnatisected coronal leaf.

The plant dioecious. Receptacle terete, shortly stipitate, tapering upward. Female receptacle 2-3 cm long and 3 mm in diameter. Male one 4-7 cm long and 2 mm in diameter, often slightly curved. Receptacle formed at first terminally on branchlet, and later smaller ones arising in basipetal order resulting in a raceme. Maturation in winter to early spring in the southern part of its distribution, and in summer in northern extreme.

This species grows in the subtidal zone. An annual species.

Japanese species of Sargassum subgenus Bactrophycus


I

Japanese species of Sargassum subgenus Ractrohycus

Fig. 8. Distribution of Sargassum homeri compiled from the specimens in SAP.


KOREA: Cheju Island, Apr. 25, 1974, leg. I. K. LEE, SAP 034606; Pusan, Mar. 12, 1935, leg. M. NODA, SAP 043896; Shimpo, Jan. 1901, leg. H. KATO, SAP Herb. OKAMURA.

This species is one of the most common species around Japan. Although dioecism is usually confirmed for this species, OKUDA (1979) reported monoecious individuals collected at Tsuyazaki, Fukuoka Pref. Male conceptacles occupied proximal part of a receptacle. Hermaphrodite conceptacles were also observed.

The lectotype (Fig. 7 A) is a fragment of male individual, now deposited in BM (K). TURNER’s illustration (Fig. 7 B), somewhat different from the type specimen, is sufficient to identify our plant to this species. Its elongated stem, pinnatisected leaf, cylindrical vesicle and big receptacles are quite distinct in the genus. An only resembling species is S. filicinum HARVEY, which is easily discriminated by its spherical to elliptical vesicle and monoecism. Size and form of leaf are very variable. Even when compared the basal leaves of young stem, one extreme is that the leaf pinnatisected deeply to midrib throughout the whole length, and the pinnae are narrowly linear, once or twice dichotomously or digitately divided. This type of leaf is clearly seen in the lectotype of S. polyodonthum J. AGARDH (Fig. 7 C) and S. horneri f. furcatodentatum KUNTZE (1880, pl. 2, f. 25). Other extreme is those
with shallowly pinnatisected leaf often encountered in the population from Pacific coast of Honshu. This state is represented by the lectotype of *S. spathulatum* J. AGARDH (Fig. 7 D) and figures given by YENDO (1907, pl. 10, f. 1) and OKAMURA (1923, pl. 202, f. 1). Subspecific distinction basing on the leaf form needs further study.

*S. horneri* var. *densum* C. AGARDH is lectotypified by a specimen (Fig. 7 E), which is a terminal part of an individual with very narrow leaves. As for *S. horneri* f. *minus-dentata* of GRUNOW, I cannot make any comment until the specimen is examined.

2. *Sargassum filicinum* Harvey 1859: 327. (Figs. 9–10)


*Sargassum fengeri* J. AGARDH 1889: 58. DE TONI 1895: 21. Lectotype: LD (Herb. Agardh No. 2874 “Ad insulam extra ostia Amuris, leg. Navarsha FENGER 1868”) (Fig. 9 C).

Japanese name: Shida-moku (YENDO)

Thallus usually attaining several meters high. Holdfast scutellate, up to 2 cm in diameter, constructed by radiating finger-like protuberances growing out from the basal part of the stem. Stem simple, upright, 5 mm wide, angular with shallow longitudinal furrows, ornamented with spinal processes, simple or once forked, about 1 mm long. Spines deciduous. Lateral branches always arising in axil of subtending leaves, shorter in length than the stem. Leaf spirally disposed with 2/5 divergence of phyllotaxis, slightly retroflexed at the base, linear lanceolate in outline with obtuse apex, 7 cm long and 1 cm wide, alternately pinnately dissected, with the sini being round and deep to the midrib. Segments of pinnatisected leaf ascending, sometimes shallowly dentate at apices. Midrib slightly elevated and sharply defined, vanishing near the apex. Cryptostome absent. Vesicle spherical to fusiform in shape, 3–4 mm in diameter, shortly stipitate, with coronal leaf similar to leaves on the stem.

Plant monoecious. Receptacle terete, 2–4 cm long and 2–4 mm in diameter according to sexual condition. Receptacle thicker when female conceptacles predominated and in slender part only male conceptacles observed. Male conceptacles located in proximal part and female ones in more distal part of the androgynous receptacle. Hermaphrodite conceptacle often mixed. Proportion of male and female regions variable even in the same individual. Receptacle formed at first terminal to small branchlet axil to subtending leaf,
Japanese species of *Sargassum* subgenus *Bactrophycus*

and later smaller receptacles often produced basipetally assuming racemose disposition. Maturation period late spring to summer.

This species grows in the subtidal zone down to 20 m deep. An annual species.


After the original description by Harvey (1859), this species was rather ambiguously known, until Sawada (1955, 1956, 1958) and Okuda (1977) added precise knowledge concerning the basal morphology and sexuality. According to him, sexual expression is somewhat variable in this species.

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Most common individuals are said to be androgynous, i.e., male conceptacles are formed in the proximal part of a receptacle and female conceptacles occupy most of distal part. Hermaphrodite conceptacles occur rarely mixed with male or female ones. There also observed a few individuals possessing androgynous and male receptacles on the same thallus. Male individuals are very rare occurrence.

I had no opportunity to examine the lectotype of this species deposited in TCD (Fig. 9 A) except its photograph. There are several specimens of this species in LD, BM (K) and PC. All of them are fragments with a few lateral branches, and seem to be a part of the same individual. Therefore they may be assumed to be isotypes. Characteristic features of this taxon is well represented in the figure drawn by HARVEY (in DAWSON 1959), reproduced in Fig. 9 B.

The lectotype of *S. fengeri* J. AGARDH (Fig. 9 C) is a fragmentary specimen. Its vesicles are elliptical in shape. As has been shown by SAWADA (1956) and OKUDA (1977), vesicles are variable in shape from spherical to elliptical. My own observation on the specimens in SAP confirms this variation. The lectotype specimen has bigger angrogynous receptacles and slender male ones. In spite of usual attribution of *S. fengeri* as a synonym of *S. horneri*, I propose here to treat *S. fengeri* as synonymous with *S. filicinum*.

Section *Teretia* YOSHIDA, sect. nov.

Caulis erectus, plus minusve abbreviatus, ramo principali semper brevior,
Japanese species of *Sargassum* subgenus *Ractrophycus* 125

ramus principalis angulatus, receptaculum teres. Species typicus: *S. confusum* C. Agardh.

Stem erect, more or less abbreviated, always shorter than main branches, main branch angulate, receptacle terete.


(Figs. 11–13)


Lectotype: BM “e japonia, Horner” (Fig. 12 A).


Japanese name: Fushi-ito-moku (Okamura)

Thallus usually less than 1 m high. Holdfast complanated discoid, up to 3 cm in diameter. Stem usually solitary, upright, becoming 20 cm long, slightly compressed, 3–4 mm wide. In the individuals several years old, scars of fallen main branches giving a knotty appearance to the stem. Main branches issued alternately in one plane, slightly compressed or angulate, 2 mm wide. Spinal processes rarely present on the main branch. Lateral branches formed abundantly. Leaf always filiform, 3–4 cm long and less than 0.5 mm wide. Cryptostomata conspicuous, giving a knotty appearance to the leaf. Vesicle spherical to obovoid in shape, up to 3 mm in diameter, shortly stipitate, with round apex, often numerously formed on the basal part of lateral branches.

Plant dioecious. Female and male receptacles terete, tapering towards the apex, 5 mm long and 1 mm in diameter. Receptacle disposed racemously or paniculately on the upper part of branches, usually with linear bracteal leaf except terminal ones. Receptacle usually simple, sometimes with proliferated small receptacle on the surface. Maturation in spring to early summer.

This species grows subtidally down to 20 m deep or more.

Fig. 11. *Sargassum microceratium* (TURNER) C. AGARDH. A, whole plant. B, basal part with adventitious shoots from holdfast.
Setchell (1933 a) stated that he could not locate the type of *Fucus microceratius* Turner in the herbarium of Kew Garden (K). In BM, there are 2 sheets of specimen of this taxon. One of which indicated as Iso/Syn-type seems to be used for Turner’s illustration (Fig. 12 B) and it is appropriate to designate this specimen (Fig. 12 A) as the lectotype. This is a small fragment with receptacles. The other sheet has a label ‘e mari coreano’ and there is a very poor fragment on it. Identity of this latter specimen is difficult to determine, as Yendo annotated that “This specimen is quite impossible to determine”. There are 3 sheets of specimen of this taxon in PC, and a specimen in LD (Herb. Agardh No. 3225 “e japonia, Tilesius”). These specimens are all fragmentary, but the identity is clear.

This species was variously treated as for the subgeneric placement in

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**Fig. 12.**  A. Lectotype of *Fucus microceratius* Turner. “e japonia, Horner” BM.  
the genus, because of the imperfectness of the type material. J. AGARDH (1889) placed it in the "Species Inquirienda". YENDO (1907, p. 55) amalgamated with S. piluliferum in the subgenus Phyllotrichia. GRUNOW (1915) treated as "Incertaine sedis, forsan Eusargassis ad numeranda". OKAMURA (1936, p. 322) was of opinion that this taxon was different entity from S. piluliferum in the Phyllotrichia.

Recent collections of this species from several localities along the coast of Japan Sea show that the morphology of the basal part is similar to S. confusum and S. pallidum. Filiform leaves are quite characteristic in the genus. Subgeneric attribution to the Bactrophycus is reasonable.

In a specimen (Fig. 11 B), many adventitious shoots from a holdfast were observed. It is not ascertained whether these young shoots contribute to propagation and maintenance of population.

4. *Sargassum confusum* C. AGARDH 1824: 301. (Figs. 14–16)


_Fucus heterophyllus_ C. AGARDH 1815: 43 (non TURNER).

_Sargassum expansum_ J. AGARDH 1896: 60 (non O. KUNTZE 1880). Lectotype: LD (Herb. Agardh No. 3226 "Japonia: Kap Nomo, 1882-1-11, J. PETERSEN") (Fig. 15 B).

_Sargassum validum_ J. AGARDH 1896: 59. Lectotype: LD (Herb. Agardh No. 3217 "Hakodate: Shirisawabe, 1881-11-8, J. PETERSEN") (Fig. 15 C).
Japanese species of *Sargassum* subgenus *Bactrophycus*


*Sargassum confusum* var. *papillata* GRUNOW 1915: 354. Type not located “ad oras Japoniae”.


*Sargassum turneri* YENDO in Okamura 1916: 201 (non O. KUNTZE 1880). Type not designated.

Japanese name: Fushi-suji-moku (Okamura)

Thallus more than 2 m high when well grown. Holdfast discoid, up to 2 cm in diameter. Stem upright, terete or slightly compressed, up to 20 cm high and 3–5 mm wide, simple usually without branching. Spinal processes about 1 mm long often formed on the stem when young, later they dropped off. Main branches issued more or less alternately in one plane, angular, 2–3 mm wide, beset with spinal processes which later dropped off. Lateral branches well developed. Leaf issued spirally with a phyllotaxis of 2/5 on the branches. Lower leaves elliptical to lanceolate up to 10 cm long and 1.5 cm wide, shortly stipitate, with round or acute apex, coriaceous in substance, usually dark brown in color in drying. Margin entire or minutely serrulate. Midrib immersed, reaching to the apex. On the distal part of the main branch and on lateral branches leaves becoming smaller and narrower to linear in shape with evanescent midrib and nearly entire margin. Cryptostomata scattered on the leaf surface. Vesicle spherical to pyriform, shortly stipitate, with round apex, up to 5 mm in diameter.

Plant dioecious. Receptacle terete, shortly stipitate, tapering upwards, disposing racemously. Female receptacle 3–4 mm long and 1–1.1 mm in diameter. Male one longer than the female, 10–15 mm long. Maturation in spring to early summer in the southern part of its distribution, in summer in northern areas.

This species grows on rock and stones in the upper subtidal zone.

Fig. 14. *Sargassum confusum* C. AGARDH.
Japanese species of *Sargassum* subgenus *Bactrophycus*


Fig. 16. Distribution of Sargassum confusum. Solid circles compiled from the specimens in SAP, and open circles from CHIHARA & YOSHIZAKI (1970), KANG (1965), KAJIMURA (1975), TOKIDA (1954) and NAGAI (1940).


C. Agardh (1824) gave no figure at the time of original description of this taxon. Although the lectotype is fragments of terminal part of an immature thallus (Fig. 15 A), it clearly shows characters that accord the current usage of the name by Japanese authors.

Later, J. Agardh (1896) described 2 new species relating to S. confusum, S. expansum and S. validum, basing on the specimens collected by Petersen from Cape Nomo, Nagasaki Pref., and Shirisawabe, Hokkaido, respectively. The lectotype of both taxa (LD, Herb. Agardh Nos. 3226, 3217) are immature specimens (Fig. 15 B,C). Conspicuousness of both taxa with S. confusum is undiscutable. The type of S. expansum is devoid of spinous processes on the stem and branches. This state, combined with lanceolate leaf with acute apex, seems to be identical with that of S. turneri Yendo. Frequency of spinal processes changes clinally, decreasing in southern population, and it is difficult to distinguish subspecific taxa basing on this character.

J. Agardh placed his S. expansum and S. validum in his subgenus Eusargassum together with S. confusum. Characters of receptacle as well as horizontally expanded lower leaves warrant the placement in the Bactrophycus.

Setchell (1933) thought that S. confusum was synonymous with S. pallidum. This was followed by Chinese authors (Tseng & Chang 1954). They distinguished several forms in S. pallidum. From the description and figures given by them, it seems to me that these forms belong to S. confusum. Comparison of specimens is needed before any further comments on these Chinese forms.

As shown in the treatment under S. pallidum, I came to the conclusion that S. confusum is distinct enough at specific level from S. pallidum.

5. Sargassum pallidum (Turner) C. Agardh 1820: 39. (Figs. 17–19)


Fucus pallidus Turner 1808: 149, pl. 67. Lectotype: BM (K) “e mari Coreano” (Fig. 18 A).

Halochloa pallida (Turner) Kützing 1849: 634; 1860: 33, pl. 94, f. 2.

Japanese name: Usu-iro-moku (nov.)

