

First Record of *Spatoglossum asperum* J. Agardh (Phaeophyceae, Ochrophyta) from Japan

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Abstract A benthic marine brown alga, *Spatoglossum asperum* J. Agardh (Phaeophyceae, Ochrophyta) was recorded from Japan and the East Asia for the first time. This species differs from the other two Japanese species of the genus *Spatoglossum*, *S. crassa* J. Tanaka and *S. latum* J. Tanaka, in having dentate margins, narrow apical marginal meristems consisting of 4–12 apical cells, thin medullary layers consisting of 1–3 cells, and spherical sporangia without stalk cells.

Key words: brown algae, Dictyotales, Japan, Phaeophyceae, *Spatoglossum asperum*, *Spatoglossum crassa*, *Spatoglossum latum*.

A brown alga referable to *Spatoglossum asperum* J. Agardh (Dictyotaceae, Dictyotales, Phaeophyceae) was collected from the coasts of the western Japan. This species has a wide distribution in the Indian Ocean and the west side of the Pacific Ocean, though this is the first report from the East Asia because the scarcity of macroscopic characters in this genus makes identification difficult. The *Spatoglossum* Kützting (1843, p. 339) is a macroalgal genus placed under the tribe Zonarieae with *Dictyopteris*, *Distromium*, *Padina*, *Zonaria*, etc., that have marginal rows of apical meristematic cells. The *Spatoglossum* species have flattened thalli lacking midribs and veins in surface view, and the thalli are composed of cortical and medullary cells irregularly arranged in transverse view. In the genus, twenty species are currently recognized from the tropical and temperate waters of the Indian Ocean, the Pacific Ocean and the Atlantic Ocean (Guiry and Guiry, 2010). In Japan, six species had been recorded so far: *Spatoglossum cornigerum* J. Agardh (Yendo, 1916), *S. solieri* (Chauvin ex Montagne) Kützting (Yendo, 1916), *S. variabile* Figari et De Notaris (Yendo, 1916), *S. pacificum* Yendo (Yendo, 1920), *S. crassum* J. Tanaka

(Tanaka, 1991), *S. latum* J. Tanaka (Tanaka, 1992). However, *S. cornigerum* sensu Yendo and *S. variabile* sensu Yendo were correctly referred to *S. pacificum* and *S. crassum* respectively by Yoshida *et al.* (1995) based on the personal communication with Dr. Jiro Tanaka and *S. solieri* sensu Yendo was treated as a synonym of *S. pacificum* by Tanaka and Yoshida in Yoshida (1998). In consequence, Yoshida and Yoshinaga (2010) listed three species as Japanese *Spatoglossum*: *S. crassum*, *S. latum* and *S. pacificum*. However, Hwang *et al.* (2004) transferred *S. pacificum* to the genus *Dictyopteris* based on the material from Korea.

In this study, to confirm the identity of the present plants collected from West Japan and to clarify the morphological characters for the species of *Spatoglossum* in Japan, anatomical observations were made on the material using a microscope. For preservation, the material was dried on sheets of paper or fixed in 10% Formalin-seawater. Voucher specimens were deposited in the algal herbarium of the National Museum of Nature and Science (TNS).

Descriptions

Dictyotales Kjellman in Engler et Prantl, 1896
Dictyotaceae J.V. Lamouroux ex Dumortier, 1822

Spatoglossum asperum J. Agardh

Acta Univ. Lund. 29 (9): 36 (1894). [Type locality: Sri Lanka (Silva *et al.*, 1996)]. [Figs. 1–10]

Plants erect, up to 28 cm in height, epilithic, attached by a stipe with rhizoids on subtidal rocks. Thalli light to medium brown in color, flattened, irregularly or subdichotomously divided 2–5 times into spreading blades. Blades lanceolate to obovate, 1–6 cm in width, lacking entirely midribs and veins (Fig. 1). Margins of blade dentate or irregularly proliferous (Fig. 2). Apical marginal meristems narrow, composed of 4–12 cells (Figs. 3 and 10). Blades thin, 110–150 μm in thickness, composed of 1- or 2-layered cortex and 1–3 layered of medulla or lacking medulla. Cortical cells roundly quadrangular, 24–48 μm in width, 34–70 μm in height, pigmented, possessing many chloroplasts. Medullary cells irregularly arranged, 30–74 μm in width, 22–50 μm in height, colourless. Phaeophyceae hair tufts scattered on both surfaces of the thalli, arising from depressions (Fig. 4).

