

## Marine Algal Endophyte and Epiphytes New to New Caledonia

Taiju Kitayama<sup>1</sup> and Claire Garrigue<sup>2</sup>

<sup>1</sup>Department of Botany, National Science Museum,  
4-1-1 Amakubo, Tsukuba, Ibaraki, 305-0005 Japan

<sup>2</sup>ORSTOM, BP A5, Nouméa, New Caledonia

**Abstract** Four microscopic multicellular algae, *Phaeophila dendroides* (Chlorophyceae, Phaeophilales), *Feldmannia irregularis*, *Feldmannia indica* (Phaeophyceae, Ectocarpales), *Stylonema alsidii* (Rhodophyceae, Porphyridiales) were recorded for the first time from the coast of New Caledonia. *Phaeophila dendroides* is an endophyte in *Dictyota* and the rest are epiphytes on *Turbinaria ornata* or *Sphacelaria rigidula*. The three genera and the three orders are new records in New Caledonia.

**Key words:** Algal flora, endophyte, epiphyte, *Feldmannia indica*, *Feldmannia irregularis*, New Caledonia, *Phaeophila dendroides*, Phaeophyceae, Rhodophyceae, *Stylonema alsidii*, Ulvophyceae.

Since Kützing (1863) published the first records of New Caledonian algae based on E. Vieillard's collections, there have been few further publications focussed on marine benthic algae from New Caledonia including Gepp (1922), Catala (1950), May (1953, 1966), Garrigue (1987) and Ajisaka (1991). In their catalog of the Marine Benthic Algae from New Caledonia (based on the previous records), Garrigue and Tsuda (1988) enumerated 130 species of green algae, 59 species of brown algae and 147 species of red algae. However, to date there have been few studies on minute endophytes or epiphytes on macroalgae in New Caledonia. This is because it is difficult to find microscopic algae living within or on the tissue of the preserved dried plants specimens previously collected. While in New Caledonia on a study trip the first author collected fresh samples with the aim of examining the microscopic marine algae of New Caledonia.

### Materials and Methods

A green algal endophyte within the thallus of *Dictyota* spp. (Phaeophyceae, Dictyotales) and two brown algal epiphytes and red algal epiphytes on branches of *Turbinaria ornata* (Turner) J. Agardh (Phaeophyceae, Fucales) were collected by the first author at Pointe aux Longs Cousins, Nouméa (22°17'S, 166°28'E), in February 1995. The materials collected were fixed in 5–10% Formalin-seawater at the laboratory within four hours of collection for later microscopic examination of their anatomy.

The voucher slide specimens are deposited in the herbarium of National Science Museum, Tokyo (TNS).

In this report we followed the taxonomic system used in the check list of marine algae of Japan made by Yoshida *et al.* (1995); however, I adopted Ulvophyceae Mattox et Stewart (1984) as a class including most of benthic marine green algae.

## Descriptions

Class ULVOPHYCEAE Mattox et Stewart

Order Phaeophilales Chappell, O'Kelly, Wilox et Floyd

Family Phaeophilaceae Chappell, O'Kelly, Wilox et Floyd

1. **Phaeophila dendroides** (P. Crouan et H. Crouan) Batters (Figs. 1, 5A, B)  
*Journal of Botany* **40**: 13 (1902). — *Ochlochaete dendroides* P. Crouan et H. Crouan, *Algues marines du Finistère...Brest*. no. 346. (1852).

Plants are endophytic in cortical layers of *Dictyota* spp. They are green in color and composed of uniseriate filaments with long setae. Filaments are prostrate, cylindrical or irregular in shape, 10–25  $\mu\text{m}$  in diameter. Setae are elongate, tubular, 3–5  $\mu\text{m}$  in diameter, often twisted on the upper portions (Fig. 1 arrowhead). They project out from the surface of the host cortices (Fig. 5A). Zoosporangia were unilocular,

