

# Problems in the identification of “*Sargassum duplicatum*” group

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**Abstract**—The morphological variations of characteristics of leaves and vesicles were studied in a *Sargassum duplicatum* Bory population from Owase, Mie Prefecture, Japan. Even in this small population, four morphologically different plants (type 1, 2, 3 and 4) were distinguished by their characteristics of leaf and vesicles, as follows. Type 1 had slender oblanceolate leaves and entire vesicles, type 2 had broader elliptical leaves and apiculated, or crowned or phyllocyst vesicles, type 3 had slender lanceolate leaves and variable vesicles, and type 4 had broader elliptical leaves and entire or apiculated vesicles, respectively. However, these all plants from Owase showed scutellate holdfasts and slightly compressed primary branches. From the characteristics of holdfast, primary branch and dioecious sexuality, all these plants (type 1 to 4) from Owase should be identified as *Sargassum duplicatum* Bory having very wide variation ranges of leaves and vesicles, regardless of few cup-shaped characteristic leaves.

Typical *S. duplicatum* has been usually distinguished its morphology of cup-shaped leaves, vesicles with horn-like appendages and dioecious sexuality in the receptacles. On the other hand, typical *S. crassifolium* showed the leaves with double seriated margin, phyllocyst-like vesicles, and monoecious sexuality in the receptacles. However, there were some confusing on the morphology of these leaves and vesicles, so these two species were now called the member of “*S. duplicatum*” group including several species (*S. cristaefolium*, *S. turbinatifolium*, *S. turbinarioides* et al.). From the wide variation in the leaves and vesicles of *S. duplicatum* in Japan as above, we need furthermore study of morphological variations and DNA analysis on these species in the East Asian and Southeast Asian populations.

**Key words:** morphology, variation, *Sargassum*, *S. duplicatum*, *S. crassifolium*, *S. cristaefolium*, *S. turbinarioides*, *S. turbinatifolium*

## Introduction

Among the various features of warm to tropical water species of *Sargassum* (subgenus *Sargassum*), the species group of “*S. duplicatum*” was mainly characterized by different morphologies of the leaf margin. It could be separated into two types. In the first type, the leaf margin was “duplicated” or formed a pocket producing two rows of serration (=one row behind the end) (see Fig. 12 in Ajisaka et al. 1997). In the second type, the terminal leaf margin was expanded, leaving a depression that formed a shallow cup (=cup-shaped leaf) (see Fig. 11 in Ajisaka et al. 1997). The species which has the former characteristics has been named *S. crassifolium* J. Agardh, and the species having the latter characteristics named *S. duplicatum* Bory (Ajisaka et al. 1997), respectively. However, these characteristic leaves have already dropped in the early (young) stage of growing. So we could not find the characteristic leaves on the field plants of mature stage.

In the *Sargassum* specimens from Owase population, we could divide four types from the morphology of leaves and vesicles. Wide ranges of morphological variations of leaves

and vesicles were observed, measured and studied statistically. The result showed these were in the intra-species variation of one species, *S. duplicatum* Bory. However, many species with duplicated and/or cup-shaped leaves has been described in the world. Several species should be identified as the synonym to *S. duplicatum* or *S. crassifolium*. The type specimen of these species were only a part of the thallus, so we need furthermore studies on the morphological variations and DNA analysis in these species of “*S. duplicatum*” group.

## Materials and Methods

*Sargassum* plants were collected on Aug. 6, 2002, from Owase, Mie Prefecture. by Mr. S. Kamura (Inst. Marine Ecology Co. Ltd.). Samples were preserved in the Formaldehyde (Formaline) solution. Later, these specimens were dried and deposited in the herbarium of Kyoto University.

The morphological characteristics of these plants has observed on the preserved wet materials. After measurements of leaves and vesicles, statistical analysis were done. Cross sections of the receptacles were also observed under the microscope for the sexual determination.

