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First Report of *Polysiphonia morrowii* Harvey (Ceramiales, Rhodophyta) in the Mediterranean Sea

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Polysiphonia morrowii Harvey (Rhodophyta), native to Japan, Korea, China and Russia, is here reported for the first time from the Mediterranean Sea. Thalli were first found in 1999 off the Island of Chioggia, where imported clams and fish are handled; the following year, plants were also found near the Island of Venice itself. *Polysiphonia morrowii* is similar to *Polysiphonia senticulosa* Harvey, as reported from Japan and the north Pacific, and to *Polysiphonia stricta* (Dillwyn) Greville [= *Polysiphonia urceolata* (Dillwyn) Greville] from the Mediterranean basin. The specimens collected in the Lagoon of Venice are characterised by two of the most significant specific features of *P morrowii*: endogenous axillary branchlets forming from the central axial cells, and tufts of axillary tetrasporangial branchlets on the axils of mature plants. The morphology and reproduction of *P morrowii* are examined on the basis of the material collected at Venice.

Introduction

Within the framework of floristic macroalgal research in the Lagoon of Venice (islands of Chioggia and Venice), thalli of red alga, identified as *Polysiphonia morrowii* Harvey, have been found for the first time for the Mediterranean algal flora. This species was originally described by Harvey (1856) on the basis of specimens collected in Japan. It has also been reported from China (Segi 1951), Korea (Yoon 1986) and Russia (Perestenko 1980) and, as an introduction, in Australia (Womersley 1979), New Zealand (Nelson and Maggs 1996) and the Netherlands (Maggs and Stegenga 1998).