Sporangia scattered over both sides of the blades (Figs. 5 and 6), embedded in the cortical layer (Fig. 7), without stalk cells (Fig. 8), transformed directly from cortical cells (Fig. 9), spherical, 72–98 μm in height, 64–105 μm in width. Sexual reproductive organs not seen in the Japanese specimens.

Specimens examined: Kasumi, Kami-cho, Mikata-gun, Hyogo Pref., Japan (35°39'2"N, 134°37'44"E), 2 Aug. 1990, leg. T. Kitayama (TNS-AL 158690); Kurosaki, Nushima Isl., Minami-awaji-shi, Hyogo Pref., Japan (34°10'49"N, 134°49'15"E), 1 Aug. 1990, leg. T. Kitayama (TNS-AL 158691–158695).

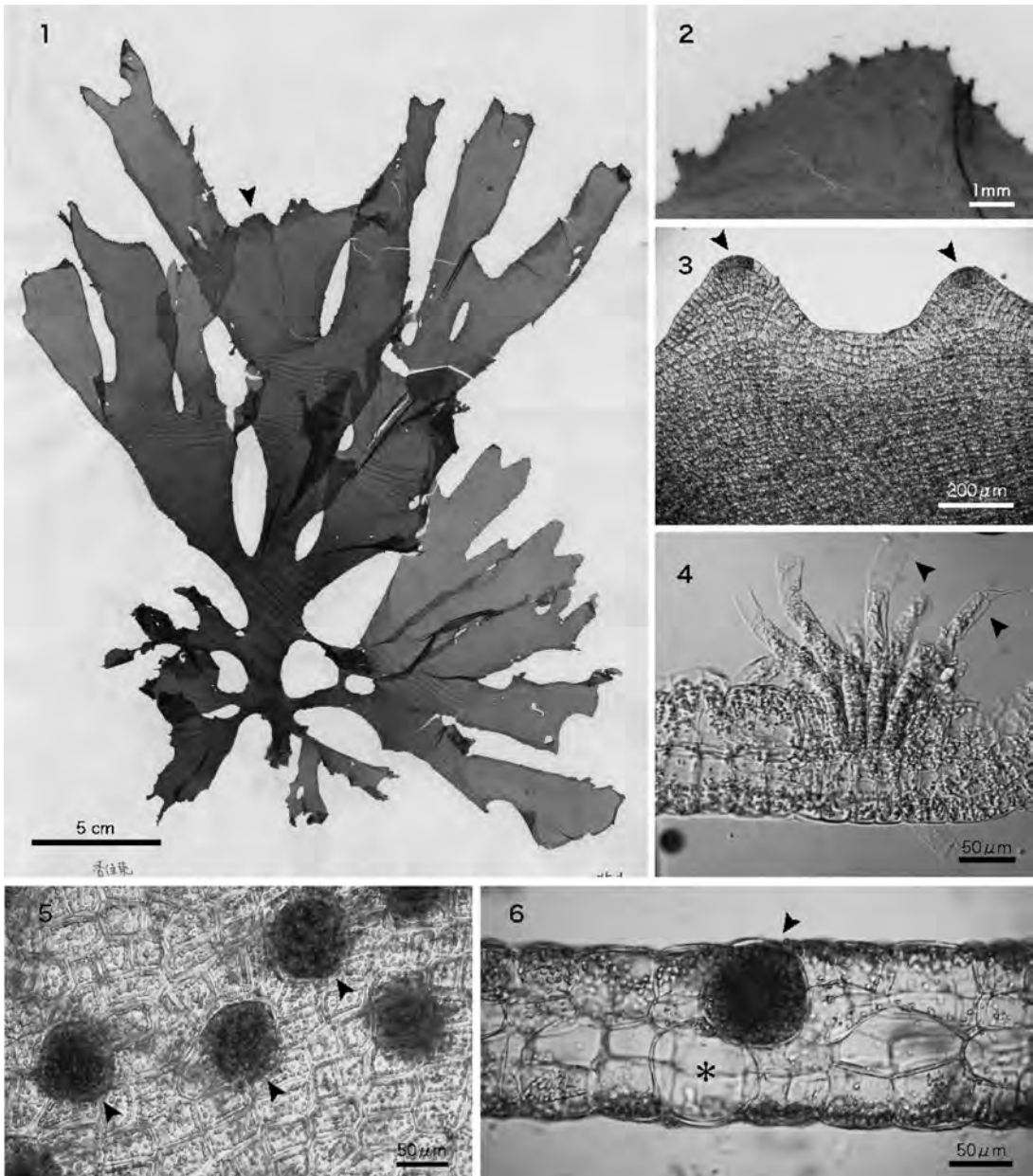
Japanese name: Monnashi-gusa (nom. nov.).