## Results and discussion

### Observations (description) of four types in Owase population

From the observations on leaves and vesicles of the materials, four types of plants were divided in this population, as follows;

#### Type 1 (Fig. 1A, 2A and 3A)

Holdfast small scutellate, up to 18 mm in diameter. Stem terete, up to 10 mm high. Primary branches up to 75 cm in length, cylindrical at base, slightly compressed at lower to middle part, up to 3.0 mm in width, up to 2.0 mm in depth, with smooth surface. Primary leaves had already dropped. Secondary leaves slender oblanceolate, up to 53 mm in length, up to 13 mm in width, base cuneate, apex obtuse, margin entire or small dentate, midrib immersed, vanishing below the tip of the leaves, scattered small, conspicuous cryptostomata. Vesicles spherical to obovoid or ellipsoid, up to 13 mm in length, entire or rarely apiculated at apices, or with small spines, stalks terete or rarely leafy, up to 7 mm in length, shorter than the vesicles.

Plant dioecious. Female receptacles up to 8 mm in length, slightly compressed at distal part, with spines, simple or once divided, racemously arranged. Male receptacles unknown.

#### Type 2 (Fig. 1B, 2B and 3B)

Holdfast and stem unknown. Primary branches up to 67 cm in length, cylindrical at base, slightly compressed at lower to middle part, up to 2.5 mm in width, up to 2.0 mm in depth, with smooth surface. Primary leaves broader elliptical to oblong, up to 40 mm in length, up to 16 mm in width. Secondary leaves smaller elliptical to lanceolate, up to 28 mm in length, up to 13 mm in width, base cuneate, apex usually obtuse and rarely cup-shaped, margin entire to small dentate, midrib immersed, vanishing at the center of leaves, scattered small, conspicuous cryptostomata. Vesicles compressed ellipsoid or obovoid, up to 10 mm in length, with sharp spines, appendages or rarely phyllocyst/crown leaves, stalks terete, up to 3 mm in length, shorter than the vesicles.

Plant dioecious. Female receptacles up to 6 mm in length, compressed, with spines on the margin and distal part, simple and rarely once divided, racemously arranged. Male receptacles unknown.

#### Type 3 (Fig. 1C, 2C and 3C)

Holdfast unknown. Stem terete, up to 11 mm high. Primary branches up to 65 cm length, cylindrical at base, slightly compressed at lower to middle part, up to 3.0 mm in width, up to 2.5 mm in depth, with smooth surface. Primary leaves broader elliptical to lanceolate up to 43 mm in length,

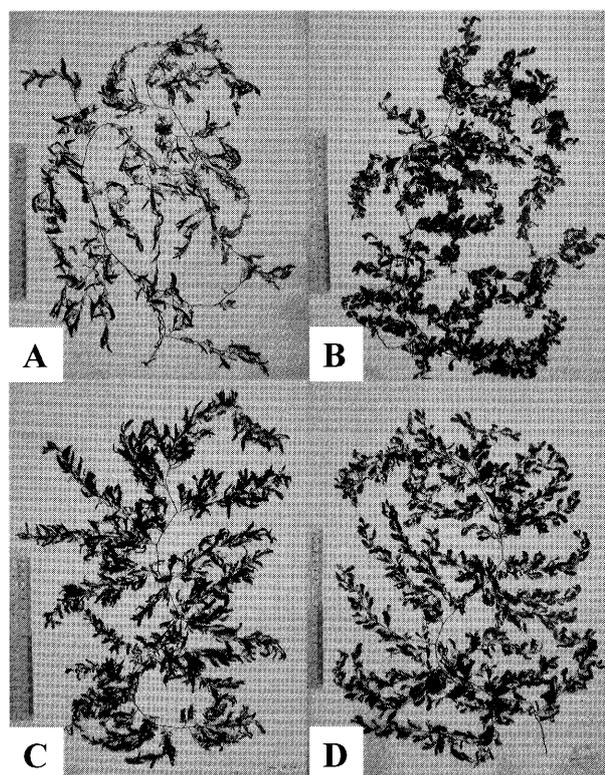


Fig. 1. Full dried specimens of type 1–4 in *S. duplicatum* Bory from Owase population.

up to 18 mm in width. Secondary leaves narrower elliptical to lanceolate, up to 40 mm in length, up to 14 mm in width, base cuneate, apex obtuse, margin entire to small dentate, midrib immersed, vanishing below the tip of the leaves, scattered small, conspicuous cryptostomata. Vesicles compressed ellipsoid or obovoid, up to 10 mm in length, with sharp spines or appendages or crown leaves, stalks terete, up to 3 mm in length, shorter than the vesicles.