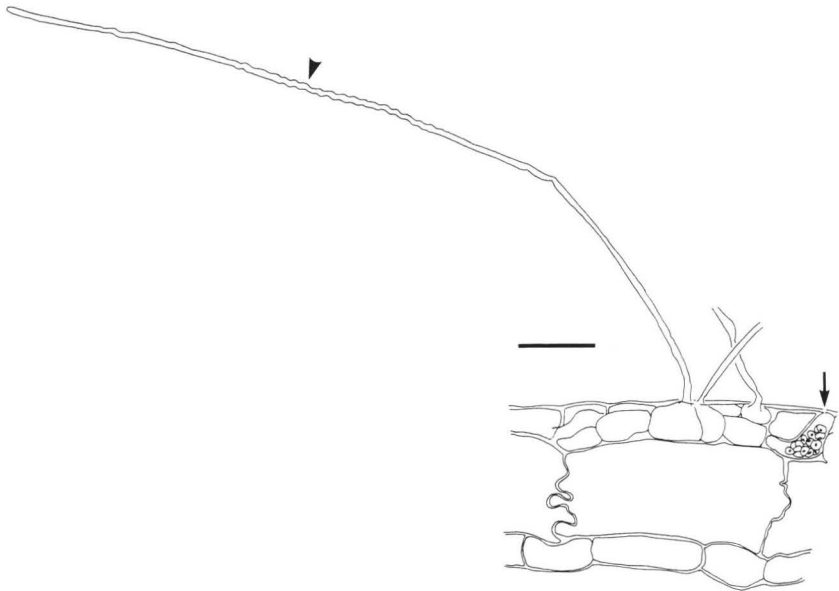


Fig. 1. *Phaeophila dendroides* (P. Crouan et H. Crouan) Batters (TNS-AL-45001). Thallus endophytic in *Dictyota* spp. with seta (arrowhead) and sporangium (arrow). Scale bar = 50  $\mu\text{m}$ .

rounded or often bent, containing several zoospores (Fig. 1 arrow).

Specimen examined: Nouméa. 15 Feb. 1995 (TNS-AL-45001).

Geographical distribution: Bermuda, British Columbia, Eastern Canada, Europe, Indian Ocean, Japan, Mediterranean, Philippines, Washington.

*Phaeophila dendroides* may be a cosmopolitan species, but there are few records from the Pacific Ocean: British Columbia (O'Kelly and Yarish 1980), Philippines (Tanaka 1967) and Japan (Kitayama and Yoshida 1992). Although this species is related to the Ulvellaceae of the Ulvales in having characteristically twisted setae, Chappell *et al.* (1990) proposed the new order Phaeophilales and the new family Phaeophilaceae on the basis of the species because of its unique flagellar apparatus provided with six microtubular rootlets and single-lobed terminal caps, and unique zoosporangia whose mother cells became multinucleate in the early developmental stage (O'Kelly and Yarish 1980).

Class PHAEOPHYCEAE Kjellman

Order Ectocarpales Setchell et Gardner

Family Ectocarpaceae C. Agardh

2. **Feldmannia indica** (Sonder) Womersley et Bailey (Figs. 2, 5C)  
Phil. Trans. Royal Soc. London **259**(B): 288 (1970). —*Ectocarpus indicus* Sonder, 2, 3 (1854).

Plants are epiphytic on branches of *Turbinaria ornata*. They are light brown in color, forming tufts, up to 2 mm in height, consisting of monostichously branched erect filaments and unbranched laterals each with a meristematic zone at the base (Fig. 2A–C). Filaments are uniseriate, cylindrical, 12–25  $\mu\text{m}$  in diameter. Laterals are tapering when young, attenuated above with an acute apex, occasionally terminated in a phaeophycean hair. Cells of the filaments are straight, 40–85  $\mu\text{m}$  in length, containing several discoid chloroplasts with a small pyrenoid (Fig. 2D). Plurilocular sporangia are sessile or occasionally pedicellate, cylindrical, elongate, with a rounded tip, 22–38  $\mu\text{m}$  in diameter, 95–188  $\mu\text{m}$  in length.

Specimen examined: Nouméa. 15 Feb. 1995 (TNS-AL-45002).

Geographical distribution: Indian Ocean, Japan, Philippines, Southern Australia (Type locality: Bima Bay, Sumbawa, Indonesia).

The taxonomic position of this species is not clear. In the check list of Japan revised by Yoshida *et al.* (1995), the species was listed as *Hincksia indica* (Sonder) J. Tanaka due to its lack of hair-like branches that the members of the genus *Feldmannia* possess (Tanaka 1990). Occasionally, however, our plants have phaeophycean hairs on the tip of the long erect filaments. Alternatively, Silva *et al.* (1997) treated the species as *Feldmannia indica* (Sonder) Womersley et Bailey in their recent catalogue for the Indian Ocean. Clayton (1974), Abbott and Hollenberg (1976), and