Thallus usually less than 1 m high. Holdfast complanate discoid, up to 3 cm in diameter. Stem usually solitary, upright, terete or slightly compressed, attaining 20 cm long or more and 3–4 mm wide in several years. Main branches issued alternately in one plane. After falling off of the branches, scars giving alternate succession of knots on the stem. Main
Fig. 17. *Sargassum pallidum* (Turner) C. Agardh.
branches slightly compressed. Leaves formed in early season long elliptical to lanceolate, reaching more than 10 cm long and 2 cm wide, with cuneate base and round or acute apex. Margin of the leaf minutely serrulate. Midrib diminishing to the apex. Lower leaves arising alternately in one plane. Leaves thin papyraceous in texture, rather pale in color and turned greenish when treated with formalin. Cryptostomata small, numerous, scattered on the leaf surface. Leaves formed in later season or on distal part of the branch diminishing in size, narrow lanceolate to linear with entire margin, midrib becoming inconspicuous. Vesicles spherical, shortly stipitate with round or mucronate apex, up to 10 mm in diameter, usually formed singly in axil of the leaf. Vesicles formed on the upper part of the branch obovoid in shape with diminishing size.

Plant dioecious. Receptacle terete, tapering towards the apex, 3–4 mm long and 1 mm in diameter, disposing racemosely or paniculately on distal part of the ultimate branches.

This species grows in subtidal zone.


The holotype of *Fucus pallidus* Turner is a fertile fragment deposited in BM (K), as shown in Fig. 18 A. I could not locate any other specimen referable to this species in several european herbaria (L, LD, BM, PC). The holotype is well illustrated by Turner (Fig. 18 B). Although the type is fragmentary, it has characteristic spherical vesicles and thinner papyraceous leaves. SETCHELL (1933 a, p. 207), after examined this specimen, considered that "*F. pallidus* Turner, *F. microceratius* Turner and *Sargassum confusum* C. Agardh are names for one and the same species of the Japanese coasts" and chose the designation of *S. pallidum*. TSENG & CHANG (1954) followed the opinion of Setchell, whereas the Japanese authors did not pay attention to this treatment.

In SAP, we have several collections from Akita and Niigata Prefectures referable to this taxon. Basal part of the thallus resembles to that of *S. confusum* and *S. microceratium*, while leaves are thinner in texture and paler in color. Spherical vesicles are bigger than those of *S. confusum* or *S. microceratium*. Distal part of fertile specimens is quite similar to the type of *S. pallidum*. Therefore, I am certain to identify our specimens as *S. pallidum*. More collection is needed to obtain informations on reproductive structure. This species is one of deep water habitants.
Japanese species of *Sargassum* subgenus *Bactrophytes*

Fig. 18. A. Lectotype of *Fucus pallidus* TURNER. "e mari Coreano" BM(K). B. Illustration of *Fucus pallidus* TURNER, Hist. Fuc. Pl. 67.

Fig. 19. Distribution of *Sargassum pallidum*, compiled from the specimens in SAP.
6. *Sargassum muticum* (Yendo) Fensholt 1955: 313. (Figs. 20–23)

Yoshida 1978 a: 122, f. 4.  
*Sargassum kjellmanianum* f. *muticum* Yendo 1907: 104.  
Lectotype: TI “Itsumo, Prov. Kii, April 1902” (Fig. 22).  
*Sargassum kjellmanianum* sensu Okamura (pro parte) 1924: 45, pl. 212, f. 2; 1936: 340.  
Segawa 1956: 51, pl. 30, No. 226.

Japanese name: Tama-hahaki-moku (Yoshida)

Thallus more than 1 m high. Holdfast complanate discoid in shape, up to 1.5 cm in diameter. Stem solitary on the holdfast, upright, terete, 2–3 mm in diameter, up to 2 cm high, usually unbranched, sometimes once or twice branched in the upper part. Several main branches issued spirally from the terminal part of the stem. Main branch angular, 2 mm wide. Lateral branches numerous developed. Leaves arranged spirally with a phyllotaxis of 2/5 on the main branch. Leaves on lower part of the main branch oblong to long elliptical, usually 2–3 cm long and 3–4 mm wide, with entire or slightly serrulate margin. Midrib absent. Leaves on the upper part of the branch becoming smaller, cuneate or sometimes slightly hemipellous, with dentation in distal part. Cryptostomata scattered on leaves and vesicles. Vesicles shortly stipitate, spherical or pyriform in shape, up to 3 mm in diameter, with round or mucronate apex. Vesicles formed abundantly on lower part of lateral branches.

Plant monoecious. Male and female conceptacles mixed in an androgynous receptacle. Receptacle terete, shortly stipitate, tapering upwards, 10–12 mm long and 1 mm in diameter. Maturation period in winter to early summer.

This species grows on rocks rather protected from wave action, in a zone from lower intertidal to upper subtidal.

Japanese species of *Sargassum* subgenus *Bactrophycus*

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Fig. 20. *Sargassum muticum* (YENDO) FENSHOLT.
Shimoda, Shizuoka Pref., Mar. 31, 1976, leg. T. YOSHD


This taxon was first described as a form of *S. kjellmanianum* by YENDO (1907). FENSHOLT (1955) raised it to the specific rank. Japanese authors customary used the name *S. kjellmanianum* for this taxon. YOSHIDA (1978 a) selected the lectotype (Fig. 22) and consented with the treatment of FENSHOLT.
Japanese species of *Sargassum* subgenus *Bactrophyicus*

Fig. 22. Lectotype of *Sargassum kjellmanianum f. muticum* YENDO. “Itsumo, Prov. Kii, Honshu, April 1902” TI.

Fig. 23. Distribution of *Sargassum muticum*, compiled from the specimens in SAP.
The lectotype, collected at Itsumo, Wakayama Pref. is a sterile specimen. INOH (1930) found out that this taxon is monoecions in sexuality in the population of Misaki, Kanagawa Pref. Monoecism is rather rare occurrence among the species of the *Bactrophycus*.

There is local variation in leaf morphology. In the typical form, leaves on lower part of main branch are usually up to 3 cm long and densely cover the young shoot. While the specimens at hand collected from Seto Inland Sea have longer leaf up to 5 cm and issued more sparsely when compared with the typical form.

The plants identified to this species are widely distributed along the coast of Europe (CRITCHLEY 1981), as well as Pacific coast of North America (DEWREEDE 1978). I had a chance to collect some specimens in Zeeland district of the Netherlands, and noticed that the individuals of Zeeland population are similar to those of Seto Inland Sea population rather than to typical form in having longer leaf sparsely arising.

TSENG & CHANG (1954 a) described *S. kjellmanianum* f. *longifolium*. Judging from the description and figures, YOSHIDA (1978 a) transferred this form to *S. muticum*. This form seems to have resemblance with Seto Inland Sea population and with European population. As I have not yet examined any specimen of this form from China, I must retain to discuss the relation between Japanese and Chinese plants.

Biology of this species was investigated by American and British phycolologists (e.g. NORTON 1977, DEWREEDE 1978, CHAMBERLAIN et al. 1979, CRITCHLEY 1981). Expansion of distribution was followed and well documented in Europe.


(Figs. 24, 25)


*Fucus thunbergii* MERTENS ex Roth 1806: 104, *pl. 3* (α *simplex*, β *racemosa*). TURNER 1809: 158, *pl. 133*. C. AGARDH 1815: 103. THUNBERG 1815: 144. Lectotype: Roth 1806, *pl. 3* “e Chinae et Iaponiae maribus attulit III. THUNBERG” (Fig. 24 A).

*Cystoseira thunbergii* (MERTENS ex Roth) C. AGARDH 1820: 81.

*Myagropsis thunbergii* (MERTENS ex Roth) KÜTZING 1849: 635; 1860: 33, *pl. 93*, f. 2 c, d.

*Cystophyllum thunbergii* (MERTENS ex Roth) J. AGARDH 1848: 233. DE TONI 1895: 157; 1895 a: 47. OKAMURA 1902: 140.

*Rhodomela thunbergii* (MERTENS ex Roth) C. AGARDH 1824: 199.

*Turbinaria thunbergii* (MERTENS ex Roth) YENDO 1905: 153.

*Fucus swartzii* C. AGARDH 1815: 105, *pl. 4 A*. Lectotype: LD (Herb. Agardh No. 935 “in
Japanese species of *Sargassum* subgenus *Bactrophycus* 143

Archipelago Japonico, Tilesius") (Fig. 24 B).

*Cystoseira swartzii* (C. Agardh) C. Agardh 1820: 82.

*Rhodomela swartzii* (C. Agardh) C. Agardh 1824: 198.

*Myagropsis swartzii* (C. Agardh) Kützing 1860: 33, pl. 93, f. 1.

*Myagropsis thunbergii var. swartzii* (C. Agardh) Kützing 1849: 635.


*Turbinaria swartzii* (C. Agardh) Yendo 1905: 153.


*Sargassum thunbergii* f. swartzii (C. Agardh) Okamura 1923: 8.

*Sargassum thunbergii* f. swartzianum (Yendo) Okamura 1923: 8, pl. 203, f. 2; 1936: 338.

Japanese name: Umi-toranowo.

Thallus usually less than 0.5 m high, but exceeding 1 m in a calm habitat. Holdfast depressed disc shaped, 1–1.5 cm in diameter. Stem upright, less than 1 cm high, terete, about 2 mm in diameter, once or twice branched at the distal part. Main branches issued from the distal part of the stem, 1–1.5 mm in diameter, angulate. In early season, main branches simple without lateral branches and densely covered with leaves and vesicles. Later, numerous lateral branches produced. Lateral branches being longest in the middle portion of the main branch, gradually decreasing in length approaching upward and downward. Leaves disposed with 2/5 divergence of phyllotaxis on the main branch. Leaf formed near the basal part scale-like, becoming linear, cuneate to filiform in shape, up to 1 cm long and 1 mm wide with a few dentations on terminal part. Cryptostomata present on leaves. Vesicle fusiform in shape, tapering to both ends, 3–4 mm long and 1 mm in diameter, formed numerously in the upper part of the branch. Rarely 2 to 3 seriate vesicles observed.

The plant dioecious. Receptacles terete, shortly stipitate, gradually tapering upward, formed on abbreviated racemes. Female receptacle 3 mm long and 1 mm in diameter. Male one up to 10 mm long and less than 1.3 mm in diameter. Maturation in spring to early summer.

This species grows on rocks of middle to lower level in the intertidal zone, forming a conspicuous belt in places not so exposed to strong wave action.

Specimens examined: Hokkaido: Nemuro, Aug. 3, 1929, leg. S. Akiyama, SAP 7848; Erimo-misaki, Hidaka Prov., Apr. 24, 1978, leg. H. Kawai, SAP 034346; Samani,
Japanese species of Sargassum subgenus *Bactrophycus*  


Fig. 24. A. Illustration of Fucus thunbergii MERTENS ex ROTH, Catal. Bot. vol. 3, pl. 3. Left, \( \alpha \) simplex, right, \( \beta \) racemosa. B. Holotype of Fucus zwartzii C. AGARDH. "in Archipelago Japonico, TILESius" LD, Herb. Agardh No. 935. C. A specimen used by TURNER for his Hist. Fuc. Pl. 133, BM (K). D. A specimen used by KÜTZING for his Tab. Phyc. vol. 10, Pl. 93. L 937, 109, 102.
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![Distribution map](image)

**Fig. 25.** Distribution of *Sargassum thunbergii*, compiled from specimens in SAP.

According to Koster (1969, p. 557), the type materials of A. W. Roth (1757–1834) were "mostly destroyed, a few specimens in Lund, Inst. Syst. Bot. (LD), London, Brit. Mus. (BM) and Munich, Bot. Staatssamml. (M)". I could locate no specimen of this taxon examined by Roth neither in LD nor in BM. As it cannot be located also in M (Herzel, personal communication), the type seems to be lost, and we must designate Roth's figure (Roth 1806, pl. 3, f. a), reproduced here in Fig. 24 A, as the lectotype of *Fucus thunbergii*. This figure represents only a small fragment, but suffi-
ciently characteristic as for the identity. Another specimen (Fig. 24 C) also sent by MERTENS is now deposited in BM (K), and used for the illustration of TURNER. In the Herbarium KÜTZING housed in L, there is a specimen (“e mari Coreano” L. 937.109.102, Fig. 24 D), that was used by KÜTZING for his illustration in his Tabulae. These two specimens have basal part, but most of leaves fell off, indicating that the collection was made in later period of maturation.

The holotype of *Fucus swartzii* C. AGARDH (LD, Herb. Agardh No. 935, Fig. 24 B) is also a fragment collected by TILESius. Identity of this taxon with *Fucus thunbergii* var. *racemosus* Roth was already pointed out by KÜTZING (1849, p. 635), and I agree to this treatment. YENDO (1907, p. 114) gave a new name *S. swartzianum* for the Agardhian species because the epithet ‘*swartzii*’ had been preoccupied (*S. swartzii* C. AGARDH = *Fucus swartzii* TURNER 1819: 120, nom. illeg.) in the genus *Sargassum*. At the same time, YENDO distinguished other two forms under *S. thunbergii* as f. *nipponicum* and f. *latifolium*, because of the relative development of lateral branches or size of leaves. These characters are rather variable with the age of plant, as shown by UMEZAKI (1974). I did not made any effort to discriminate taxa at subspecific level.

### 8. *Sargassum fulvellum* (TURNER) C. AGARDH 1820: 34. (Figs. 26, 27)

*Fucus fulvellus* TURNER 1808: 148, pl. 66. Holotype: BM (K) “e mari Coreano, HORNER” (Fig. 26 A).


*Spongocarpus enervis* KÜTZING 1843: 55; 1849: 631; 1860: 31, pl. 89, f. 2. Lectotype: L 937. 71.531 “China, MERTENS” (Fig. 26 D).

*Sargassum mertensii* ENDLICHER 1843: 32.

*Sargassum fulvellum* var. *wilkesii* GRUNOW 1915: 349. Type not located “In mari Japonico, leg. WILKES”.

Japanese name: Hondawara.

Thallus usually 1–2 m high, sometimes attaining up to 5 m. Holdfast conical, scutellate, composed of finger-like outgrowths from the basal part of the stem, up to 2 cm in diameter. Distal part of radiating components
not fully coagulated with each other. A single stem arising from the holdfast, short in length, terete and unbranched, usually not exceeding 1 cm high. Several main branches issued spirally from the distal part of the stem, triangular, 3–4 mm wide, often twisting loosely. Lateral branches numerous. Leaf of the basal part of the main branch retroflexed at the base, elliptical to lanceolate in shape, 3–4 cm long and 1 cm wide, with obtuse apex, provided with shallow serration on the margin, thick but soft in substance. Slightly elevated midrib discernible only in short distance from the petiole. Phyllotaxis of leaves on the main branch 1/3. Leaves in the middle part of the branch lanceolate to linear in shape, with slightly or acutely serrate margin, 6 cm long and 1 cm wide, with cuneate base and obtuse apex. Midrib absent. Cryptostomata small, scattered on the leaf surface. Larger vesicle elliptical or pyriform in shape, up to 1 cm long and 0.7 cm in diameter, with round or mucronate apex, rarely provided with small coronal leaf up to 1 cm long. Stipe slender, up to 5 mm long. Vesicles formed in the distal part becoming smaller and slenderer nearing to fusiform in shape.