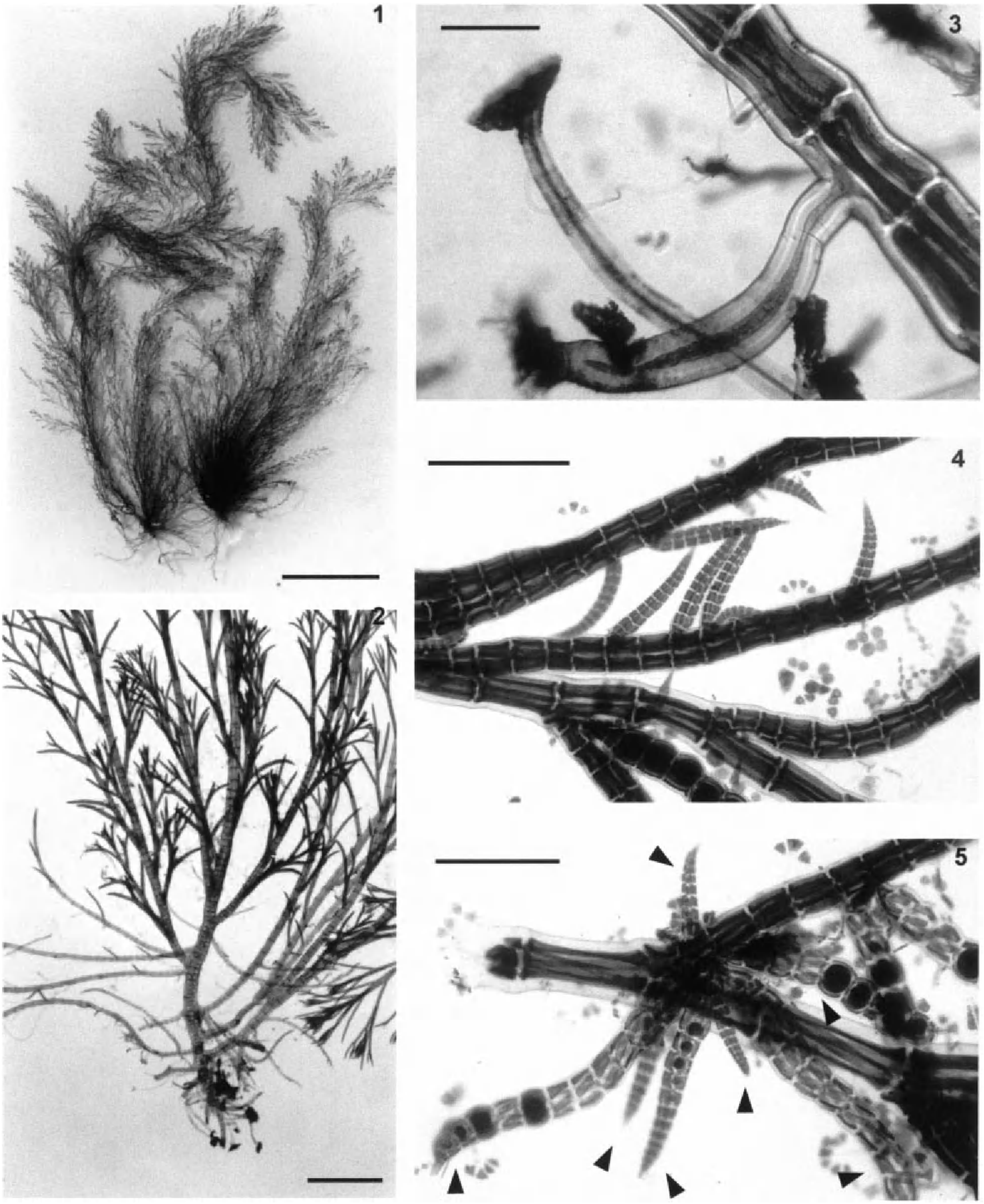
Polysiphonia morrowii is similar to *P senticulosa* Harvey and *P stricta* (Dillwyn) Greville [= *Polysiphonia urceolata* (Dillwyn) Greville]. According to Segi (1951) and Tokida (1954), the main features used to identify this species are: 1) tufts of axillary tetrasporangial branchlets, 2) endogenous axillary branchlets forming from the central axial cells, 3) dark reddish thalli and 4) length of segments of the main axis. However, these characters are regarded as varying with age and habitat (Kudo and Masuda 1981, Yoon 1986, Kim *et al.* 1994). Some authors state that *P senticulosa* is a synonym for *P. morrowii;* others note the need for further taxonomic studies (Kudo and Masuda 1981, Yoon 1986). To identify our *Polysiphonia*, the criterion used was the number of axillary tetrasporangial branchlets, considered by Kudo and Masuda (1988, 1992) to be the most prominent feature distinguishing the two species in fully mature plants: up to 7–8 in *P morrowii* and 3 or fewer in *P. senticulosa*. In the Mediterranean Sea no species belonging to the genus *Polysiphonia* bearing both endogenous axillary branchlets and axillary tetrasporangial branchlets has been reported previously. Only *P stricta* is similar to our plant in cystocarp shape, and in the thickness and length of segments of the main axis. This paper describes the habit, the vegetative and the reproductive morphology of *P morrowii* in the Lagoon of Venice. Data on the associated algal vegetation are also presented.

Materials and Methods

Specimens were collected on the Island of Venice from hard substrata such as wooden piles and embankments, between the intertidal and sublittoral zones. Field collections were carried out from December 1999 to July 2000. Occasional harvestings in Chioggia were carried out to verify the presence of this species. Each month, twenty plants were collected and preserved in 4 % Formalin seawater. Permanent slides were prepared for microscope observation. Monthly water temperatures varied between 6 °C in February and 25.5 °C in July and salinity between 23 and 37 ‰, with an average of 31 ‰.

Results

Macroscopic thalli appear in November–December and begin to wear off in July. In May and June, they are thickly covered by epiphytic algae. The plant (Figs 1–2) is composed of a primary upright axis and prostate filaments, tightly entangled and attached to the substratum with adventitious unicellular rhizoids. These rhizoids (25–90 µm thick and up to 1600 µm long) arise as outgrowths of pericentral cells without septation;