Distribution: *Asia*: Japan (Hyogo Pref.), Philippines (Silva *et al.*, 1987; Trono, 1997); *Oceania*: Australia (Kraft, 2009), French Polynesia (N'Yeurt and Payri, 2006), New Caledonia (Garrigue and Tsuda, 1988); *Indian Ocean*:

Andaman Isl., India, Nicobar Isl., Pakistan, Sri Lanka, Yemen (Silva *et al.*, 1996), Oman (Wynne and Jupp, 1998); *Africa*: Kenya, Madagascar, Mauritius, South Africa, Tanzania (Silva *et al.*, 1996).

Remarks: The present *Spatoglossum* plants from Hyogo Prefecture, the western Japan are in strikingly morphological agreement with Australian plants of *Spatoglossum asperum* J. Agardh described by Kraft (2009, p. 233, fig. 76) in both of vegetative and reproductive morphology (Table 1). In addition, the Pakistan plants of *S. asperum* described by Nizamuddin and Perveen (1986) is also similar to the Japanese plants, though there are a couple of differences in morphology of reproductive organs: conical sporangia with stalk-like cells (Table 1), though it seems that the cells are not real stalk cells because there are two cells under the sporangium judging from the illustration (Nizamuddin and Perveen, 1986, f. 2D). However, the Mauritius plants of *S. asperum* illustrated by Børgesen (1941, 1957) differ from the Japanese plants in having thick medulla composed of over 10 layers of cells (Børgesen, 1957, f. 2). Although more information about the entity of the species are required, I regard the present Japanese plants as *S. asperum* because it has a distribution in the tropical to warm temperate Indo-West Pacific and broad thin thalli with dentate margins and spherical sporangia without stalk cells.

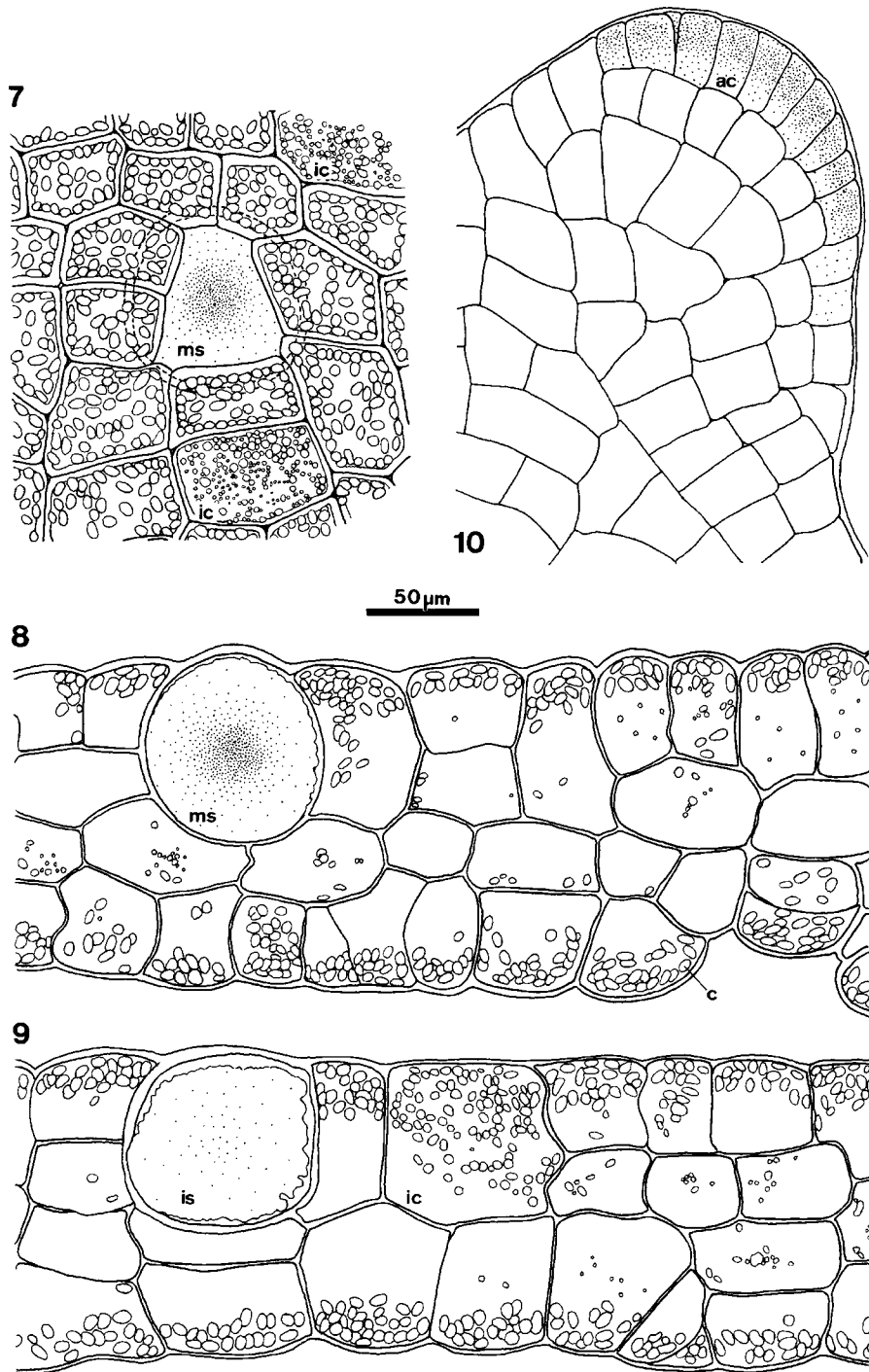
The plants of *Spatoglossum asperum* can be distinguished from the other two Japanese species, *S. crassum* J. Tanaka and *S. latum* J. Tanaka, by the following morphological characters: 1) conspicuous dentate margins, 2) narrow apical marginal meristems consisting of 4–12 apical cells, 3) thin medulla composed of 1 to 3 layers of irregularly rectangular cells, 4) spherical sporangia lacking stalk cells. In particular, formation of spherical sporangia embedded without stalk cells can be regarded as a notable feature of the species. The initial cells of sporangia become spherical slightly increasing the size when mature, and the adjoining cortical cells tend to decrease their size. Thus the exposure