Plant dioecious. Female receptacles slightly compressed, up to 7 mm in length, with spines on the distal part, simple or rarely once divided, racemously arranged. Male receptacles unknown.

#### Type 4 (Fig. 1D, 2D and 3D)

Holdfast and stem unknown. Primary branches up to 66 cm in length, cylindrical at base, compressed at lower to middle part, up to 3.0 mm width, up to 1.5 mm in depth, with smooth surface. Primary leaves broader elliptical to oblong up to 42 mm long, up to 22 mm wide. Secondary leaves narrower elliptical to lanceolate, up to 34 mm in length, up to 15 mm in width, base cuneate, apex obtuse, margin entire to small dentate, midrib immersed, vanishing below the tip of the leaves, scattered small, conspicuous cryptostomata, undulate and membranaceous. Vesicles compressed ellipsoid or obovoid, up to 9.5 mm in length, entire or with short spines, stalks terete, or rarely leafy up to 7 mm in length, usually shorter than the vesicles.

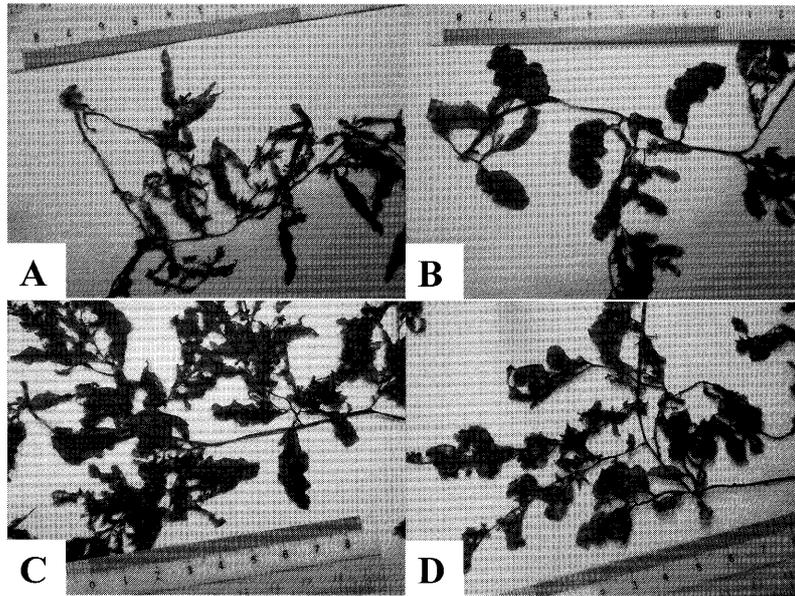


Fig. 2. Basal part of type 1–4 specimens in *S. duplicatum* Bory from Owase population.

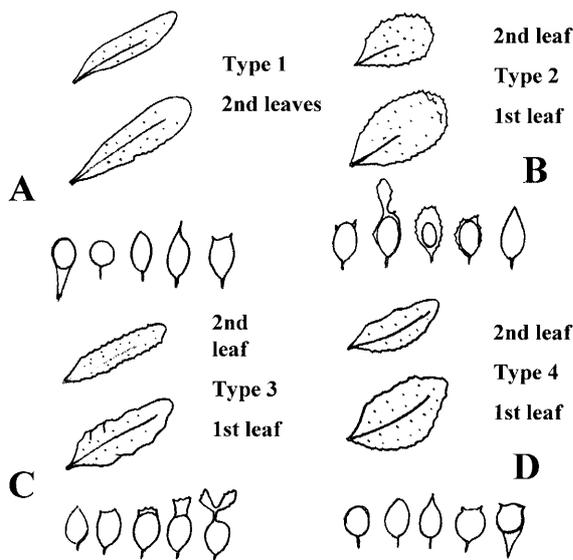


Fig. 3. Drawing of leaves and vesicles of the 4 types of *Sargassum* plants from Owase population.

Plant dioecious. Female receptacles slightly compressed or triquetrous, up to 9 mm in length, with spines on the margin and the distal parts, simple or rarely once divided, racemously arranged. Male receptacles unknown.