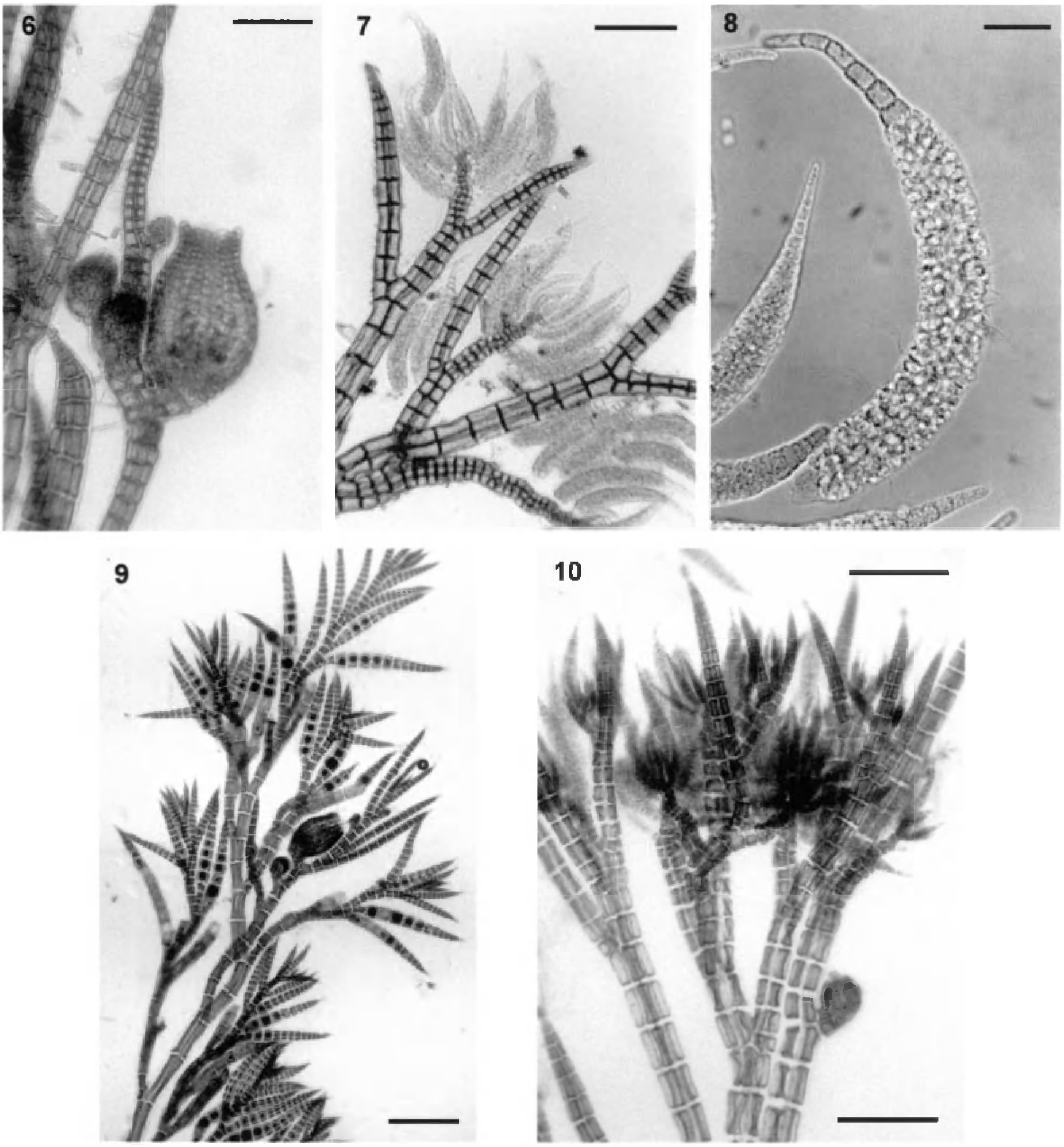


Figs 1–5.
Fig. 1. Herbarium specimens collected from the island of Venice (scale bar = 4 cm). Fig. 2. Primary upright axes and prostate branches (scale bar = 1 mm). Fig. 3. Unicellular rhizoid not cut off by cross wall (scale bar = 100 µm). Fig. 4. Adventitious branches forming endogenously (scale bar = 500 µm). Fig. 5. Axillary endogenous branchlets (arrowheads) with tetrasporangia (scale bar = 300 µm).

some of them are provided with discoid haptera (Fig. 3). They develop on prostrate filaments [65–115 μm thick and length/width (L/W) ratio of segment 1–1.3] or on the basal portion of erect axes; in June, adventitious rhizoids are observed on the apical portions of the main axes in tetrasporic plants. Upright axes are slender and elongate, reaching 50 cm and consisting of four pericentral cells without cortication.