The plant dioecious. Receptacle terete, shortly stipitate, tapering upward, racemously or paniculately disposed on fertile branches. Female receptacle up to 1 cm long and 1 mm in diameter. Male one 3–5 cm long and 1–1.5 mm in diameter. Maturation in winter to spring.

This species grows on rocks of upper subtidal zone.


Japanese species of *Sargassum* subgenus *Bactrophyes*

**Fig. 27.** Distribution of *Sargassum fulvellum*, compiled from specimens in SAP.

NOMURA, SAP 034462; Misaki, Ehime Pref., May 31, 1979, leg. T. YOSHIDA, SAP 034640.


The holotype of *Fucus fulvellus* TURNER (Fig. 26 A) is a fertile fragment, well represented in the illustration of TURNER (Fig. 26 B). The lectotype of *Sargassum enerve* C. AGARDH (Fig. 26 C) is a portion of sterile thallus, with leaves distantly disposed. As for the identity of these 2 taxa, SETCHELL (1933) was the first to state the opinion. Later, YAMADA (in MAKINO 1949) agreed with SETCHELL and adopted the name *S. fulvellum*, which has priority over *S. enerve*.

The holotype of *Fucus biserratus* THUNBERG was examined by YAMADA (1955), who stated that this name was synonymous with *S. fulvellum*. KÖTZING described *Spongocarpus enervis*, basing on the specimen collected in China and sent to him by HENSCHEL (Fig. 26 D). He considered that his species was similar to *Sargassum enerve* C. AGARDH, but differed in that the
vesicle was more round in shape in C. Agardh's species. As the vesicle is often becoming slender in the distal part of a thallus, there is no need to separate Kützing's species. Endlicher (1843) gave a new name S. mertensii to Kützing's taxon in the genus Sargassum.

Grunow (1915, p. 349) described var. wilkesii of this species, basing on the specimen collected by Wilkes "in mari Japonico". As I have not yet examined any reliable specimen, I cannot discuss the relationship of this variety.

This species is usually considered as annual in longevity. Small shoots are often observed on the periphery of holdfast. It is not clear whether these shoots establish new individuals of the next year. Perennation to second year of growth seems to occur at least in several individuals of the population, because we can collect specimens with fertile main branches and young shoots.


Holotype: SAP 041891 "Futomi, Chiba Pref., May 25, 1978, leg. T. Konno" (Fig. 28).
Isotype in the herbarium of Tokyo University of Fisheries.

Japanese name: Suna-biki-moku (Konno & Yoshida)

Thallus more than 2 m high. Holdfast flat disc usually 5–8 cm in diameter. Growing margin of the disc composed of prostrate finger-like terete protuberances about 2 mm in diameter, which later fused with each other to form a flat disc. Many stems issued from the surface of the disc. The stem terete, 2.5–3.5 mm in diameter, up to 3–4 cm long, upright usually without branching. Several main branches formed in spiral succession near the apex of the stem. Main branch triquetrous with rounded edges, 3–5 mm wide, twisting loosely or strongly. In the lower part of the main branch, spinal processes 1–3 mm long present on the ridges. Lateral branches longest in the middle part of the main branch, attaining 20–30 cm in length, then becoming gradually shorter above. Leaves shortly stipitate, very variable in shape according to season, age or position on the branch. Lower leaves thicker in texture and bigger, spread horizontally, obovoid, elliptical or lanceolate in shape, 3–6 cm long and 1–2 cm wide, with entire or irregularly minutely serrulate margin, with rotundate or acute apex, and obtuse or cuneate base. Phyllotaxis of the leaves 1/3 on the main branch. Midrib evanescent at a half length to the apex. Leaves on the distal part of the main branch or on lateral branches thinner in texture, obovoid, lanceolate, ob lanceolate or even hemiphyllous in shape, becoming smaller in size. Small dots scattered on the leaves, but no cryptostome observed. Vesicles formed singly or in
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groups in axil of leaves or on branchlets. Vesicles in the lower part of the main branch spherical or pyriform in shape, 5–7 mm long and 4–6 mm in diameter, shortly stipitate, mucronate or with round apex, rarely with small coronal leaf or wings, becoming smaller and slenderer above, pyriform to fusiform in shape.

The plant dioecious. Receptacle terete, tapering upwards, with short stipe, formed singly in axil of stipule-like leaflet, arranging in racemose or paniculate disposition. Female receptacle 9–12 mm long, 0.5–1.0 mm in diameter. Male one longer than the female, 15–18 mm long. Receptacles usually simple, but rarely smaller receptacle or vesicle proliferating laterally. Maturation period May to July.

This species grows near low water mark, on the open coast with good exchange of sea water, forming a thick coverage on rather flat rock surface. The holdfast is often covered by drift sand.


The holdfast of this species is unique in the genus. A flat discoid holdfast is constructed by horizontally expanding rhizomatous filaments, which are apparent only in peripheral parts. A tangential section of the holdfast shows clearly this construction distinguishable by the disposition of brown pigment in the epidermal layer of original finger-like filaments. New growing apices differentiate on the flat disc, and by this process, vegetative multiplication is maintained. Although this type of multiplication of shoots may occur in

**Fig. 28.** Holotype of *Sargassum autumnophilum* YOSHIDA et T. KONNO. "Futomi, Chiba Pref., May 25, 1978, leg. T. KONNO" SAP 041891.
S. patens or S. piluliferum, it is exceptional in the Bactrophyccus.

This species was sometimes confused with S. muticum (as S. kjellmani­nianum) by several authors. When the specimens are devoid of basal part, distinction becomes somewhat difficult. Larger leaf, spinal processes on the branch and bigger vesicle of S. ammophilum can be reliable in separation from S. muticum. Dioecism is another distinction from the latter.

10. Sargassum hemiphyllum (Turner) C. Agardh 1820: 39.

(Figs. 30–32)


Spongocarpus hemiphyllus Turner 1811: 86, pl. 167. Holotype: BM(K) “In portu Nangasaki Japoniae, Horner” (Fig. 31 A).

Sargassum hemiphyllum var. micromerum J. Agardh 1889: 62. De Toni 1895: 27. Lectotype: LD (Herb. Agardh No. 2987 “ad oras Japoniae, Kap Nomo, 1882–6–28, leg. J. Petersen”) (Fig. 31 C).

Sargassum micromerum (J. Agardh) J. Agardh 1896: 57.

Sargassum hemiphyllum var. anisophyllum Grunow 1915: 351. Type not located “ad Lemma Island, leg. C. Wright”.

Sargassum hemiphyllum var. anisophyllum f. edentata Grunow 1915: 351. Type not located “ad litora orientalia Japoniae, leg. C. Wright”.

Sargassum hemiphyllum f. serrata P. H. Ho 1967: 276. Type not located “Nha-Trang, Vietnam”.

Fig. 29. Distribution of Sargassum ammophilum, compiled from specimens in SAP.
Japanese species of *Sargassum* subgenus *Bactrophycus*

*Sargassum henslowii* Greville 1848: 85, pl. 6, f. 1. Type not located “in mari Chinensi”.

**Japanese name:** Iso-moku.

Thallus usually less than 1 m high. Holdfast composed of many radiating filamentous outgrowths from the basal part of the stem. These filaments up to 2–3 cm long, 0.8 mm wide, branched irregularly several times, creeping to form a mat on the substratum. Stem upright, short in length, less than 1.5 cm and 1.5–2 mm wide, terete or angulate and unbranched. Several main branches issued spirally from the terminal part of the stem. Main branch triangular in cross section with rounded ridges, 1.5–2 mm wide, sending off many lateral branches. Several leaves formed near the base of main branch spreading horizontally, and upper leaves becoming vertical in direction. Phyllotaxis of the leaf 1/3 on the main branch. Horizontally expanding lower leaves elliptical to long elliptical in shape, 1.5 cm long and 0.7 cm wide, with cuneate base and obtuse apex, having coarsely serrate margin and inconspicuous midrib near the base. Vertically expanding leaves on main and lateral branches markedly hemiphyllous in shape, 1–1.5 cm long and 0.5 cm wide, with minute serration on lower margin. Leaves on distal part becoming smaller and narrower to linear in shape. Midrib not discernible. Cryptostomata scattered on the leaf. Vesicle elliptical or pyriform to fusiform, with apex mucronate or terminated into short filiform coronal leaf or short leaf.

![Fig. 30. *Sargassum hemiphyllum* (Turner) C. Agardh. A, terminal part of the plant with receptacles. B, basal part.](image-url)
running down for short distance to form wings, up to 5 mm long and 1.5 mm wide.

The plant dioecious. Receptacle terete, shortly stipitate and tapering upward. Female receptacle 2–3 mm long and 0.7 mm wide, Male one up to 7 mm long and 0.6 mm in diameter. Receptacle disposing racemously or panically on the distal parts. Maturation in spring to early summer.

This species grows on rocks of lower intertidal to subtidal zones, in the area rather protected from strong wave action.

Japanese species of *Sargassum* subgenus *Bactrophycus*


KOREA: Cheju Island, Aug. 11, 1979, leg. S. A. Yoo, SAP 034600.

The holotype of this species (Fig. 31 A) is a sterile fragment now deposited in BM (K). This is well illustrated by Turner in his ‘Hist. Fuc.’ pl. 167 (Fig. 31 B), which was reproduced in Kützing’s Tabulæ vol. 10, pl. 90, f. 2.

Later, J. Agardh (1889) described 2 varieties of this species, i.e., var. *micromerum* and var. *chinense*. The lectotype of var. *micromerum* (Fig. 31 C) was collected at Cape Nomo, located about 20 km from Nagasaki Port, the type locality of *Fucus hemiphyllus*. I am of opinion that there is no need to distinguish var. *micromerum*. Hemiphyllous shape of leaves is often inconspicuous in the population growing on the coast of Japan Sea. In the population of Pacific coast, leaves are often wider and conspicuously hemiphyllous.
Japanese species of *Sargassum* subgenus *Bactrophycus*

Var. *chinense* (=*S. chinense*), with the type locality in Hong Kong (Fig. 31 D), has larger leaves when compared with Japanese population. Relations between Japanese and Chinese population need further study.

Under this species several subspecific taxa were described other than those of *J. Agardh*, namely var. *anisophylla* Grunow (1915, p. 351), f. *edentata* Grunow (1915, p. 351) and f. *serrata* Ho (1967, p. 276). As I have not yet examined the types of these taxa, I have no opinion as for the validity of them.

*S. henslowii* Greville (1848, p. 85) was usually referred as a synonym under *S. hemiphyllum* (*J. Agardh* 1889). His figure (pl. 6, f. 1) is too fragmentary to give enough idea as for the identity.

Earlier records of *S. nipponicum* from the coast of Japan Sea may be referable to *S. hemiphyllum*, judged from the specimens in SAP.


(Figs. 33–35)


Japanese name: Tama-nashi-moku (Yendo)

Thallus less than 1 m long. Holdfast composed of a small disc and filamentous outgrowths about 1 mm in diameter. The filaments growing out...
Fig. 33. *Sargassum nipponicum* YENDO. A, whole plant, B, C, terminal part with receptacles.
rather freely, branching irregularly and intricately with each other, forming a dense mat up to 10 cm in diameter, covering the substratum. Stem upright, short in length, without branching. Main branches slender and smooth, often slightly angulate, less than 1 mm wide. Leaf linear to linear oblanceolate, sometimes slightly hemiophyllous tapering toward the filiform stipe, up to 25 mm long and 4 mm wide. Midrib immersed and vaguely discernible only in the lower leaves when dried. Leaves on the lower part of the main branch expanding horizontally. Leaves on the upper part of the main branch and lateral branches narrow linear. Cryptostomata small and few in number, difficult to discern. Lateral branches much shorter in length than the main branch. Vesicles few in number especially in younger thalli, slender fusiform, tapering towards both ends, 5 mm long and 1 mm in diameter, with linear or filiform coronal leaf up to 4 mm long.

Plant dioecious. Receptacle terete, formed singly or racemously on ramulet in axil to subtending linear leaf, usually simple, very rarely once forked. Female receptacle 2-3 mm long, 0.5 mm in diameter. Male one longer than the female, up to 5 mm long. Maturation in summer.

This species grows on steep rock surface, exposed to strong wave action, in lower intertidal and upper subtidal zones.

Fig. 34. Lectotype of Sargassum nipponicum YENDO. “Takamatsu, Prov. Hiuga, July 1900” TL.
Fig. 35. Distribution of *Sargassum nipponicum*, compiled from specimens in SAP.


Distribution of this species is confined to the Pacific coast of Japan, as shown in Fig. 35, according to the specimens at hand. Previous records from the coast of Japan Sea seems to be a misidentification of specimens of *S. hemiphyllum*.


Japanese name: Miyabe-moku (*Yendo*)

Thallus less than 1 m high. Holdfast small discoid up to 1 cm in diame-
Japanese species of *Sargassum* subgenus *Bactrophycus*.

Disc with smooth periphery at first, later many fibrous outgrowths about 1 mm in diameter issued from the disc. New shoot arising from the terminal part of the fibrous creeping outgrowths (Fig. 36 A). Stem erect, short in length less than 2 cm high, terete and simple, 2-3 mm in diameter. Several main branches issued spirally from the terminal part of the stem, 1.5-2 mm wide, angular. Lateral branches numerous. Leaf arranged spirally on the branch, with 1/3 to 2/5 phyllotaxis, narrow lanceolate in shape, 10-

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Fig. 36. *Sargassum miyabei* YENDO. A, B, basal part of young plant. C, male receptacles. D, terminal part of female plant with receptacles.
15 mm long and 1–2 mm wide, sometimes asymmetrical in outline, usually with entire margin, often dentate near the apex, gradually attenuated towards the base. Stipe short, filiform and delicate. Midrib absent. Lower leaf expanded horizontally. Upper leaf becoming vertically directed. Cryptostomata scattered on leaves and vesicles. Vesicles fusiform in shape, 5–6 mm long and 1.5 mm in diameter, mucronate or with short linear coronal leaf.