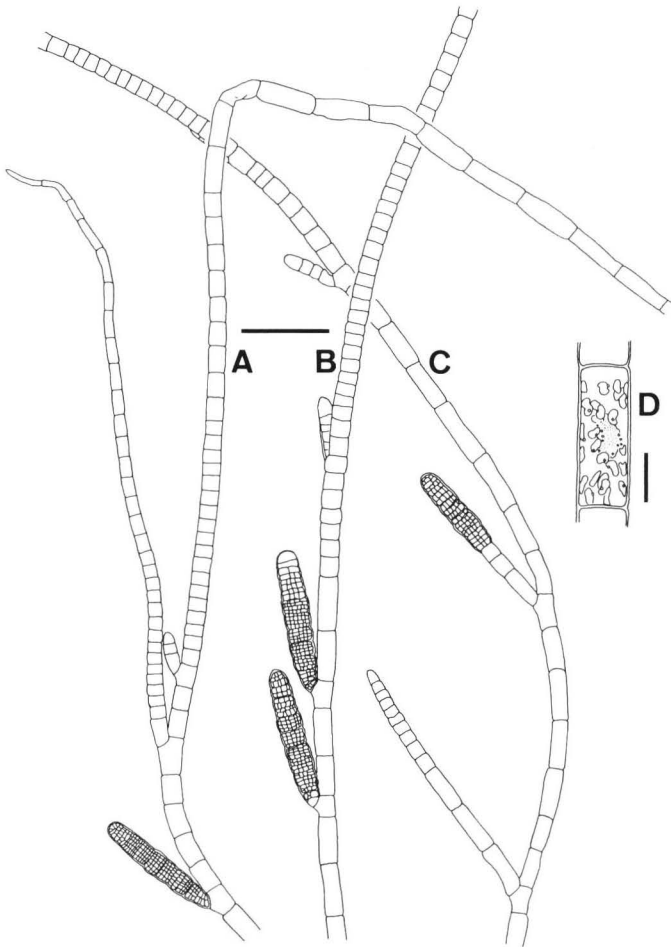


Fig. 2. *Feldmannia indica* (Sonder) Womersley et Bailey (TNS-AL-45002). A–C. Erect filaments with plurilocular sporangia. Scale bar=100  $\mu\text{m}$ . D. Cell with discoid chloroplasts. Scale bar=20  $\mu\text{m}$ .

Womersley (1987) noted in the key to the genera of Ectocarpales that the genus *Feldmannia* is characterized by meristematic zones at the base of unbranched terminal filaments. Thus we used *Feldmannia indica* for the time being, following the treatment by Silva *et al.*, although detailed studies are needed to elucidate the relation between *Feldmannia* and *Hincksia* (earlier correct name of *Giffordia*, Silva *et al.* 1987).

### 3. *Feldmannia irregularis* (Kützing) G. Hamel

(Figs. 3, 5D)

Pheophycées de France. Fasc. V: xvii, f. 61F (1939). —*Ectocarpus irregularis* Kützing, Phycologia Germanica: 234 (1845).

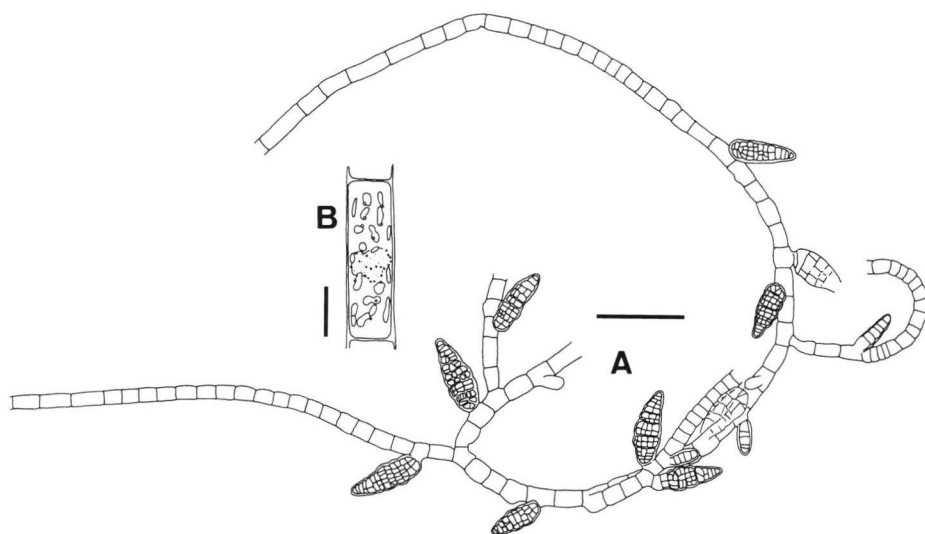


Fig. 3. *Feldmannia irregularis* (Kützinger) G. Hamel (TNS-AL-45003). A. Prostrate filaments with plurilocular sporangia. Scale bar=100  $\mu\text{m}$ . B. Cell with discoid chloroplasts. Scale bar=20  $\mu\text{m}$ .