The basal portions of the erect axes are 100–300 μm in diameter and the L/W ratio of the segment is 0.4–2; in the middle portion values are 150–225 μm in diameter and the L/W ratio is 5–20.

Most first-order indeterminate branches grow exogenously, usually every 3–7 segments, spirally arranged on a phyllotaxis of about ¼, except the lower branches which arise simply and are strongly recurved.



Figs 6–10.
Fig. 6. Urceolate mature cystocarp (scale bar = 250 μm). Fig. 7. Tufted spermatangial branchlets borne on ordinary branches (scale bar = 300 μm). Fig. 8. Spermatangial branchlet with a long sterile tip (scale bar = 70 μm). Fig. 9. Mixed-phase plant bearing two cystocarps and tetrasporangia (scale bar = 500 μm). Fig. 10. Mixed-phase plant bearing one cystocarp and spermatangia (scale bar = 300 μm).

The second-order branches are divided into shorter branches up to the third or fourth orders, with sharply pointed apices. Adventitious branches, endogenously forming from the central axial cells, are observed in April on the erect axes of mature tetrasporic plants (Fig. 4). Axillary endogenous branchlets rise from the axils of branches, increasing in number from February (1–2) to April (7) and in fully mature plants (April), all of which bear tetrasporangia (Fig. 5).

Colourless trichoblasts occasionally occur near the apices of indeterminate branches and are 2–3 times furcate. Tetrasporangia, in straight series (up to 9), form first on the ultimate branches of erect axes (February) and later on endogenous axillary branchlets (March–April). Cystocarps, numerously borne on the middle and upper branchlets, are urceolate and shortly pedicellate, 430–650 µm long and 270–390 µm wide, with a neck and ostiole at the apex (Fig. 6). Procarps with trichogynes may be observed in February. Numerous spermatangial branches arise on the apices of branchlets, 435–750 µm long and 55–95 µm wide, with a long sterile tip consisting of 4–7 cells (Figs 7–8). Besides monoecious phases, two mixed-phase plants were found in February: one with cystocarps and tetrasporangia, and the other with cystocarps and spermatangia (Figs 9–10).

Ecology

Polysiphonia morrowii grows in the lower intertidal and upper sublittoral zones from 0 to –0.60 m on the vertical banks and wooden piles flanking canals. On the Island of Chioggia, *P. morrowii* is associated with the dominant brown algae *Sargassum muticum* (Yendo) Fensholt, *Undaria pinnatifida* (Harvey) Suringar and *Desmarestia willii* Reinsch, and in Venice with *Undaria pinnatifida*. The principal associated algae on the substrata are the red algae *Ceramium rubrum* auctorum and *Rhodymenia ardissonei* J. Feldmann and the green algae *Bryopsis plumosa* (Hudson) C. Agardh, *Enteromorpha intestinalis* (Linnaeus) Nees, *Enteromorpha prolifera* (O. F. Mueller) J. Agardh and *Ulva rigida* C. Agardh. From May onwards, specimens are thickly covered with epiphytes such as the red algae species *Ceramium diaphanum* (Lightfoot) Roth, *Antithamnion pectinatum* (Montagne) Brauner *ex* Athanasiadis *et* Tittley, *Antithamnion cruciatum* (C. Agardh) Naegeli, *Nitophyllum punctatum* (Stackhouse) Greville, the brown algae *Ectocarpus siliculosus* (Dillwyn) Lyngbye var. *siliculosus*, *Hinksia* spp., and several microalgae of the genera *Navicula*, *Melosira* and *Tabellaria*.

Discussion

The *Polysiphonia* species found in the Lagoon of Venice and identified as *P. morrowii* may have been misidentified as the Mediterranean *P. stricta* (= *P. urceolata*) and the Pacific *P. senticulosa* (= *P. pungens* Hollenberg). *Polysiphonia stricta* shares several common taxonomic features with *P. morrowii* (profusely branched slender thalli with sharply pointed branchlets, four pericentral cells, lack of cortical cells, L/W ratio in erect axes, urceolate cystocarps), but lacks endogenous axillary branchlets and axillary tetrasporangial branchlets (Segi 1951, Maggs and Hommersand 1993, Kudo and Masuda 1992).