The plant dioecious. Receptacle terete, tapering towards the apex. Female receptacle up to 10 mm long and 1.2 mm in diameter. Male one 15–20 mm long, slenderer than the female. Receptacles disposed in racemose or planiculate manner. Maturation in summer.

This species grows on rocks of lower intertidal or upper subtidal levels of rather protected area, forming a zone just below that of *S. thunbergii*.


USSR: Ussuri Bay, June 2, 1928, leg. KUZNETZOV, SAP 032467.

YOSHIDA (1978a) concluded that *S. miyabei YENDO* and *S. kjellmanianum* YENDO were synonymous, after examining the syntypes of both species deposited in SAPA and selecting the lectotype for each species (Fig.

**Fig. 37.** A. Lectotype of *Sargassum miyabei* YENDO. "Cape Soya, Prov. Kitami, Hokkaido, July 18, 1892, leg. FUKUSHIMA" SAPA. B. Lectotype of *Sargassum kjellmanianum* YENDO. "Takashima, Prov. Shiribeshi, Hokkaido, June 4, 1901, leg. K. MIYABE" SAPA.
Both taxa have characteristic holdfast in possessing short filamentous outgrowths from basal disc and elliptical to fusiform apiculate vesicles, and are dioecious in sexuality. Because the name S. kjellmanianum was often applied to S. kjellmanianum f. muticum (=S. muticum), which has blunt vesicle and is monoecious, YOSHIDA (1978 a) chose the name S. miyabei to avoid unnecessary confusion, in spite of the fact that the name S. kjellmanianum appeared in earlier page of YENDO'S monograph.

**Section Halochloa (KÜTZING) YOSHIDA, stat. nov.**

**Basionym:** Halochloa KÜTZING 1843: 55.

**LT:** S. siliquastrum (TURNER) C. AGARDH

Stem erect, abbreviated, always shorter than main branch, main branch ancipitous to triangulate, lower leaf retroflexed at the base, receptacle compressed, flat or triquetrous, with entire or serrulate margin.

(Figs. 39–42)

*Sargassum racemosum* YAMADA et SEGI in SEGI 1948: 97, f. 1–2 (non O. KUNTZE 1880).  
SEGAWA 1956: 52, pl. 31, No. 232. Holotype not located. Isotypes: SAP 024849 (Fig. 41 A), 024851 “Nagashima, Kii Prov., Aug. 1941, leg. T. SEGI”.

*Sargassum ringgoldianum* f. ellipticum OKAMURA 1936: 333. Holotype: SAP (Herb. Okamura “drift at Hamashima, Mie Pref., Aug. 10, 1929” (Fig. 41 B).
Japanese species of *Sargassum* subgenus *Bactrophycus*

Fig. 39. *Sargassum segii* YOSHIDA. A, young plant. B, C, distal part with male and female receptacles, respectively.
Japanese name: Nagashima-moku (Segi)

Thallus up to 1 m high. Holdfast conical, 1.5 cm in diameter, composed of several lobes formed from the stem. Stem very short, terete. Several main branches issued spirally from the upper part of the stem. Main branch
Japanese species of *Sargassum* subgenus *Bactrophycus*

compressed with thinner margin, 5–6 mm in width in the lower part. Margin of the main branch smooth. Phyllotaxis 1/2 at least in lower part of the main branch. Leaves on the lower part of the main branch elongate elliptical to linear lanceolate in shape with cuneate base and obtuse apex, up to 10 cm long and 1–1.5 cm wide. Leaf margin entire. Lower leaves retroflexed conspicuously at the base. First formed several leaves spread horizontally, but upper ones becoming vertical because of the tortion at the transitional part between blade and petiole. Midrib evanescent. Upper leaves oblanceolate in shape with obtuse or acute apex and with entire margin, becoming gradually smaller. Midrib not discernible in smaller leaves. Cryptostomata absent. Vesicle shortly petiolated, linear oblong to obovate in shape, 1–1.7 cm long and 0.3–0.5 cm in diameter, with coronal leaf which extending downwards to form wings. Those on upper branches gradually elongated and often crowned with a linear leaf. They usually formed singly at the base of lateral branch.

The plant dioecious. Receptacles disposed in abbreviated racemes or panicles on upper part of branches. Female receptacles linear in shape, slightly compressed, 2–3 mm long and 0.5–0.7 mm wide, usually provided with a under leaf. Male ones compressed, linear in shape, up to 7 mm long and 1 mm wide. Maturation in autumn to early winter.

This species grows on rocks rather exposed to wave action, subtidally down to 10 m or more deep.


I have not yet located the specimen clearly designated as type by original authors. The specimens in SAP cited above (SAP 024849, 024851) can certainly be assumed as isotypes. Characteristic basal part with very short stem, elliptical to lanceolate leaves and slender receptacles racemously or panicularly disposed on abbreviated branches are distinctive features of this taxon. I failed to collect this species at the type locality, Nagashima, Mie Pref. This species seems to be of more common occurrence around eastern coast of Mie Prefecture, and has very restricted area of distribution.

OKAMURA (1936, p. 337) described *S. ringgoldianum* f. *ellipticum*. After examination of the holotype (Fig. 41 B), I came to the conclusion that this is synonymous with *S. segii* in every respects.

SEGI (1948) referred this taxon to the subgenus *Arthrophyicus*. Distinction of the 2 subgenera, *Bactrophycus* and *Arthrophyicus*, given by J. AGARDH
Fig. 41. A. Isotype (T) of *Sargassum racemosum* YAMADA et SEGI. “Nagashima, Kii Prov., Aug. 1941, leg. T. SEGI” SAP 024849. B. Holotype of *Sargassum ringgoldianum f. ellipticum* OKAMURA. “Drift at Hamashima, Mie Pref., Aug. 10, 1929” SAP, Herb. Okamura.

Fig. 42. Distribution of *Sargassum segii*, compiled from specimens in SAP.
(1889) is solely based on the morphology of receptacles. As shown in this enumeration of species, receptacles are not only "simplicia siliquaeformia et inermia" as seen in *S. horneri*, but also spatulate or forked in the other species. At present, as I have not examined any of species belonging to the *Arthrophyccus* in living state, discussions on the subgeneric arrangement must be postponed. Here I treat *S. segii* as a species of the *Bactrophycus*, assuming that the *Arthrophyccus* is a group occurring only in the southern Hemisphere.

14. *Sargassum yamamotoi* YOSHIDA, spec. nov. (Figs. 43-46)

*Sargassum serratifolium* sensu YENDO (pro parte) 1907, pl. 11, f. 1-2.

Thallus altitudinem 1 vel 2 m. Hapteron conicum vel scutatum sulco radianti, 1-1.5 cm in diametro. Caulis brevissimum, minus quam 1 cm altus, plerumque non ramosus. Aliquot rami principales ad apicem caulis enascentes. Ramus principalis planus, nervo elevato longitudinali et alis marginibus tenuioribus. Margines ramosum principalium integri vel in parte irregulariter dentati. Ramis lateralis numerosi et bene crescentes. Folia enascentia prima partem basalem elliptica, 2-3 cm longa et 1-1.5 cm lata. Folia inferiora lanceolata 10 cm vel longiora et 2 cm lata, basi conspicue retroflexa. Lamina basi in petiolum complanatum abrupte transiens. Apex folii obtusus. Margines folii integri vel irregulariter dentati serrative. Textura folii crassa membranacea. Folia in parte distali versus linearia angustescencit, margine parce dentata. Cryptostomata in pagina folii dispersa. Vesicula grandis obovata vel elliptica, usque ad 2 cm longa et 1.5 cm in diametro, stipite 0.5 cm longo et folio coronae simplici. Vesicula gradatim parvescens et angustescens in parte distali.

Planta dioica. Receptacula in parte distali rami racemose disposita. Receptacula feminina oblanceolata, 3-4 mm longa et 1-1.5 mm lata. Receptacula masculina linearia, compressa, 1-3 cm longa et 1-1.5 mm lata. Maturation sero verne et ineunte aestate est.

Holotypus: Nomi-wan, Kochi Pref., maio 25, 1979, leg. T. YOSHIDA, SAP 043447 (Fig. 45). Isotypi in BM, L, LD, PC, UC, US.

Japanese name: Yoremoku-modoki (nov.)

Thallus attaining 1 or 2 m long. Holdfast conical or scutate with radiating furrows, 1-1.5 cm in diameter. Stem very short in length, less than 1 cm high, usually unbranched. A few main branches arising on top of the stem. Main branch ancipitous, 5 mm or more in width, with longitudinal costal elevation and thinner marginal wing portion. Margin of main branch entire or partly irregularly dentate. Lateral branches abundant and well
developed. Lower leaf conspicuously retroflexed at the base. Leaves first formed near the basal part of the main branch elliptical, 2–3 cm long and 1–1.5 cm wide. Leaves succeeding on upper part lanceolate in shape, 10 cm

Fig. 43. *Sargassum yamamotoi* YOSHIDA. Young plant.
or more in length and 2 cm in width. Basal part abruptly passing into complanate petiole. Apex obtuse. Margin entire or irregularly dentate or serrate. Texture thick membranaceous. Leaves on distal part becoming narrower to linear in shape with sparse dentation on the margin. Cryptostomata scattered on the leaf surface, Larger vesicle obovoid or elliptical, up to 2 cm long and 1.5 cm in diameter, with stipe 0.5 cm long and simple

Fig. 44. Sargassum yamamotoi YOSHIDA. Fertile plant.
coronal leaf 3 cm long. Vesicles becoming smaller and narrower in distal part.

The plant dioecious. Receptacle disposed racemosely on the distal part of the branches. Female receptacle oblanceolate, 3–4 mm long and 1–1.5 mm wide. Male one linear, compressed, 1–3 cm long and 1–1.5 mm wide. Maturity in late spring to early summer.

This species grows on rocks in the subtidal zone down to 5 m or more deep in the area rather exposed to wave action.


This taxon has usually been classed under the name *S. tortile* (= *S. siliquastrum*). Morphology of basal part with very short stem, broad main branch, thinner leaf and linear receptacle are quite distinct from branched stem, coriaceous leaf and spatulate receptacle of *S. siliquastrum*.

The specific epithet is dedicated to Mr. Torao YAMAMOTO, Wakayama Prefecture, an enthusiastic collector of algae.
Fig. 45. Holotype of Sargassum yamamotoi YOSHIDA. “Nomi-wan, Kochi Pref., May 25, 1979, leg. T. YOSHIDA” SAP 043447.

Fig. 46. Distribution of Sargassum yamamotoi, compiled from specimens in SAP.
15. *Sargassum tenuifolium* YAMADA 1942: 505, f. 10-11. (Figs. 47-50)

YAMADA 1944: 9. SEGAWA 1956: 52, pl. 31, No. 231. Holotype: SAP 026453 “Kushimoto, Kii Prov., July 1940, leg. S. INOH” (Fig. 49).

Japanese name: Usuba-moku (YAMADA)

Thallus less than 1 m high. Holdfast small, discoid to conical, 1-1.5 cm in diameter. Stem upright, 1.5 mm in diameter, very short in length, usually 2-3 mm high, rarely attaining to 0.5 cm. A few main branches issued spirally from the distal part of the stem. Main branch terete only at basal part, compressed at distal part, 4-5 mm wide, with smooth margin, and assuming triquetrous appearance because of the ridge running down from the petiole of leaf. Lateral branches well developed. Lower leaf retroflexed at the base, shortly stipitate, lanceolate with obtuse apex in shape, irregularly incised at the margin, up to 5 cm long and 1.2 cm wide. Midrib evanescent near the apex. Cryptostomata few in number. Leaf papyraceous in substance. Leaves

![Fig. 47. Sargassum tenuifolium YAMADA. Terminal part of fertile plant.](image1)

![Fig. 48. Sargassum tenuifolium YAMADA. Leaves with various degree of incision.](image2)
on the distal part becoming narrower, with deeper serration more acute and thinner in texture. Vesicle spherical to ovoid in shape up to 8 mm in diameter, devoid of cryptostome, with mucronate apex or coronal leaflet up to 1 cm long and with serrate margin. Stipe of the vesicle short in length, terete or flattened.

Plant monoecious. Receptacle com­ planate, spatulate in shape, 3–4 mm long and 1.5 mm wide, with spinal processes on the margin, disposing racemously in the distal part of the branch. Male and female conceptacles formed in the same receptacle. Maturation period in summer.

This species grows on rock of upper subtidal zone.


Fig. 49. Holotype of Sargassum tenui­ folium YAMADA. "Kushimoto, Kii Prov., July 1940, leg. S. INOH" SAP 028453.

Fig. 50. Distribution of Sargassum tenuifolium, compiled from specimens in SAP.
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By a feature of receptacle armed with spines, YAMADA placed this species in the subgenus Micracantha. As discussed under S. micracanthum, I treat this taxon in the Bactrophycus. Monoecism is rather rare case in this subgenus.

16. Sargassum ringgoldianum Harvey 1859: 327. (Figs. 51-54)


Japanese name: Ohba-moku.

Thallus usually 1 m or more in length. Holdfast conical, up to 3-4 cm in diameter. A single stem arising from the holdfast. Stem terete, 5 mm in diameter, attaining 20 cm or more in several years, branched several times. Several main branches formed annually, leaving scars on the stem. Main branch ancipitous with a longitudinal costal elevation, with smooth margin, 5 mm wide. Lateral branches well developed. Lower leaf retroflexed at the base, lanceolate to linear in shape, base gradually passed into complanate petiole, 20 cm or more in length, up to 2 cm wide, with entire margin. Apex of leaf obtuse. Midrib immersed, evanescent near the apex. Leaf thick, coriaceous in texture. Phyllotaxis of leaves on main branch 1/2. Upper leaves becoming smaller and narrower. Cryptostomata scattered on the leaf surface. Larger vesicles elliptical in shape, 2 cm long and 1-1.3 cm wide, with complanate stipe. Simple coronal leaf often running down to form wings. Smaller vesicles formed in distal part becoming narrower to fusiform, usually with wing.

The plant dioecious.