Figs. 1–6. *Spatoglossum asperum* from Kasumi, Hyogo, Japan (TNS-AL 158690). 1. Habit. 2. Detail of dentate margins of the thallus (arrowhead in Fig. 1). 3. Apical growth zones with several apical cells (arrowheads). 4. Transverse section of young blades with a deeply inset tuft of phaeophycean hairs (arrowheads). 5. Surface view of a blade showing sporangia (arrowheads). 6. Transverse section of a blade showing two sporangia: one (arrowhead) filled with a spherical reproductive body and another evacuated (asterisk).

areas of the mature sporangia on the surface of cortex are considerably small (Fig. 7). In *S. asperum* the sporangia are considered to be developed directly from the cortical cells inside the cortex,

without producing any new reproductive cells and any supporting or stalk cells outside the initial cells (Fig. 9). According to the original descriptions (Tanaka, 1991, p. 577, 1992, p. 29), in



Figs. 7–10. *Spatoglossum asperum* from Kasumi, Hyogo, Japan (TNS-AL 158690). 7. Surface view of the thallus showing a mature sporangium (ms) embedded in a cortical layer and two initial cells of sporangium (ic). 8–9. Transverse section of blades showing a mature sporangium (ms), an immature sporangium (is) and initial cell of sporangium (ic); chloroplasts (c) clustered in the outer side of the cortical cells, while the initial cell of sporangium (ic) filled with scattered many reduced chloroplasts. 10. Surface view of a tooth in dentate margin of the thallus showing apical cells (ac).

Table 1. Morphological comparison of *Spatoglossum asperum* and the original descriptions of *S. latum* and *S. crassum*