The morphological features of *P. senticulosa* overlap those of *P. morrowii* and some authors have reduced it to a synonym for *P. morrowii* or note the need for further experimental study to characterise the genuine status of the species (Kudo and Masuda 1981, Yoon 1986, Kim *et al.* 1994). In addition, in *P. morrowii* Lee and Lee (1991) and Kim *et al.* (1994) observe that the L/W ratio, an important taxonomic character for species separation in *Polysiphonia*, is not stable but varies according to month, phase of life, and location. To identify the specimens collected in the Lagoon of Venice, we used two diagnostic features, currently believed to be valid in distinguishing between the two species: the number of axillary tetrasporangial branchlets in mature plants (7–8 in *P. morrowii;* 3 or fewer in *P. senticulosa*) and the number of sterile cells at the apices of mature spermatangial branches (5–8 in *P. morrowii*) (Kudo and Masuda 1981, 1988, Lee and Lee 1991, Kim *et al.* 1994). In our specimens, the number of axillary branchlets varies from 1 or 2 in February–March up to 7 in April–May, when all of them bear tetrasporangia. In male gametophytes the mature spermatangia bear from 4 to 7 sterile apical cells.

Each phase of life of *P. morrowii* in the Lagoon of Venice shows a similar phenology to Korean plants (Kim *et al.* 1994). Tetrasporic plants are observed from January to July, cystocarpic plants from February to June, and spermatangial plants only in February and March. As in Korea, the tetrasporic stage predominates over the sexual ones (Fig. 11).

Maximum plant height (50 cm) is greater than that of specimens recorded in Korea (16–25 cm) (Yoon 1986, Kim *et al.* 1994) and Japan (35 cm) (Kudo and Masuda 1992). Instead, our thalli have more slender main axes (100–300 µm) than Japanese plants (260–550 µm in Kudo and Masuda 1992; 450 µm in Segi 1951), but are similar to Korean ones (150–300 µm in Yoon 1986; 50–180 µm in Kim *et al.* 1994). In our plants, the maximum L/W ratio of segments in the middle main axis (20) appears to be higher than in the Korean (13.5 in Kim *et al.* 1994) and Japanese plants (11.7 in Kudo and Masuda, 1992).

The finding of this new alga in the Lagoon of Venice does not appear to be an isolated occurrence, as it is found together with *Desmarestia willii* Reinsch, a new brown alga for the Mediterranean Sea. In the last decade, other new species for the Mediterranean flora have been recorded in Chioggia and Venice, e.g. *Undaria pinnatifida*, *Sargassum muticum*, *Antithamnion*

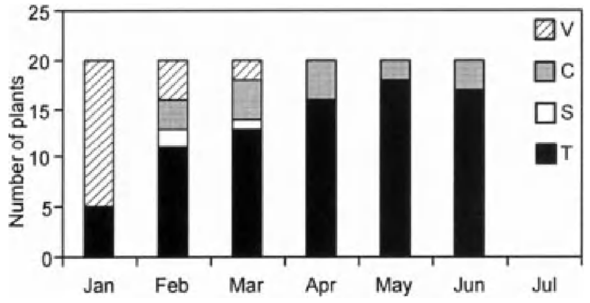


Fig. 11. Number of plants in various phases of life (C, cystocarpic plant; S, spermatangiate plant; T, tetrasporic plant; V, vegetative plant).

pectinatum and *Sorocarpus* sp. (Rismondo *et al.* 1993, Gargiulo *et al.* 1992, Curiel *et al.* 1996, 1999). The occurrence of these algal species in the Venice Lagoon is probably connected with the intensive shipping traffic which takes place in the harbours of Venice and Chioggia and to the handling of imported molluscs and fishes. These species may have arrived as packaging material or as a fouling species, from other European locations or directly from their endemic areas.

A survey on trade exchanges of marine species at the Public Health Service of Venice has pointed out that in the Lagoon of Venice (Chioggia Island) live molluscs are imported from aquaculture sites in the European North Atlantic Ocean (*Mytilus galloprovincialis* Lam. from Scotland) and from the Mediterranean Sea (*Tapes decussatus* L. from Tunisia and Turkey; *Venus verrucosa* L. from Greece; *Mytilus edulis* L. from Spain; *Crassostrea gigas* Thunberg from France).