Key to the subspecies of S. ringgoldianum
1. Receptacles foliose, 2-5 cm long and 4-5 mm wide, racemously disposed . . . . . . . . . . . . . . . . . . . . . . . . . . Subsp. ringgoldianum
2. Receptacles oblanceolate to linear, 5-10 mm long and 1 mm wide, disposed in abbreviated racemes or panicles . . . . . . Subsp. coreanum

Sargassum ringgoldianum subsp. ringgoldianum (Fig. 51)

Receptacle foliose, spatulate to oblanceolate in shape, usually without bracteal leaf, disposing racemously in distal branches. Female receptacle
Japanese species of *Sargassum* subgenus *Bactrophycus*

measuring up to 2 cm long and 5 mm wide. Male one 2-5 cm long and 4 mm wide, often resembling to smaller leaf. Maturation in summer.

*Fig. 51. Sargassum ringgoldianum ssp. ringgoldianum.* Terminal part of female plant.
Fig. 52. *Sargassum ringgoldianum* ssp. *coreanum* (J. AGARDH) YOSHIDA. A, fertile plant. B, male receptacles. C, female receptacles.
(Fig. 52)

Basionym: *Sargassum coreanum* J. Agardh 1889: 58. Lectotype: LD (Herb. Agardh No. 2881 “ex insulis Corea, mis. CROUAN”. Lectotypified by A. B. CriBB, 1957-7-11) (Fig. 53 A).

Japanese name: Yanagi-moku.

Receptacles disposed racemosely or paniculately on small ramulet arising in axil of leaf. Female receptacle narrow oblanceolate, slightly compressed, 5 mm long and 1 mm wide. Male one linear, complanate, up to 10 mm long and 1 mm wide. Maturation in autumn.


Fig 53. A. Lectotype of *Sargassum coreanum* J. AGARDH. “ex Insulis Corea, sub No. 10 mis. CROUAN” LD, Herb. Agardh No. 2881. B. Illustration of *Sargassum ringgoldianum* HARVEY, taken from DAWSON (1959).
Japanese species of *Sargassum* subgenus *Bactrophyus*

*KOREA*: Cheju Island, Oct. 8, 1934, leg. Hosino, SAP 043898.

*S. ringgoldianum* was described by Harvey (1859), basing on the specimens collected at Shimoda, Shizuoka Pref. The type deposited in TCD is a fertile branch, which has foliar receptacles clearly depicted by Harvey (in Dawson 1959, pl. 2), reproduced in Fig. 53 B. This species is easily recognized by its long lanceolate leaves with entire margin.

As for *S. coreanum*, J. Agardh (1889, p. 58) gave the locality of the taxon as “ad oras Corea (Herb. Crouan!) ad ostia Amuris Navarsha Fenger!” The specimen in Herb. Agardh No. 2881 with a label ‘Ex insulis Corea, Ind. No. 10, mis. Crouan’ (Fig. 53 A) was chosen as the lectotype by Cribb and I follow this decision. One of other specimens, No. 2883 labeled ‘ad insulum Sachalin extra ostia Amuris, legit Navarsha Fenger’ also corresponds to the citation by J. Agardh. The lectotype specimen has linear receptacles, that is easily distinguishable from foliose receptacle of subsp. *ringgoldianum*.

Yendo treated this taxon as a synonym of *S. ringgoldianum*. These 2 taxa are difficult to distinguish at immature state. At maturity, size and shape of receptacles are quite different. Because of the similarity in immature state, I provisionally treat the taxon of J. Agardh at subspecific level. Subspecies *coreanum* is distributed widely on the coast of Japan Sea and also western part of Pacific coast of Honshu to Kyushu including Shikoku. On the other hand, subsp. *ringgoldianum* is distributed on the coast from Miyagi to Shizuoka Pref. on the Pacific side of Honshu (Fig. 54).
Habitat preference shows difference between the 2 subspecies. Subsp. *ringgoldianum* grows on rocks often influenced by drift sand or unstable stones. While subsp. *coreanum* colonizes on stable substratum.

Yoshida (1960) showed that growth rings found in the holdfast of this species formed annually, and that the age of an individual could be determined by counting number of rings. Oldest individual examined possessed 6 rings. That means the longevity of 7 years.

(Figs. 55–58)

*Carpacanthus trichophyllus* Kützing 1843: 57; 1843 a: 368; 1849: 622; 1861: 12, pl. 37, f. 2.  
J. Agardh 1848: 348. Lectotype: L 937.71.691 “Japan, Tilesius” (Fig. 57 A, B).


Japanese name: Ito-yore-moku (nov.)

Thallus less than 1 m high. Holdfast conical, 1 cm in diameter. Stem terete, about 2 mm in diameter, 2–3 times branched. A few main branches arising from the distal part of the stem. Lower part of the main branch flattened caused by a conspicuous retroflexy of the leaf base. Middle part of the main branch becoming triquetrous with the phyllotaxis of the leaf 1/3. Simple spinous

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Fig. 55. *Sargassum trichophyllum* (Kützing) O. Kuntze. Terminal part of fertile plant.

Fig. 56. *Sargassum trichophyllum* (Kützing) O. Kuntze. Variation in leaf shape.
processes sparsely present on the edge of the main branch. Leaf formed on the proximal part of the main branch elliptical to lanceolate in shape, 3 cm long and 1 cm wide, with inconspicuous midrib. Margin nearly entire. Leaf changing abruptly into deeply serrate form with acute lobes. Leaf on the middle part of the branch assuming a form with midrib and alternately disposed filiform pinnules. Pinnules often once divided dichotomously. Midrib 4–5 cm long with pinnules 1–1.5 cm long. Cryptostomata nearly absent. Vesicles spherical to obovoid in shape, 7 mm long and 5 mm in diameter, in lower part of the main branch, and becoming narrower to fusiform in distal part, with mucronated apex or with coronal leaf similar to that on the branch.

Plant dioecious. Receptacle spatulate to linear spatulate, often triquetrous with minute spinal processes on the margin, 5–8 mm long and 1–1.5 mm wide,
Fig. 58. Distribution of *Sargassum trichophyllum*, compiled from specimens in SAP.

disposing racemosely or paniculately. Maturation in autumn to winter.


I selected a specimen in L (No. 937.71.691) as the lectotype of this taxon. This is a specimen without basal part (Fig. 57 A, B). Conspicuous characteristic of this taxon is triquetrous receptacles with repand or serrulate ridges, clearly shown by KÜTZING (1861) in his Tabulae (Fig. 57 C). Because of this feature, KÜTZING (1843) placed this taxon in his genus *Carpacanthus*. Leaves in the middle to upper parts of branches are also characteristic in that they are composed of filiform midrib and filiform pinnules once or twice branched (Fig. 56).

Specimens clearly represent above characteristics are deposited in SAP. I recognize them as distinct entity. The name *S. trichophyllum* was placed in the synonymy of *S. tortile* by YENDO (1907, p. 86) with some hesitation. The specimens at hand show that this species matures in autumn to winter. Difference in maturation period is another distinction from *S. siliquastrum* (=*S. tortile*).

Combination from *Carpacanthus* to *Sargassum* was made by KUNTZE
Japanese species of Sargassum subgenus Bactrophycus

(1880, p. 228). This publication antedates the description of a name Sargassum trichophyllum J. Agardh in 1889. Womersley (1954, p. 351) placed S. trichophyllum J. Agardh as a synonym of S. verruculosum (Mertens) C. Agardh. Therefore, a new name is not necessary for Agardhian species.

18. Sargassum sagamianum Yendo 1907: 151, pl. 17, f. 6–9.
(Figs. 59–61)


Japanese name: Neji-moku (Yendo)

The plant more than 1 m long when well developed. Holdfast conical up to 5 cm or more in diameter. Stem terete, forking pseudodichotomously several times. Lower part of the stem becoming buried in the conical holdfast, giving an appearance that several stems arising from the surface of a holdfast. Several main branches issued annually from the terminal part of the stem in spiral succession. Main branch trigonous with sharp edges, twisting loosely. Leaves in the lower part of the main branch retroflexed, spread horizontally, linear lanceolate in shape, 4–7 cm long and 5 mm wide, with acute apex, decurrent at the base, with sparsely serrate margin. Midrib evanescent, not reaching to the apex. Phyllotaxis of the leaves on main branch 1/3. Leaves on upper part of the main branch and lateral branches becoming narrower to linear in shape. Cryptostomata rare or nearly absent. Vesicles elliptical or fusiform in shape, 15–18 mm long, 5–8 mm in diameter, mucronate or with linear coronal leaf. Vesicles formed rather sparsely on the basal part of lateral branches or branchlets.

The plant dioecious. Female receptacles usually triquetrous, but compressed oblanceolate ones often mixed, 12–15 mm long and 1.5 mm wide. Male one linear in shape, compressed, 20–30 mm long, 1.5 mm wide, sometimes forked or with smaller proliferation. Receptacles disposed in racemose or paniculate manner. Maturation period in autumn to winter.

This species grows on rocks rather exposed to wave action, from low water mark to 2 m deep.


Taxonomic history of this species was briefly given by Yoshida (1980)
and YOSHIDA & KONNO (1983). The lectotypification by YOSHIDA (1980) also specified the type locality of this taxon as Osatsu, Mie Pref. This is unfortunate in that Yendo approved its occurrence in Sagami Province (Kana-

Fig. 59. *Sargassum sagamianum* YENDO.
Japanese species of *Sargassum* subgenus *Bactrophyceus*

gawa Prefecture) by the epithet 'sagamianum', but this taxon has narrow range of distribution only in Kii Peninsula.

Fig. 60. Lectotype of *Sargassum sagamianum* YENDO. "Osatsu, Prov. Shima, Feb. 2" T.I.

Fig. 61. Distribution of *Sargassum sagamianum*, compiled from specimens in SAP.

(Figs. 62–64)


**Halochloa micracantha** Kützing 1843: 56; 1843a: 367; 1849: 633; 1860: 34, pl. 98, f. 2.

Holotype: L 937. 55. 8 “Japan, TILESJUS” (Fig. 63 A).

**Sargassum micracanthum** var. **stipulatum** Yendo 1907: 125, pl. 15, f. 18–21. Okamura 1916: 206; 1936: 345. Holotype: LD (Herb. Agardh No. 2919 “ex Japonia, KJELLMAN”) (Fig. 63 C).

**Sargassum kiushianum** Yendo 1907: 121, pl. 15, f. 6–9. Grunow 1915: 348. Okamura 1916: 205. Holotype: TI “Jyono, Fukuoka Pref., leg. S. YANO” (Fig. 63D).

**Japanese name**: Toge-moku (Yendo)

Thallus less than 1 m high. Holdfast conical up to 5 cm in diameter. Stem terete, about 3 mm in diameter, frequently branched in short distance. Lower part of the branching stem becoming buried in the conical holdfast, assuming an appearance that many stems issued on the surface of stout holdfast. Main branches arising from the dorsal side of obliquely directed stem, triquetrous with sharp or round ridges, about 3 mm wide, loosely twisted. Lateral branches numerous, but much shorter than the main branch. Leaf lanceolate to linear lanceolate in outline, 6 cm long and 0.8 cm wide, with complanated short stipe, usually alternately pinnatisected, with the round sini often reaching to the percurrent midrib. At the insertion to the branch, stipe often expanding like a stipule. Phyllotaxis of leaves on the main branch 1/3. Cryptostomata very rare to almost absent. Vesicle obovoid to elliptical in shape, 8 mm long and 7 mm in diameter, with stipe about 5 mm long, provided with small coronal leaf up to 3 cm long with serrate margin and often with several small spinal projections.

The plant dioecious. Receptacle spatulate in shape, often with small serration on terminal or upper margin. Female receptacle 7 mm long and 3 mm wide. Male one rather slender. In early season, receptacle formed singly on small branchlet in axil of subtending leaf, and several smaller receptacles formed later in basipetal succession resulting in abbreviated racemes. Maturation in late winter to spring.

This species grows in upper subtidal region of rocky coast.

Japanese species of *Sargassum* subgenus *Bactrophycus*


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Fig. 62. *Sargassum micracanthum* (Kützing) Endlicher.
The author of the name was usually cited as (KÜTZING) YENDO or
Japanese species of *Sargassum* subgenus *Bactrophycus*

Fig. 63. A. Holotype of *Halochloa micrantha* Kützing. "Japan, TILESUS" L. 937. 55. 8.
B. Illustration of *Halochloa micrantha* Kützing, Tab. Phyc. vol. 10, pl. 98, f. 2.
D. Holotype of *Sargassum kiushianum* Yendo. "Jyono, Fukuoka Pref., leg. S. YANO" TI.
(Kützing) Grunow. The earliest author made this combination seems to be Endlicher (1843), as I use here.

The holotype of this species (Fig. 63 A) is a sterile fragment with leaves rather membranaceous in substance, illustrated by Kützing in his Tabulae (Fig. 63 B). Dissected lobes of the leaf are narrower. In this respect, the holotype of *S. kiushianum* Yendo resembles to the type of *Halochloa micracantha*. In describing *S. kiushianum*, Yendo (1907) emphasized a characteristic of receptacle which formed singly in axil of subtending leaf. His specimen represents an early stage of maturation. Successive observation on the process of formation of receptacles shows that additional receptacles are produced in basipetal order, resulting in a small raceme. Okamura (1924) already expressed his opinion concerning the solitary receptacle in *S. kiushianum*. Placement of *S. kiushianum* in the synonymy of *S. micracanthum* is quite convincing.

Yendo (1907) distinguished var. *stipulatum* basing on *S. micracanthum* sensu J. Agardh. The holotype of this taxon is therefore that deposited in LD, Herb. Agardh as No. 2919 (Fig. 63 C) which was not examined by Yendo in preparing his description. As for the distinction of subspecific taxa in *S. micracanthum*, much investigation is needed.

Yendo (1907, p. 121) described a new section *Micracanthae* under the *Bactrophycus*, using the character of receptacles. Receptacles are ovate, ancipitous, excavated on one surface and longitudinally elevated on the other,
and minutely spinoso-dentated on the margin or at the apex, disposing on abbreviated fertile ramules. He included in his new section following species: *S. kiushianum, S. micracanthum* and *S. nigrifolium*. Later, he (in OKAMURA 1916, p. 205) raised the status to subgenus. This is followed by OKAMURA (1936) and others. As a species with dentate receptacles, YAMADA (1942) described *S. tenuifolium*. Carpacanthus trichophyllus Kützing has clearly spinose, triquetrous receptacles. Morphology of basal part of those species is very different from each other. For example, *S. micracanthum* has erect branched stem, while *S. nigrifolium* has decumbent stem, and in *S. tenuifolium* stem is erect but very short in length without branching. Delimitation of subgenus by only one character is not reasonable. Therefore I am of opinion that the *Micracantha* of YENDO do not deserve to be recognized at subgeneric rank, and all the species are included here in the subgenus *Bactrophycus*.