	<i>S. asperum</i> (Present plants)	<i>S. asperum</i> (Kraft, 2009)	<i>S. asperum</i> (Nizamuddin and Perveen, 1986)	<i>S. latum</i> (Tanaka, 1992)	<i>S. crassum</i> (Tanaka, 1991)
Width of blades (cm)	1–6	1–5	—*	3–8	0.6–1.8
Thickness of blades (μm)	110–150	160–200	—*	260–350	300–600
Margins	dentate	smooth or spinous	denticulate	entire	entire
Number of apical cells	4–12	—*	—*	20–40	10–20
Width of cortical cells (μm)	24–48	25–40	20–68	20–40	15–20
Height of cortical cells (μm)	34–70	25–45	20–92	50–60	50–60
Width of medullary cells (μm)	30–74	—*	52–144	50–60	50–80
Height of medullary cells (μm)	22–50	—*	40–80	80–120	60–120
Number of medullary cells	(0)1–3	2–3	4	3–6	—*
Phaeophyceae hair tufts	present	present	present	present	absent
Sporangia	spherical	spherical**	conical**	conical	conical
Height of sporangia (μm)	72–98	65–100	80–120	70–110	80–145
Width of sporangia (μm)	64–105	65–100	45–90	60–95	70–100
Stalk cells of sporangia	absent	absent	present (?)	present	present

* no description.

** Judging from their photos and illustrations.

S. crassum and *S. latum*, flat stalk cells are formed by transverse division of the sporangial initials, though Tanaka and Yoshida in Yoshida (1998, p. 232) described that the stalk cells are absent in *S. latum*. It is considered in general that differences in manner of forming sporangia are useful for distinction among these species. In an outward appearance, however, *S. asperum* shares a close similarity with *S. latum* because of the broad and thin thalli. Thus it is not easy to distinguish the both species without anatomical observation on the apical and medullary cells using a microscope. It may be possible that distributional records of *S. latum* include the ones of *S. asperum*. On the other hand, *S. crassum* differs strikingly from *S. asperum* and *S. latum* in having linear thalli and thick thalli with small cortical cells (under 20 μm in width) (Table 1).

Spatoglossum asperum J. Agardh also differs from the four species of *Spatoglossum* recorded from the Japanese coasts by Yendo (1916, 1920): *S. cornigerum* J. Agardh, *S. solieri* (Chauvin ex Montagne) Kützing, *S. variabile* Figari et De Notaris and *S. pacificum* Yendo. Of these, the occurrence of *S. cornigerum*, *S. solieri* and *S. variabile* in Japan had been pointed out to be doubtful by

Okamura (1936) and Tanaka (1991, 1992). The Austlarian species *S. cornigerum* was synonymized to *S. macrodontum* J. Agardh by Allender and Kraft (1983). *S. macrodontum*, which is also Australian species, is different from *S. asperum* in lacking stalk and attaching by prostrate strap-like holdfast (Kraft, 2009). The type species of the genus, *S. solieri*, which is distributed in the Mediterranean Sea and Africa, has no dentate margins (N'Yeurt and Payri, 2006). Also *S. variabile*, which is distributed in the Indian Ocean and Africa, has no dentation on the margin, according to the description by Nizamuddin and Perveen (1986). However, information on these species is insufficient to discuss on the relationships with *S. asperum*. *S. pacificum* is different from not only *S. asperum* but also probably all members of *Spatoglossum* in having protuberant reproductive organs on the outside cortex. Lee and Lee (1996) noted that *S. pacificum* from Korea has a partial midrib-like structure on the lower part of the thalli. Furthermore, Hwang *et al.* (2004) showed that *S. pacificum* has a strong relationship with *Dictyopteris divaricata* and *D. undulata* based on molecular analyses using plastid genes and anatomical observations on several

species of *Spatoglossum* and *Dictyopteris*. As a result, they proposed a new combination, *Dictyopteris pacifica* (Yendo) I.-K. Hwang, H.-S. Kim

et W. J. Therefore, three species are currently listed for *Spatoglossum* in the Japanese flora: *S. asperum*, *S. crassum* and *S. latum*.

Key to the species of *Spatoglossum* in Japan

- 1a. Thalli narrow, linear, straplike, up to 2 cm in width; cortical cells slender, smaller than 20 μm in width; phaeophycean hair tufts absent *S. crassum*
- 1b. Thalli broad, lanceolate to obovate, mostly 1–8 cm in width; cortical cells cubic, mostly 20–40 μm in width; phaeophycean hair tufts present 2
- 2a. Margins of blades entire; blades thick, mostly 260–350 μm in thickness; marginal apical growth regions broad, with 20–40 apical cells; medulla thick, 3–6 layered; sporangia conical, with stalk cells *S. latum*
- 2b. Margins of blades dentate; blades thin, mostly up to 200 μm in thickness; marginal apical growth regions narrow, with up to 12 apical cells; medulla thin, 1–3 layered; sporangia spherical, lacking stalk cells *S. asperum*