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References

Curiel, D., M. Marzocchi and G. Bellemo. 1996. First report of fertile *Antithamnion pectinatum* (Ceramiales, Rhodophyceae) in the north Adriatic Sea (Lagoon of Venice, Italy). *Bot. Mar. 39*: 19–22.

Curiel, D., G. Bellemo, M. Iuri, M. Marzocchi and M. Scattolin. 1999. First report of the genus *Sorocarpus* Pringsheim (Fucophyceae, Ectocarpaceae) in the Mediterranean. *Bot. Mar. 42*: 7–10.

Gargiulo, M. G., F. De Masi and G. Tripodi. 1992. *Sargassum muticum* (Yendo) Fensholt (Phaeophyta, Fucales) is spreading in the lagoon of Venice (Northern Adriatic Sea). *Giorn. Bot. Ital. 126*: 259.

Harvey, W. H. 1856. Algae, in Asa Gray, list of dried plants collected in Japan by S. W. Williams, Esq. and Dr. J. Morrow. *Mem. Amer. Acad. Art. Sci. 2*: 331–332.

Kim, M. S., I. K. Lee and S. M. Boo. 1994. Morphological studies of the red alga *Polysiphonia morrowii* Harvey on the Korean coast. *Korean J. Phycol. 9*: 185–192.

Kudo, T. and M. Masuda. 1981. A taxonomic study of *Polysiphonia morrowii* Harvey (Rhodophyta, Ceramiales). *Jpn. J. Phycol. 29*: 263–272.

Kudo, T. and M. Masuda. 1988. Taxonomic notes on *Polysiphonia senticulosa* Harvey and *P. pungens* Hollenberg (Ceramiales, Rhodophyta). *Jpn. J. Phycol. 36*: 138–142.

Kudo, T. and M. Masuda. 1992. Taxonomic features of *Polysiphonia morrowii* Harvey (Ceramiales, Rhodophyta). *Korean J. Phycol. 7*: 13–26.

Lee, W. J. and I. K. Lee. 1991. Mixed phase reproduction of *Polysiphonia morrowii* Harvey (Rhodomelaceae, Rhodophyta) in culture. *Jpn. J. Phycol. 39*: 115–121.

Maggs, A. and M. H. Hommersand. 1993. *Seaweeds of the British Isles.* British Museum Publication (Natural History), London, Vol. 1, part 3A. 444 pp.

Maggs A. and H. Stegenga. 1998. Red algal exotics on North Sea coasts. *Helgolander Meeresunters. 52*: 243–258.

Nelson, W. A. and A. Maggs. 1996. Records of adventive marine algae in New Zealand: *Antithamnionella ternifolia, Polysiphonia senticulosa* (Ceramiales, Rhodophyta) and *Striaria attenuata* (Dictyosiphonales, Phaeophyta). *New Zealand J. Mar. Freshwat. Res. 30*: 449–453.

Perestenko, L. P. 1980. *Algae of Peter the Grand Bay.* Nauka, Leningrad. 232 pp. (in Russian).

Rismondo, A., S. Volpe, D. Curiel and A. Solazzi. 1993. Segnalazione di *Undaria pinnatifida* (Harvey) Suringar a Chioggia (Laguna Veneta). *Lavori Soc. Ven. Sc. Nat. 18*: 328–330.

Segi, T. 1951. Systematic study of the genus *Polysiphonia* from Japan and its vicinity. *J. Fac. Fish. Pref. Univ. Mie 1*: 169–272, pls 1–6.

Tokida, J. 1954. The marine algae of southern Saghalien. *Mem. Fac. Fish. Hokkaido Univ. 2*: 1–264.

Womersley, H. B. S. 1979. Southern Australian species of *Polysiphonia* Greville (Rhodophyta). *Aust. J. Bot. 27*: 459–528.

Yoon, H. Y. 1986. A taxonomic study of genus *Polysiphonia* (Rhodophyta). *Korean J. Phycol. 1*: 3–86.