20. **Sargassum giganteifolium** YAMADA in OKAMURA 1925: 105, pl. 230. (Figs. 65-67)


**Japanese name**: Ohba-nokogiri-moku (YAMADA)

Thallus more than 1 m long. Holdfast conical or discoid, up to 4 cm in diameter. Stem upright, terete, up to 5-6 mm in diameter, branched once or twice, attaining 6 cm high or more. Main branches spirally disposed near the apices of the stem, ancipitous, up to 1 cm wide, marginal area thin, with spinal processes at irregular interval. Lateral branches well developed. Lower leaf retroflexed at the base, linear lanceolate in shape, 20 cm or more long and 3 cm wide, with rounded apex and decurrent at the base. Margin irregular dentate. Midrib slightly elevated, evanescent near the apex. Phylotaxis 1/2 in the lower part of main branch. Leaves becoming gradually smaller with inconspicuous midrib and acute apex on upper part of the branches. Cryptostomata scattered on the leaf. Vesicles usually solitary near the base of lateral branches, spherical to elliptical, 1.5 cm long and 1.2 cm in diameter, mucronate or coronated with a serrated leaflet at the apex, with a stipe about 1 cm long.

Plant dioecious. Receptacles disposed in abbreviated raceme or panicle on ramules in axil of subtending leaf. Female receptacle flat, spatulate in shape with slightly emarginate apex, 3-4 mm long and 1-1.5 mm wide. Male one compressed, linear in shape, 8 mm long and 1 mm wide, usually simple,
sometimes once forked. Maturation in autumn.

This species grows in the subtidal zone down to more than 10 m deep.


Fig. 65. *Sargassum giganteifolium* YAMADA.
Japanese species of *Sargassum* subgenus *Bactrophycus*


This species is primarily distinguishable from the species of *Siliquastrum* group in that this species has larger leaves with shallower dentation, not modified to the extremely skeletonized types as in *S. siliquastrum* or *S. macrocarpum*. Paniculately disposing slender receptacles of this species also contrast to the spatulate receptacles disposing racemously in *S. siliquastrum* and *S. macrocarpum*.

Setchell (1933) assumed that this species as an extreme ecophene or possibly a gigantic mutant of a tetraploid type, without convincing data. At present we have no chromosome data for

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**Fig. 66.** Syntype of *Sargassum giganteifolium* YAMADA. “Enoshima, Sagami Prov., Oct. 1923, leg. Y. YAMADA” SAP, Herb. Okamura.

**Fig. 67.** Distribution of *Sargassum giganteifolium*, compiled from specimens in SAP.
this species. With its maturation period in autumn, as well as other morphological characters, this taxon is an independent entity.

This species is one of deep water inhabitants.

21. *Sargassum macrocarpum* C. Agardh 1820: 36. (Figs. 68–70)


*Halochloa macrocarpa* (C. Agardh) Kützing 1849: 634.

*Sargassum tortile* var. *macrocarpum* (C. Agardh) Yendo 1905: 156.


*Sargassum tortile* var. *angustifolium* (Turner) C. Agardh 1820: 16.


Japanese name: Nokogiri-moku.

Thallus attaining several meters long. Holdfast conical, up to 5 cm in diameter. A single stem arising from the holdfast, upright, terete, 4–5 mm in diameter, branching several times with an interval of about 1 cm or more, reaching up to more than 10 cm high. Several main branches produced annually at the distal part of the stem in spiral succession, leaving knots on the stem surface. Main branch ancipitous, 3–4 mm wide with a longitudinal costal elevation. Margin of the main branch armed by many protuberances with round or acute apex about 2 mm long in irregular intervals. Lateral branches well developed, becoming triquetrous in distal part. Lower leaf retroflexed at the base, thick coriaceous in substance, lanceolate to linear in shape, 10 cm or more long and 1.5 cm wide, with percurrent midrib. Marginal serration varying from shallow dentation to deep serration reaching to the midrib. Double serration common in leaves on lower to middle portion of the main branch. Phyllotaxis 1/2 on flat branches. Upper leaves becoming narrower to linear. Phyllotaxis on triquetrous branchlets changing to 1/3. Cryptostomata very rare to almost absent. Vesicle spherical to elliptical in shape, up to 1–1.2 cm long and 1 cm in diameter, with mucronate apex or beset with coronal leaf similar to that on the branch.

The plant dioecious. Receptacle oblanceolate to linear in shape, racemose disposed. Female receptacle up to 1 cm long and 3 mm wide. Male one slender, up to 1.5 cm long and 2 mm wide. Maturation period in summer.

This species grows on rocks of subtidal zone down to 10 m deep or more.
Japanese species of *Sargassum subgenus Bactrophycus*

Fig. 68. *Sargassum macrocarpum* C. AGARDH.


KOREA: Cheju Island, Oct. 8, 1934, leg. HOSHINO, SAP 043895.

The name *S. macrocarpum* C. AGARDH was variously treated in the
Fig. 69. A. Illustration of *Fucus longifolius* var. *angustifolius* TURNER, Hist. Fuc. Pl. 104, f. 1 b. B. Lectotype of *Fucus longifolius* var. *angustifolius* TURNER. "e port. Nangas." BM (K), seems to be used above illustration. C. Lectotype of *Sargassum macrocarpum* C. AGARDH. "ex Japonia, TILESUS" LD, Herb. Agardh No. 2903.
past. J. AGARDH (1848, 1889, 1896), DETONI (1895) and GRUNOW (1915) accepted it as a distinct species. YENDO (1905, 1907) referred this taxon as a variety under *S. tortile*. This is followed by subsequent Japanese authors.

In the Agardhian herbarium (LD), many specimens (Nos. 2895-2917) are placed in the same cover. Most of them are collection of KJELLMAN sent to J. AGARDH. Therefore I propose to select No. 2903 (Fig. 69 C) as the lectotype, because only this specimen seems to be examined by C. AGARDH. The lectotype is a small sterile fragment of about 15 cm long. Its ancipitous branch has obtuse projections on the margin. Leaf is coriaceous in texture and has coarse dentation on the margin. Double dentation is also clearly discernible. These characters are very distinct and in common with the individuals referred to *S. serratifolium* by most Japanese authors of the present day.

*Fucus longifolius* var. *angustifolius* TURNER was based on the specimen collected at Nagasaki and housed in BM (K) (Fig. 69 B). Illustration made by TURNER (Fig. 69 A) gives rather different impression as to the width of leaf and pinnae. Closer examination shows that this specimen represents a sterile upper part of an individual referable to *S. macrocarpum*. This taxon was later treated as a variety under *S. tortile*.

NAKAJIMA & KONNO (unpublished) and ARIYAMA (unpublished) observed that there are two different populations as for the maturation period, although they are morphologically very similar. Deep water population matures earlier
and shallow water population later in season. Taxonomic treatment of them needs further investigation.

This species is perennial in growth. YOSHIDA (unpublished) observed individuals with 7 growth rings in a population of North Kyushu.

**22. Sargassum autumnale** YOSHIDA, spec. nov.  
(Figs. 71-74)

Thallus plerumque usque ad 50 cm altus. Hapteron conicum, 3-5 cm in diametro. Caulis erectus, teres, 2-3 mm in diametro, compluriens ramificans, usque ad 8 cm altus. Aliquot rami principales ex parte distali caulis enacentes. Rami principals triqueteri, margine acuti, 2 mm lati, aliquot spinis acutis circa 2 mm longis in margine exorientibus. Rami laterales multi, sed ramo principali multo breviores. Folia in parte proximali rami principalis conspicue basi retroflexa, anguste lanceolata vel linearia, 3-5 cm longa et 4-6 mm lata, margine serrata. Costa immersa et in apicem versus deminuens. Folia angustescensia in parte superiori, margine inconspicue denticulata. Folia in parte distali filiformia, 4-5 cm longa et 0.2-0.3 mm lata. Costa incognita. Cryptostomata praesentia super folio. Vesicula obovata vel pyriformis usque ad 8 mm longa et 6 mm in diametro, apice mucronata vel folio coronae filiformi usque ad 1 cm longo munita.

Planta dioica. Receptacula in parte distali rami racemose vel paniculatim disposita. Receptacula femina spathulata 2-3 mm longa et 1.5 mm lata. Receptacula masculina linearia, 5-8 mm longa et 0.5 mm lata. Maturatio autumno est.

Holotypus: Nomozaki, Nagasaki Pref., Sept. 24, 1976, leg. T. YOTSUI, SAP 043407 (Fig. 73). Isotypi in BM, L, LD, PC, TNS, UC, US.

Japanese name: Aki-yore-moku (nov.)
Fig. 71. *Sargassum autumnale* YOSHIDA.
Japanese species of *Sargassum* subgenus *Bactrophycus*

**Fig. 72.** *Sargassum autumnale* YOSHIDA. A, male receptacles. B, female receptacles.

discernible. Cryptostomata present on the leaf. Vesicle obovoid or pyriform in shape, up to 8 mm long and 6 mm in diameter, mucronate at apex or with filiform coronal leaf up to 2 cm long.

The plant dioecious. Receptacle racemously or panically disposed in the distal part of the branch. Female receptacle spatulate, 2–3 mm long and 1.5 mm wide. Male one linear, 5–8 mm long and 0.5 mm wide. Maturation in autumn.

This species grows on rocks near the low water mark, in area rather protected from wave action.


KYUSHU: Iwaya, Fukuoka Pref., June 5, 1981, leg. T. YOSHIDA, SAP 043319; Tsuyazaki,
Fig. 73. Holotype of *Sargassum autunnale* YOSHIDA. "Nomozaki, Nagasaki Pref., Sept. 24, 1976, leg. T. YOTSUI" SAP 043707.

Fig. 74. Distribution of *Sargassum autunnale*, compiled from specimens in SAP.
Japanese species of Sargassum subgenus Bactrophycus


The plants of this taxon were usually referred to S. tortile (=S. siliquastra) by earlier authors. Characters such as slender leaves often assuming filiform shape, maturation in autumn to winter, are sufficiently different from S. siliquastra which has wider leaf especially on young shoots and maturation period in spring to early summer. S. autumnale grows at shallower and more protected places than S. siliquastra.

(Figs. 75–81)


Fucus siliquastra MERTENS ex TURNER 1809: 26, pl. 82. Lectotype: BM “Port. Nangasaki” (Fig. 77 A).

Cystoseira siliquastra (MERTENS ex TURNER) C. AGARDH 1824: 288.

Halochloa siliquastra (MERTENS ex TURNER) KÜTZING 1843: 55; 1849: 634; 1860: 34, pl. 97, f. 1.

Fucus scoparius MERTENS ex TURNER 1809: 156, pl. 132. Lectotype: BM “e mari Coreano” (Fig. 77 C).


Halochloa scoparia (MERTENS ex TURNER) KÜTZING 1843: 55; 1849: 634; 1860: 33, pl. 97.

Fucus tortilis C. AGARDH 1812: 6. Lectotype: LD (Herb. Agardh No. 2933 “ex Brasilia, Tilesius”) (Fig. 78 A).


Fucus tortilis var. angustifolius C. AGARDH 1812: 6. Lectotype: LD (Herb. Agardh No. 2931 “Japonia, Tilesius”) (Fig. 78 B).


Halochloa macracantha KÜTZING 1843: 55; 1843a: 366; 1849: 633; 1860: 34, pl. 97, f. 2. Lectotype: L 937. 55. 274 “Japansches Meer” (Fig. 79 A).

Sargassum macracanthum (KÜTZING) ENDLICHER 1843: 31.

Sargassum tortile var. macracanthum (KÜTZING) GRUNOW 1915: 344.
Halochloa polyacantha KÜTZING 1843: 56; 1843 a: 367; 1849: 633; 1860: 34, pl. 98, f. 1.
   Lectotype: L 937.71.508 “Japanisches Meer” (Fig. 78 C).
Sargassum polyacanthum (KÜTZING) ENDLICHER 1843: 31.
Sargassum tortile var. polyacanthum (KÜTZING) GRUNOW 1915: 345.
Halochloa tenuis KÜTZING 1843: 56; 1843 a: 367. Lectotype: L 937.71.683 “Japan” (Fig. 78 E).
Sargassum tenuis (KÜTZING) ENDLICHER 1843: 31.

Fig. 75. Sargassum siliquastrum (TURNER) C. AGARDH.
Japanese species of *Sargassum* subgenus *Bactrophycus*

*Sargassum scoparium* var. *tenuis* (Kützing) Grunow 1915: 346.

*Halochloa pachycarpa* Kützing 1843: 55; 1843 a: 366; 1849: 634; 1860: 34, pl. 96. Lectotype: L 937.71.695 “Japanisches Meer” (Fig. 79 C).

*Sargassum pachycarpa* (Kützing) Endlicher 1843: 31.

*Sargassum scoparium* var. *pachycarpa* (Kützing) Grunow 1915: 345.

Fig. 76. *Sargassum siliquastrum* (Turner) C. Agardh.
Sargassum corynecarpum Harvey 1859:325. De Toni 1895:25. Grunow 1915:348. Dawson 1959: 6, pl. 4. Type: TCD “ad litora Japoniae prope Simoda, leg. C. Wright” (Fig. 80 A).

Sargassum tortile f. ulophylla Grunow 1915: 345. Type not located “in mari Japonico, Kiushu, leg. Rein”.


Sargassum siliquastrum var. niponensis Grunow 1915: 347. Type not located “in mari Japonico Nangasaki, leg. Schottmüller”.

Sargassum siliquastrum var. capitellata Grunow 1915: 348. Type not located “in mari Japonico, leg. Gaertner”.

Japanese name: Yore-moku.

Thallus usually over 1 m high, attaining several meters. Holdfast conical, up to 3–4 cm in diameter. A single stem arising on top of the holdfast, branching several times, 2–3 cm high. In individuals several years old, growth of holdfast burying the lower part of the stem resulting in an appearance that 2 or more stems arising from the same holdfast. Main branches issued from the distal part of the stem, flat below and triquetrous above, accompanied by the change of phyllotaxis from 1/2 to 1/3, usually with entire edges, but sparsely beset with acute spines on the edge. Leaf near the base of the main branch elliptical to lanceolate in shape, 3–4 cm long and 1–1.5 cm wide with entire margin, often giving bluish iridescence while in the water, coriaceous in texture. Midrib immersed, evanescent near the apex. This type of leaf falling off after the main branch growing longer. Leaf becoming abruptly longer and larger, up to 10 cm long and 1–1.5 cm wide, with conspicuous serration on the margin. Serration on the margin very variable. Single serration being more common, with deep sini reaching to the midrib, giving an appearance of filiform midrib and alternately arising linear spines. Double serration observed in several individuals. Cryptostomata scattered on leaf surface. Vesicle obovoid to elliptical in shape, 10 mm long and 8 mm in diameter, with mucronated apex or with coronal leaf up to 3 cm long. Vesicles on the distal part of the thallus becoming smaller and narrower to fusiform in shape.