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References

- Allender, B. M. and Kraft, G. T. 1983. The marine algae of Lord Howe Island (New South Wales): the Dictyotales and Cutleriales (Phaeophyta). *Brunonia* 6: 73–130.
- Borgesén, F. 1941. Some marine algae from Mauritius. II. Phaeophyceae. *Kongelige Danske Videnskabernes Selskabs, Biologiske Meddelelser* 16: 1–81.
- Borgesén, F. 1957. Some marine algae from Mauritius. Final part. *Kongelige Danske Videnskabernes Selskabs, Biologiske Meddelelser* 23: 1–35.
- Garrigue, C. and Tsuda, R. 1988. Catalog of marine benthic algae from New Caledonia. *Micronesica* 21: 53–70.
- Guiry, M. D. and Guiry, G. M. 2010. AlgaeBase. World-wide electronic publication, National University of Ireland, Galway. <http://www.algaebase.org>; searched on 31 October 2010.
- Hwang, I.-K., Kim, H.-S. and Wook, J. L. 2004. Confirmation on taxonomic status of *Spatoglossum pacificum* Yendo (Dictyotaceae, Phaeophyceae) based on morphology and plastid protein coding *rbcL*, *rbcS*, *psaA*, and *psbA* gene sequences. *Algae* 19: 161–174.
- Kraft, G. T. 2009. Algae of Australia: Marine Benthic Algae of Lord Howe Island and the Southern Barrier Reef, 2: Brown Algae. vi+364 pp. Australian Biological Resources Study, Canberra.
- Kützing, F. T. 1843. *Phycologia generalis*. Leipzig, xxxii+458 pp., 80 pl.
- Lee, W. J. and Lee, I. K. 1996. Note on the Dictyotaceae (Phaeophyta) from Ullungdo Island, Korea. *Algae* 11: 59–64.
- Nizamuddin, M. and Perveen, S. 1986. Taxonomic studies on some members of Dictyotales (Phaeophyta) from the coast of Pakistan. *Pakistan Journal of Botany* 18: 123–135.
- N'Yeurt, A. D. R. and Payri, C. E. 2006. Marine algal flora of French Polynesia I. Phaeophyceae (Ochrophyta, brown algae). *Cryptogamie, Algologie* 27: 111–152.
- Okamura, K. 1936. Marine Algae of Japan. [Nippon Kaiso-shi]. 25+1222 pp. Uchida Rokakuho, Tokyo (in Japanese).
- Silva, P. C., Meñez, E. G. and Moe, R. L. 1987. Catalogue of the benthic marine algae of the Philippines. *Smithsonian Contributions to the Marine Sciences* 27: iv+1–179. Smithsonian Institution Press, Washington, D. C.
- Silva, P. C., Basson, P. W. and Moe, R. L. 1996. Catalogue of the benthic marine algae of the Indian Ocean. University of California Publications in Botany 79: xiv+1–1259.
- Tanaka, J. 1991. A new species of *Spatoglossum* (*S. crassum* sp. nov.; Dictyotales, Phaeophyceae) from Japan. *Phycologia* 30: 574–581.
- Tanaka, J. 1992. Morphology and taxonomy of *Spatoglossum latum* sp. nov. (Dictyotales, Phaeophyceae) from Japan. *Korean Journal of Phycology* 7: 27–32.

- Trono, G. C. Jr. 1997. Field guide and atlas of the seaweed resources of the Philippines. Bookmark, Makati. xx+306 p.
- Wynne, M. J. and Jupp, B. P. 1998. The benthic marine algal flora of the sultanate of Oman: new records. *Botanica Marina* 41: 7–14.
- Yendo, K. 1916. Notes on algae new to Japan. IV. The Botanical Magazine, Tokyo 30: 47–65.
- Yendo, K. 1920. *Novae algae Japonicae. Decas I–III.* The Botanical Magazine, Tokyo 34: 1–12.
- Yoshida, T. 1998. Marine Algae of Japan [Shin Nihon Kaiso-shi; Nihon-san Kaiso-rui Soran]. 25+1222 pp. Uchida Rokakuho, Tokyo (in Japanese).
- Yoshida, T., Yoshinaga, K. and Nakajima, Y. 1995. Checklist of marine algae of Japan (revised in 1995). *Japanese Journal of Phycology* 43: 115–171 (in Japanese).
- Yoshida, T. and Yoshinaga, K. 2010. Checklist of marine algae of Japan (revised in 2010). *Japanese Journal of Phycology* 58: 69–122 (in Japanese).