**Variation of morphology in leaves**

Rader charts (Fig. 4) were drawn from four morphological characteristics (length, width margin and W/L ratio) of the leaves in each type plant. One hundred leaves per each type were measured and compared in the secondary leaves of type 1, 3 and 4 plants, all leaves of type 2, and primary leaves of type 4. For good understanding in this figure, we use the converted parameters as margin\*4 and W/L\*10. From this figure, type 1 and 3 were shown to be a similar

shape, and type 2 and the secondary leaves of type 4 were shown to be longer leaves. However, type 2 showed very variable margin of leaves. The shape of figure between the primary leaves and the secondary leaves was similar in type 4 plant.

In type 2 plant, the primary leaves (n=11), secondary leaves (n=60) and tertiary leaves (n=29) were separated, and measured each other (Fig. 5). From this figure, leaf length seemed to be very conspicuously distinguished along the each order of leaves (Fig. 5 A–C), and margins variable in the primary leaves (Fig. 5 D–F).

**Variation of morphology in vesicles**

Rader charts figure (Fig. 6) were drawn from six morphological characteristics (length, width, stem length, stem width, crown length and crown width) of vesicles in each type plant. One hundred vesicles were measured and compared in each type plant. Type 1 and 4 were shown to be a similar shape. However, type 1 had no crown leaves, on the other hand, type 3 had many long crown leaves. Type 2 and 3 were shown to be an another similar shape. However, stem of type 4 was longer than type 2, on the other hand, the crown leaves of type 2 was longer than the vesicles of type 4. Morphological variations of the vesicles seemed to be different from that of the leaves of the same population.

**Receptacle**

Receptacles of type 1, 2 and 3 were slightly compressed and having spines on the margin. On the other hand, type 4 had compressed to triquetrous receptacles with sharp spines on the margin and the distal parts. In this time, as all samples collected from Owase had only female receptacles, we expected these plants are dioecious.

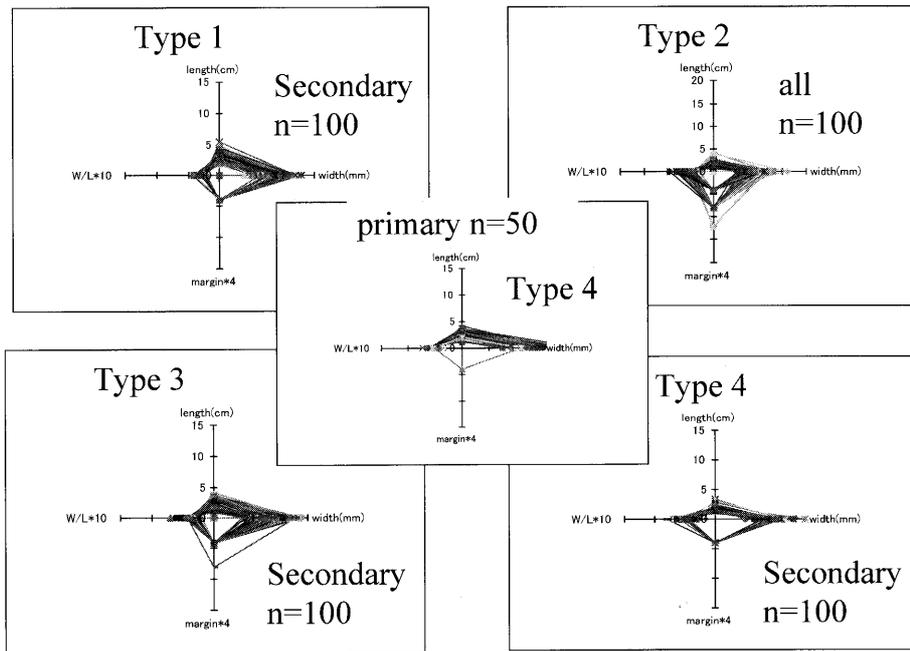


Fig. 4. Rader chart analysis by four characteristics of the *Sargassum* leaves from Owase population.