Plant dioecious. Receptacle spatulate to linear spatulate in shape, complanated with entire margin, sometimes more or less concave on one surface, rarely triquetrous and in some individuals receptacles with serrulate margin encountered. Receptacles disposing racemously or paniculately in the distal part of ultimate branches. Female receptacle 5–10 mm long and 2–4 mm wide. Male one up to 1.7 cm long and 2 mm wide. Maturation in spring to early summer in the southern part of its distribution, summer in northern extremes.
This species grows on rocks of subtidal zone down to 15 m deep.


Fig. 77. A. Lectotype of *Fucus siliquastrum* TURNER. "Port. Nangasaki" BM. B. Illustration of *Fucus siliquastrum* TURNER, Hist. Fuc. Pl. 82. C. Lectotype of *Fucus scoparius* TURNER. "e mari Coreano" BM. D. Illustration of *Fucus scoparius* TURNER, Hist. Fuc. Pl. 132.
Fig. 79. A. Lectotype of *Halochloa macracantha* KÜTZING. "Japanisches Meer" L 937. 55. 274. 
B. Illustration of *Halochloa macracantha* KÜTZING, Tab. Phyc. vol. 10, Pl. 97, f. 2.
C. Lectotype of *Halochloa pachycarpa* KÜTZING. "Japanisches Meer" L 937. 71. 695.
D. Illustration of *Halochloa pachycarpa* KÜTZING, Tab. Phyc. vol. 10, Pl. 96. Scale in A also for C.
Japanese species of Sargassum subgenus Bactrophyes 215


Fig. 80. A. Type of Sargassum corynecarpum HARVEY, "ad litora Japoniae prope Simoda, leg. C. WRIGHT" TCD. Reproduced from a photograph deposited in BM. B. Illustration of Sargassum corynecarpum HARVEY, taken from DAVIDSON (1959). C. A specimen (isotype?) of Sargassum corynecarpum HARVEY, deposited in BM.
Fig. 81. Distribution of Sargassum siliquastrum, compiled from specimens in SAP.

The taxon treated here under this name is one of the most difficult and confusing taxa among the species of the Bactrophyccus, called as Siliquastrum assemblage by Setchell (1933 a, p. 204). Currently the name S. tortile is adopted by most Japanese authors in wider or narrower sense.

As for the names given by earlier authors to this entity, Fucus siliquastrum Turner is the earliest one. This is lectotypified by a specimen in BM (Fig. 77 A). Setchell (1933 a, p. 193) wrote that no specimen could be located in Herb. Hooker at Kew. The lectotype specimen was used by Turner for his illustration of ‘Fuci’. This is a fertile female fragment of about 35 cm long, with spatulate receptacles, linear leaves and pyriform vesicles. The second species, Fucus scoparius Turner, is lectotypified by a specimen in BM (Fig. 77 C), which also escaped from the inspection of Setchell. This specimen is fertile male (?) fragment of distal part of a bigger plant. I cannot distinguish these 2 taxa at specific level.

Lectotype of Fucus tortilis C. Agardh (Fig. 78 A) is a fragmentary specimen representing a sterile state. C. Agardh noted the locality as ‘ex Brasilia’. As had been pointed out by J. Agardh (1848, p. 292), this specimen was most probably collected from Japanese coast by Tilesius. Var. angustifolius C. Agardh of this species, lectotypified by a specimen in LD (Fig. 78 B) has very narrow leaves and is also a sterile plant.

Kützing (1843), in erecting his new genus Halochloa, described new species H. macracantha, H. pachycarpa, H. polyacantha and H. tenuis,
basing on the specimens collected from Japan, which had been in possession of MERTENS and now kept in L (Figs. 78 C–E, 79). All these names are subsequently placed in the synonymy of *S. tortile* by YENDO (1907) and of *S. siliquastrum* by SETCHELL (1933 a). I also conclude that the above mentioned taxa fall into the same entity, as shown in a list of synonyms. Another name to be considered here is *S. corynecarpum* of HARVEY (1859). As shown in Fig. 80, specimens identified by HARVEY and his illustration (in DAWSON 1959) have elliptical leaves with entire margin and spatulate receptacles. It seems appropriate to place this name in the synonymy of the species concerned here. The name *S. siliquastrum* has priority over these names, and must be adopted as a legitimate name. SETCHELL (1933 a) applied this name in wider sense. I restrict the usage to that circumscribed above.

This species is distributed rather widely around Japan (Fig. 81) and also as far south to Hong Kong, according to SETCHELL (1933). Variation in subspecific level needs more extensive study.

In the conical holdfast of this species, growth rings are easily observed. YOSHIDA (unpublished) counted up to 4 rings in individuals collected from North Kyushu.

24. **Sargassum serratifolium** (C. AGARDH) C. AGARDH 1820: 16.

(Figs. 82–85)


*Fucus serratifolius* C. AGARDH 1815: 41. Lectotype: LD (Herb. Agardh No. 2939 “in mari Japonico prope Satsuma”) (Fig. 83 A).


*Halochloa longifolia* KÜTZING 1843 a: 367; 1860: 35, pl. 100 (non Fucus longifolius TURNER).

Type: L 937.55.94 “Japonia, TILESIIUS” (Fig. 83 D).

*Halochloa serratifolia* var. *longifolia* (KÜTZING) KÜTZING 1849: 632.

Japanese name: Usuba-nokogiri-moku (nov.).

Thallus 1 m or more in length. Holdfast discoid, 1–1.5 cm in diameter. Stem erect, arising on top of the holdfast, terete, 2–3 mm in diameter, up to 2 cm high, unbranched or once, rarely twice branched. A few main branches arising from the distal part of the stem. Main branch acipitous, up to 5 mm wide with smooth margin. Lateral branches well developed. Leaf issued from the basal part of main branch retroflexed conspicuously at the base, oval to lacerate with round apex in shape, up to 10 cm long and 2 cm wide, with entire margin, membranaceous in texture. Midrib elevating, attaining to the apex. Leaf in the lower to middle parts of the main branch linear with cuneate base and acute apex in shape, 10 cm long and 0.5–1 cm wide, shallowly serrate at margin. Midrib percurrent. Cryptostomata, rather rare,
Fig. 82. *Sargassum serratifolium* (C. Agardh) C. Agardh.
Fig. 83. A. Lectotype of Fucus serratifolius C. AGARDH. “in mari Japonico prope Satsuma” LD, Herb. Agardh No. 2939. B. A specimen of Fucus longifolius in BM. C. A specimen of Fucus serratifolius in PC, sent by MERTENS. D. A specimen of Halochloa longifolia KÜTZING. “Japonia, Tilesius” L. 937.56.94.
Japanese species of *Sargassum* subgenus *Bactrophycus*

scattered on the leaf surface. Vesicles spherical to elliptical, 10 mm long and 9 mm wide, beset with coronal leaf 2-3 cm long, similar to ordinary leaf.

The plant dioecious. Receptacles racemosely or paniculately disposing on the ultimate ramuli. Female receptacle linear lanceolate, 13 mm long and 1.8 mm wide. Male one linear, 10 mm long and 0.9 mm wide. Maturation in late spring to early summer.

This species grows in subtidal zone down to 17 m deep. One of the deep water species.


There are 8 sheets of specimens in the cover of *S. serratifolium* in LD, Herb. Agardh Nos. 2939-2946. Among them, Nos. 2939 and 2940 are collection of TILESIUS. I selected No. 2939 (Fig. 83 A) as the lectotype. Sheets Nos. 2941-2944 are collection of J. AGARDH sent from KJELLMAN, PETERSEN.

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**Fig. 85.** Distribution of *Sargassum serratifolium*, compiled from specimens in SAP.
and others. These specimens seemed to belong different entity from Nos. 2939 and 2940. The lectotype, its locality is indicated as ‘Satsuma’, is a sterile fragment of about 25 cm long. Sheet No. 2940 of Agardhian herbarium is a duplicate of the lectotype. Specimens deposited in BM(K) were sent by MERTENS. They were collected at ‘port. Nangasaki’ and have annotation label by SETCHEL as ‘Sargassum serratifolium’. One of them is shown in Fig. 83 B. In PC, 2 sheets of specimens referable to this entity were located. As shown in Fig. 83 C, this specimen was also sent from MERTENS. A specimen in L (No. 937.55.94) seems to be the same origin and used as a basis for Halochloa longifolia KÜTZING. All of these specimens are referable to the same taxon. They have in common thin membranaceous leaves with shallow serration on the margin and spherical vesicles. Margin of its ancipitous branch is smooth. These features contrast to a taxon with coriaceous leaf and branches with irregular projections on its margin and usually applied the name S. serratifolium by many Japanese authors. Several collections in SAP (Figs. 82, 84) accord well to the type of S. serratifolium. Description of them are given above.

Application of the name Fucus serratifolius C. AGARDH is somewhat complicated by the presence of F. serratifolius THUNBERG. On the first page of ‘Algarum decas quarta’ of C. AGARDH, a date ‘xv Junii MDCCXV’ was clearly given and this was taken as publishing date. Publication date of the name of THUNBERG is at present not clear (SILVA, personal communication), except that the issue of Nova Acta Regiae Societatis Upsaliensis appeared in 1815. I assume that the name of THUNBERG was published not earlier than June 15, to avoid further confusion concerning the name. YAMADA (1955, p. 82) stated that the specimen of F. serratifolius THUNBERG was referable to narrow-leaf form of S. tortile.

Section Repentia YOSHIDA, sect. nov.

Stem decumbent or procumbent, forming secondary attaching discs on the ventral surface. Main branch arising from dorsal side of the stem. Receptacle compressed or complanate.
(Figs. 86-88)

Holotype: SAP 034691 “Kominato, Chiba Pref., Oct. 23, 1979, leg. T. KONNO” (Fig. 87).
Isotype in the herbarium of Tokyo University of Fisheries.

Sargassum sagamianum YENDO (pro parte) 1907, pl. 17, f. 10. OKAMURA 1924, pl. 215.

Japanese name: Hira-neji-moku (YOSHIDA & KONNO)

Thallus up to 60 cm high. Stem decumbent or procumbent, 1.5–2 mm in diameter, up to 2 cm long, pseudodichotomously branched, interwoven with each other. Attaching discs small, numerously formed on ventral side of the creeping stem, sometimes fused with each other to form an irregularly shaped disc. Basal part of an individual forming a creeping mass of about 4–5 cm in diameter. Main branches issued vertically from dorsal side of the creeping stem, compressed with thin margin, 3–5 mm in width, 30–60 cm long, often strongly twisted, curving at the distal part in younger stage. Leaves issued alternately from the margin of the flat branch with phyllotaxis of 1/2 divergence. Leaves near the basal part of the main branch retroflexed, decurrent at the base, ovoid, elliptical to lanceolate in shape, 1–2 cm long and 5–8 mm wide, with entire margin, apex acute or blunt. Leaves in lower and middle parts of the main branch narrow lanceolate to linear, 4–6 cm long and 3–6 mm wide, also with entire margin, midrib evanescent, not reaching to the apex. Leaves on the upper part of the main branch and on lateral branches linear in shape. Leaves frequently becoming apparently secund because of the tortion of the branch, arranging along the external side of curved branch. Cryptostomata rare or nearly absent. Vesicle with short stipe 2–4 mm long, elliptical or fusiform in shape, 1–1.8 cm long and 4–6 mm in diameter, with mucronate apex or beset with linear coronal leaf up to 1 cm long. Vesicle formed singly in axil of leaf, rather few in number or wholly dropped off in older branches.

Plant dioecious. Receptacle spatulate or oblanceolate in shape, often forking 1 or 2 times, rarely 3 times, arranging in racemose or paniculate manner. Female receptacle 6–10 mm long, 1.5–2 mm wide. Male one longer than the female, 10–15 mm long. Maturation period in autumn to winter.

This species grows on rocks exposed to strong wave action, from lower intertidal to upper subtidal zones.

Fig. 86. *Sargassum okamurae* YOSHIDA et T. KONNO. A. Young plant. B. Terminal part of a branch with receptacles, collected at Sada misaki, Ehime Pref.
Japanese species of Sargassum subgenus Bactrophycus


Fig. 87. Holotype of Sargassum okamurae

Fig. 88. Distribution of Sargassum okamurae, compiled from specimens in SAP.
When describing his *Sargassum sagamianum*, Yendo (1907) included 3 taxa to it. Among them a taxon with above mentioned circumscription was recognized as an independent species by Yoshida & Konno (1983). This species was well illustrated by Okamura (1924, pl. 215).

Receptacle is variable as for the external form and frequency of forking. Eastern population has receptacles slenderer and forked frequently. Population of western extremity of its distribution has wider spatulate receptacles rarely forked. This geographical or clinal variation in receptacle morphology needs further study with plenty specimens and field observations.

26. *Sargassum nigrifolium* Yendo 1907: 127, pl. 16, f. 1-3. (Figs. 89-91)


Lectotype: TI "Misaki, Prov. Sagami, Aug. 1906" (Fig. 90).

Japanese name: Narasamo (Yendo).

Thallus less than 0.7 m long. Stem terete, branched, decumbent or procumbent, 1.5 mm in diameter. Attaching discs formed on the ventral surface of the creeping stem. Discs enlarging and fusing with each other to form an irregular mat with the stem. Main branches issued from the dorsal side of the stem, ancipitous except the very base, about 3 mm wide with smooth margin. Lateral branches short in length, appearing after the main branches attained their full length. Leaf shortly stipitate, elliptical to lanceolate, obliquely spatulate or nearly hemiphyllous in shape, with cuneate base and obtuse apex, 25 mm long and 10 mm wide in the lower leaf, becoming gradually smaller upwards, thick and cartilaginous in texture. Margin entire, evanescently costate. Several leaves formed near the stem extending horizontally, then the leaves becoming vertically disposed by a tortion at the petiole. Phyllotaxis of leaves on the main branch 1/2. Cryptostomata very rare or nearly absent. Vesicles formed singly in axil or on lateral branches, elliptical in shape, up to 12 mm long and 6 mm wide. Small coronal leaf often running downwards for some distance to form a narrow wing-like appendage.

Plant dioecious. Receptacle compressed, obvoid to spatulate in shape,
Japanese species of *Sargassum* subgenus *Bactrophycus*

formed singly or racemosely on a short ramulet in axil of a subtending leaf. Female receptacle 5 mm long and 3 mm wide, often provided with marginal dentation. Male one longer than the female, 7 mm long also with dentation.

*Fig. 89. Sargassum nigrifolium* YENDO. Young plant.
on the margin. Maturation in spring to early summer.

This species grows on rocks exposed to strong wave action in the lower intertidal zone.


Fig. 90. Lectotype of *Sargassum nigrifolium* YENDO. “Misaki, Prov. Sagami, Aug. 1906” TI.

Fig. 91. Distribution of *Sargassum nigrifolium*, compiled from specimens in SAP.
Japanese species of *Sargassum* subgenus *Bactrophycus*


This species is easily recognizable by its elliptical leaves with entire margin and a creeping stem. Construction of basal part with a prostrate stem resembles to that of *S. okamurae*.

Yendo (1907) classed this taxon in his Section *Micracanthae*. Discussion on the subgeneric relation is made in the note under *S. micracanthum*.


*Sargassum sagamianum* var. *yezoense* Yamada in Yamada et Kinoshita 1950: 8, pl. 52.
Kawashima 1963: 1, f. 1–2. Ogawa 1977: 73, f. 1–3. Lectotype: SAP 024318 “Nozuka, Shiribeshi Prov., Hokkaido, Aug. 1943, leg. Y. Yamada” (Fig. 94).

Japanese name: Ezo-no-neji-noku (Yamada)

Thallus less than 1 m in length. Holdfast small discoid. Stem terete, about 2 mm in diameter, branched, procumbent or decumbent, attaching to the substratum with small discs formed on the ventral surface of the stem. Main branches issued from the dorsal side of the creeping stem, triquetrous with round edges, 2–3 mm wide, often loosely twisted. Lower leaves spread horizontally, shortly stipitate, not retroflexed at the base, long elliptical to broad linear in shape, 2–4 cm long and 5–8 mm wide, with obtuse apex and cuneate base. Leaf margin entire or coarsely serrate. Midrib evanescent at a half length to the apex. Phyllotaxis of leaves on the main branch 1/3. Upper leaves linear or linear lanceolate, sparsely serrate on the margin. Cryptostomata usually present but difficult to discern, sometimes very rare. Vesicles stipitate, long elliptical to fusiform in shape, 8 mm long and 5 mm wide, mucronate or with linear coronal leaf.

The plant usually dioecious. Receptacles flat, broad spatulate or obovoid in shape, with slightly emarginate apex, formed singly or racemously in axil of the subtending leaf. Female receptacle 2.5–3 mm long, 1–1.5 mm wide. Male one more slender and longer. Maturation in summer.

This species grows on rather exposed rocks in a zone from lower intertidal to subtidal down to about 3 m deep.

Fig. 92. *Sargassum yezoense* (YAMADA) YOSHIDA et T. KONNO.
Fig. 93. *Sargassum yezoense* (YAMADA) YOSHIDA et T. KONNO. A, fertile plant. B, branch with female receptacles. C, branch with male receptacles.


Fig. 95. Distribution of Sargassum yezoense, compiled from specimens in SAP.
Japanese species of *Sargassum* subgenus *Bactrophycus*


YOSHIDA & KONNO (1983) recently raised this taxon to specific rank, because it has lower leaves not retroflexed, its branches is triquetrous with rounded edges, its attaching discs are smaller, not forming solid holdfast, and it has distribution range chiefly on the coast of Japan Sea.

Although this taxon was not recognized by YENDO and OKAMURA, the specimens referable to this species were collected by PETERSEN in Hakodate and classed in the cover of *S. corynecarpum* by J. AGARDH in his herbarium (LD, Herb. Agardh Nos. 2992–2994).

(Figs. 96–99)  
**Holotype**: SAP 025741 “Jyogashima, Kanagawa Pref., May 1950, leg. Y. YAMADA” (Fig. 98).  
*Sargassum sagamianum* YENDO 1907: 151 (pro parte).  
Japanese name: Azuma-neji-moku (YOSHIDA & KONNO)

Thallus up to 1.5 m or more in length. Stem terete, procumbent or decumbent, branching several times, forming attaching discs on its ventral surface. The attaching discs developing well to fuse each other and with stem to form a solid basal system. Main branches issued from the drosal side of the creeping stem, triquetrous with sharp edges, 3 mm wide, more or less twisting. Lateral branches developing up to 40 cm long. Leaves on the lower part of the main branch disposing spirally with 1/3 phyllotaxis, spreading horizontally, and retroflexing with decurrent base, ovate or spatulate in shape, with entire margin. Leaves on middle or upper part of the main branch lanceolate to linear in shape, about 4 cm long and 3–6 mm wide, with sparse serration on the margin. Midrib not conspicuous. Cryptostomata sparse or nearly absent, and difficult to discern. Vesicles rather few in number, with short stipe 2–4 mm long, elliptical or fusiform in shape, 1.5–2 cm long and 4–6 mm in diameter, mucronate or with linear coronal leaf up to 1 cm long.

Plant dioecious. Receptacles compressed, obovate or spatulate in shape,
formed singly or in racemose manner on ramulet in the axil of bracteal leaf. Female receptacle 6-8 mm long and 2.5-3 mm wide, and male one 10-13 mm long, 2-2.5 mm wide. Maturation in late spring to summer. Color blue-greenish brown with bluish iridescence in living state, becoming

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Fig. 96. *Sargassum yamadae* YOSHIDA et T. KONNO.
dark brown to almost black in drying.

This species grows on rocks exposed to strong wave action, from lower intertidal to subtidal zones down to 2 m deep.


This species was included in *S. sagamianum*. YOSHIDA & KONNO (1983) are of opinion that this taxon must be separated from *S. sagamianum*, by
its decumbent stem, its spatulate receptacles matured in spring to early summer.

**Doubtful or insufficiently known species**

The following species credited to Japan and adjacent waters are insufficiently known.

*Anthophycus japonicus* Martens 1866: 115. Collected at Yokohama. De Toni (1895, p. 122) referred it doubtfully to the genus *Carpophyllum*. While Yendo (1907, p. 65) considered that it was a synonym of *S. patens* in the subgenus *Schizophycus*. Grunow (1915, p. 343) was of opinion that it was referable to *S. ringgoldianum* and named it as var. *costata* at variety rank. Examination of specimen is necessary before further discussion is made.

*Halochloa heterophylla* Martens 1866: 117. Collected at Chee-Fu, China. Grunow renamed this taxon as *S. alloiophyllum* in transferring to the genus *Sargassum*. Tseng & Chang (1954, p. 239) referred it under synonymy of *S. pallidum*.

*Sargassum fuliginosum* Kützing 1849: 612. Type: L 937.71.361 “Kamtschatka, Horner”. On the label of the specimen, the locality was written as Kamtschatka. However, this specimen seems to belong to the subgenus *Sargassum*. I presume that this specimen was collected in the warmer sea, and erroneously referred to Kamtschatka.
Sargassum hemiphylloides Kützing 1849: 608. Type: L 937.84.37 “Java, ZOLLINGER No. 2385”. The type is a small fragment of about 7 cm long. Leaves are hemiphyllous and in this respect similar to S. hemiphyllum, but other features show that this is a species of the subgenus Sargassum, not of the Bactrophycus, though Yendo (1907, p. 99) placed it under the synonymy of S. hemiphyllum.

Sargassum oophorum Grunow 1915: 349. Habitat unknown. Grunow enumerated it just after S. fulvellum. Relation between them is at present unknown.

Several subspecific taxa were described by Grunow (1915): Sargassum serratifolium f. poliophyllum, f. subserra, var. amblyocystum, var. fecundum. The type material of most of them are at present not located. Among these taxa, specimens identified as S. serratifolium var. poliophyllum are housed in PC and UC. The 2 specimens seemed to difficult to attribute to the same entity. As for other subspecific taxa, it is needed to locate the type material to extend further discussion.

Sargassum siliquastrum var. pyriferum Harvey 1859: 328. Harvey gave no figure of this taxon. Yendo (1907, p. 86) referred it doubtfully III the synonymy of S. tortile. Examination of the type is needed.

Pattern of geographical distribution around Japan

Species of the Bactrophycus are distributed only in the Northern Hemisphere. Northern limit of distribution seems to be north of Sakhalin island (Petrov 1968), and the record was represented by S. confusum (as S. pallidum). This is the northernmost locality for the genus as a whole. To the south, several species have their distribution range to Hong Kong, as documented by Setchell (1931). But records from Viet-Nam of this subgenus are rather doubtful.

In this study, I prepared distribution maps for each species. Specimens used as a basis for this are deposited in SAP and their localities are represented in the list of the “specimens examined” for each species. In a few cases, information from other sources is added. Distribution ranges of each species around Japan fall into several categories.

1) Species restricted to Pacific coast: S. ammophilum (Fig. 29), S. giganteifolium (Fig. 67), S. nipponicum (Fig. 35), S. okamurae (Fig. 88), S. sagamianum (Fig. 61), S. segii (Fig. 42), S. tenuifolium (Fig. 50), S. yamadae (Fig. 99), and S. yamamotoi (Fig. 46).

2) Species restricted to the coast of Japan Sea and west coast of Kyushu: S. autunmale (Fig. 74), S. microceratium (Fig. 13), S. pallidum (Fig. 19),
and *S. serratifolium* (Fig. 85).

3) Species distributed chiefly on the coast of Japan Sea, extending to northeast coast of Honshu and Seto Inland Sea: *S. confusum* (Fig. 16) and *S. yezoense* (Fig. 95).

4) Species distributed both Pacific and Japan Sea coasts: *S. filicinum* (Fig. 10), *S. fulvellum* (Fig. 27), *S. hemiphyllum* (Fig. 32), *S. horneri* (Fig. 8), *S. macrocarpum* (Fig. 70), *S. micrancanthum* (Fig. 64), *S. muticum* (Fig. 23), *S. nigrifolium* (Fig. 91), *S. siliquastrum* (Fig. 81) and *S. thunbergii* (Fig. 25).

5) Species seems to be restricted to Seto Inland Sea: *S. trichophyllum* (Fig. 58). This species was originally recorded from Nagasaki, though I have not yet met with in the west coast of Kyushu.

Recent extension of distribution of *S. muticum* to the Pacific coast of North American and to European coasts was artificially introduced and not to be considered here.

**Acknowledgements**

I wish to express my heartiest thanks to Professor Munenao KUROGI, Hokkaido University, for his encouragement throughout this study and for his critical reading of the manuscript. Cordial thanks are due to Mr. Toshinori KONNO, Tokyo University of Fisheries, for providing me valuable information and discussions on many aspects. I want to express my appreciations to Dr. W. F. PRUD’HOMME VAN REINE, Rijksbureau Leiden, Dr. J. H. PRICE, British Museum of Natural History, Professor S. SNOGERUP, Botaniska Museet Lund, and Dr. F. ARDRE, Laboratoire de Cryptogamie, Museum National d’Histoire Naturelle de Paris, for their kindness in examining herbarium specimens. Thanks are due to Dr. Masao OHNO, Kochi University, Dr. Toshio YOTSUI, Nagasaki Prefectural Institute of Fisheries, Dr. Hitoshi KITO, Seikai Regional Fisheries Research Laboratory, Dr. Michio MASUDA, Hokkaido University and many others contributed many specimens at my disposal and aided me in many ways during the study. I am also grateful to Professor Hideo TOYOKUNI, Shinshu University, for the correction of Latin description. Special thanks are due to Miss Toki OKABE who provided all the line drawings.

It is my pleasure to dedicate this work to the late Professor emeritus Yukio YAMADA, who paid much effort to the systematics of *Sargassum* throughout his carrier. His accumulation of herbarium specimens and information concerning this group is the major base of my present work.
Japanese species of Sargassum subgenus Bactrophycus

Summary

Following the 5 subgenera system of J. AGARDH, the subgenus Bactrophycus of the genus Sargassum (Phaeophyta, Fucales) is here treated in a wider sense, including the Micracanthae of YENDO, defined as having horizontally spreading leaves at least in proximal part of the main branch, and producing usually simple receptacles, with the distribution range in temperate waters of the Northern Hemisphere.

Morphological relation of portions of the thallus is discussed with the developmental viewpoint. The stem is defined as a structure formed by the activity of an apical cell differentiated early in embryological development. Main branches are lateral formation from the stem without subtending leaf and bear leaves and lateral branches.

Twenty-eight species are credited to the Bactrophycus. Among them, S. autumnale and S. yamamotoi are described as new to science. In this subgenus, 4 sections are recognized by the characters of basal morphology, combined with the receptacle features whether it is terete structure or not. The section Spongocarpus, typified by S. horneri, has elongated stem, lateral formations always arising in axil of leaves, and terete receptacles. S. filicinum is included in this section other than the type species. The section Teretia is a group of species with more or less abbreviated erect stem and terete receptacles. This section is typified by S. confusum and contains the following species: S. microceratium, S. pallidum, S. muticum, S. thunbergii, S. fulvellum, S. ammophilum, S. hemiphyllum, S. nipponicum and S. miyabei.

The section Halochloa, typified by S. siliquastrum, differs from the Teretia in having flat or triquetrous receptacles. Other species composing this section are: S. segii, S. yamamotoi, S. tenuifolium, S. ringgoldianum, S. trichophyllum, S. sagamianum, S. micracanthum, S. giganteifolium, S. macrocarpum, S. autumnale, and S. serratifolium. The section Repentia (type species: S. okamurae) is defined by its prostrate stem, including S. nigrifolium, S. yezoense and S. yamadae.

Applications of older names described by various authors are strictly reexamined by selection and inspection of types for each name. Through this procedure, S. pallidum is concluded to be different taxon from S. confusum. The name S. siliquastrum has priority over S. tortile in the Siliquastrum assemblage. Utilization of the name S. macrocarpum to the species currently known as S. serratifolium by Japanese authors is argued. S. serratifolium is an independent entity. S. trichophyllum is revived for a taxon distributed in Seto Inland Sea, distinct from S. tortile of earlier authors.
For facilitating the identification, a key to the species is given, and line drawings are made from freshly collected materials. Maps are prepared to show distribution range for each species, based on specimens deposited in the herbarium of the Faculty of Science, Hokkaido University (SAP).

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