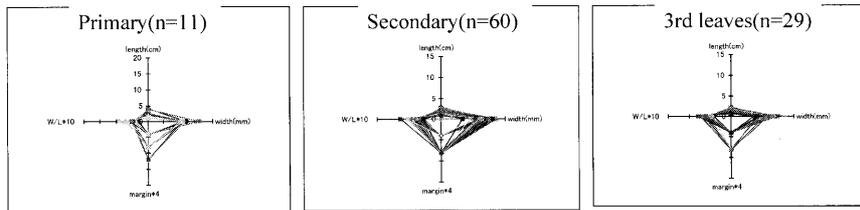


Fig. 5. Rader chart analysis by four characteristics of *Sargassum* leaves in type 2 from Owase population. Two variations are shown in the different scale of the length (cm and mm) of leaves.

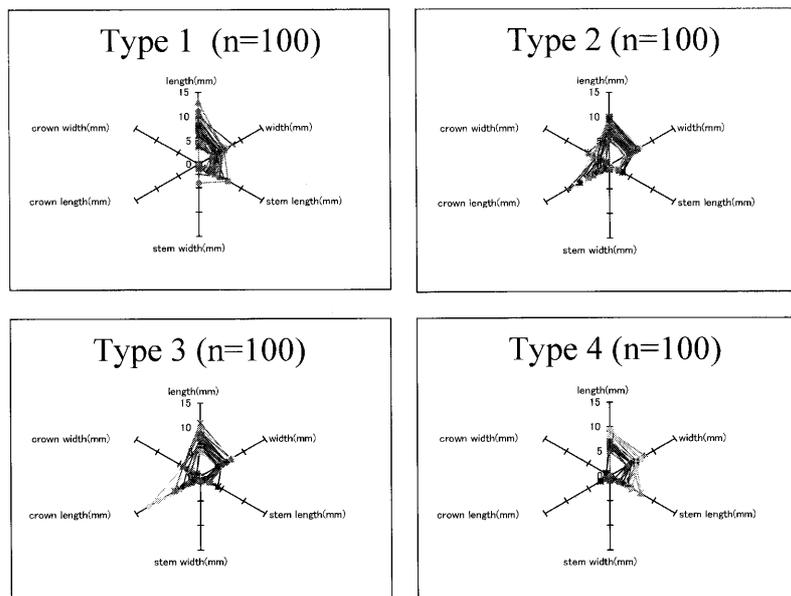


Fig. 6. Rader chart analysis by six characteristics of *Sargassum* vesicles from Owase population.

### Conclusion of the identification of the *Sargassum* plants from Owase

We found very wide range of morphological variations of leaves and vesicles (Figs. 4–6), however cup-shaped leaves has not observed in this sample plants. From these leaves and vesicles with horn-like appendages, and slightly compressed primary branches and scutellate holdfast, this plant should be identified as *Sargassum duplicatum* Bory. with wide variation of characteristics, regardless of few cup-shaped characteristic leaves.

These plants were growing on the tetrapods (2 m depth) near the waterspout of a thermal power station and a small river. Warmer temperature on account of the warm water discharged from the station and variable salinity on account of the freshwater flows from the small river may effect on the morphology of these plants.

### Species of “*Sargassum duplicatum*” group from Asian area

The subsection *Glomerulatae* was divided by Grunow (1915) into two subtribes: *Binderiana* and *Platycarpae*, which were later raised to the series, *Binderiana* and *Platycarpae* (Tseng et Lu 1995). The series *Platycarpae* is characterized by the multifarious filiform to subcylindrical nature of the upper parts of the primary branches, alternately giving rise to secondary branches from their foliar axils. J. G. Agardh (1889) listed the 9 species; *S. platycarpum* Montagne, *S. crassifolium* J. Agardh, *S. obovatum* (Harvey) J. Agardh, *S. duplicatum* Bory, *S. berberifolium* J. Agardh, *S. marginatum* J. Agardh, *S. cristae-folium* C. Agardh, *S. liebmanni* J. Agardh, and *S. hystrix* J. Agardh. Grunow (1915) accepted these 8 species, and renamed *S. berberifolium* J. Ag. as the var. *berberifolioides* of *S. spinipes* Grunow., and added 4 species; *S. polyceratium* Montagne, *S. spinipes* Grunow, *S. turbinarioides* Grunow and *S. telephyfolium* (Turner) C. Agardh. From China, Tseng et Lu (1997) reported 7 species in this series, *S. crassifolium*, *S. cristae-folium*, *S. duplicatum* and four new species. However, they reported *S. cristae-folium* was only dioecious species, and others were monoecious (androgynous) in the receptacles. In Japan and other countries, we recognized *S. duplicatum* is usually dioecious. The morphological differences in the morphology, Chinese new four species are not distinguished from their *S. duplicatum* from this study of morphological variations in Japanese *S. duplicatum* from Owase, as above.

*Sargassum sandei* Reinbold was reported from Indonesia, which leaves are cup-shaped and dioecious species (see Fig. 10 in Ajisaka et al. 1997). *S. turbinarioides* Grunow from Philippines (Trono 1992) and *S. turbinatifolium* Tseng et Lu from China (Tseng et Lu 1979) were also characterized from very small leaves, but it resembled *S. duplicatum* very much in the morphology. *S. meclurei* var. *duplicatum* also have cup-shaped leaves. However, from the *phyllocyst*, we

can distinguish these species easily from *S. duplicatum* in Vietnam. (Pham 1967)

The type specimen of *S. duplicatum* Bory is only a part of the thallus, which has few cup-shaped leaves (see Fig. 2 in Ajisaka 1997). The sexuality of the type specimen was unknown.

The information from the type specimen is very little, so we need complete study of morphology of the specimen (including morphological variations in each stage), the ecological study of the population and also the DNA analysis. In the Southeast Asian countries, we will start these researches in each populations for complete understanding the species identification of these “*S. duplicatum*” species group.

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### References

- Agardh, J. G. 1889. Species Sargassorum australiae descriptae et dispositae. Kgl. Svenska Vet.-Akad. Handl. 23(3): 1–133.
- Ajisaka, T., Huynh, Q. N., Nguyen, H. D., Baoren, L. Put, A. Jr., Moi, P. S., Noro, T. and Yoshida, T. 1997. Taxonomic and nomenclatural study of *Sargassum duplicatum* Bory and related species. In Taxonomy of Economic Seaweeds 6. Abbott, I.A. (ed.), pp. 27–36, California Sea Grant, California.
- Ajisaka, T. 2003. Taxonomy of *Sargassum* from tropical region. In Encyclopedia of Measurement and Analysis of Global Environment, vol. 3. pp. 829–830, Fuji Techno System Co., Tokyo. (In Japanese)
- Ajisaka, T. 2004. Problems of the taxonomical study of *Sargassum* in the Southeast Asian regions, and a proposal of procedure for the identification. Proceedings of the first joint seminar on coastal oceanography, pp. 173–177.
- Grunow, A. 1916. Additamenta ad cognitionem Sargassorum. Verh. Zool. bot. Gesell. Wien 66: 1–48; 136–185.
- Pham, H. H. 1967. Contribution l'étude des Algues littorales du Vietnam: Le genre *Sargassum*. Ann. Fac. Sci. Saigon, pp. 259–332.
- Reinbold, T. 1913. *Sargassum*. In Myxophyceae, Chlorophyceae, Phaeophyceae. Siboga Expedities, vol. 59a. Wever-van Bosse (ed.), A. Brill, Leiden, pp. 150–174.
- Trono, G. C. Jr. 1992. The genus *Sargassum* in the Philippines. In Taxonomy of Economic Seaweeds 3. Abbott, I. A. (ed.), pp. 43–94, California Sea Grant, California.
- Tseng, C. K. and Lu Baoren 1979. Studies on the Sargassaceae of the Xisha Islands, Guangdong Province, China, II. Stud. Mar. Sinica 15: 1–12.
- Tseng, C. K. and Lu Baoren 1995. Studies on the glomerulate *Sargassum* of China: I. The series *Binderiana*. In Taxonomy of Economic Seaweeds 5. Abbott, I. A. (ed.), pp. 67–74, California Sea Grant, California.
- Tseng, C. K. and Lu Baoren 1997. Studies on the *Glomerulate Sargassum* in China, IV. Series of *Platycarpae*. Taxonomic and nomenclatural study of *Sargassum duplicatum* Bory and related species. In Taxonomy of Economic Seaweeds 6. Abbott, I. A. (ed.), pp. 9–25, California Sea Grant, California.