Plants are epiphytic, tufted erectly or prostrate on the surface of branches of *Turbinaria ornata*. They are up to 2 mm in height, filamentous, branched irregularly and have meristematic zones each at the base of the ultimate branches terminating in a phaeophycean hair (Fig. 3A). Filaments are straight or curved, uniseriate, cylindrical, 16–22  $\mu\text{m}$  in diameter. Cells are 14–93  $\mu\text{m}$  in length, having several discoid chloroplasts containing a pyrenoid (Fig. 3B). Plurilocular sporangia are sessile or pedicellate, usually unilaterally, fusiform, conical, often upwardly curved, with an acute apex, 20–33  $\mu\text{m}$  in diameter, 43–106  $\mu\text{m}$  in length.

Specimen examined: Nouméa. 15 Feb. 1995 (TNS-AL-45003).

Geographical distribution: California, Indian Ocean, Japan, Philippines, Southern Australia (Type locality: Adriatic Sea).

Although acute, conical plurilocular sporangia of *Feldmannia irregularis* distinguish this species from *F. indica*, which has elongate, cylindrical plurilocular sporangia, we think that their relation is not yet clear. They grow on the same host tissues and their vegetative cells are very similar. Culture experiments on these algae are required.

## Class RHODOPHYCEAE Rabenhorst

## Order Porphyridiales Kylin

## Family Goniotrichaceae G. M. Smith

**4. *Stylonema alsidii* (Zanardini) K. Drew** (Figs. 4, 5E)

Botanisk Tidsskrift **53**: 72 (1956). —*Bangia alsidii* Zanardini, Bibliotheca Italiana **96**: 136 (1840). —*Goniotrichum alsidii* (Zanardini) Howe, Mem. Torrey Bot. Club **15**: 75 (1914).

Plants are epiphytic on branches of *Turbinaria ornata* or *Sphacelaria rigidula* Kützting growing on the branches of *T. ornata*. They are red in color, filamentous, irregularly pseudodichotomous, up to 660  $\mu\text{m}$  in height. Filaments are uniseriate, 12–28  $\mu\text{m}$  in diameter, including thick gelatinous sheath, having a rounded apex (Fig. 4). Cells are cylindrical or spherical, 7–11  $\mu\text{m}$  in diameter, 4–13  $\mu\text{m}$  in length. They have no pit-connections. Each cell contains a single stellate chloroplast with a pyrenoid in

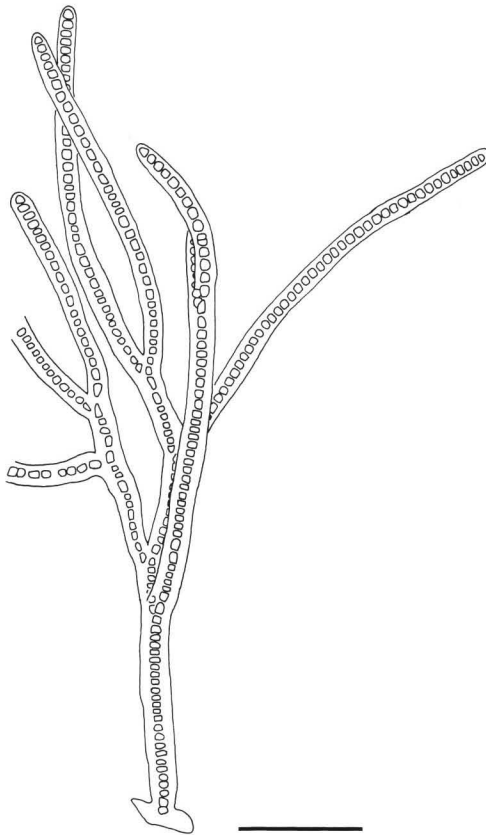


Fig. 4. *Stylonema alsidii* (Zanardini) K. Drew (TNS-AL-45004). Scale bar = 100  $\mu\text{m}$ .

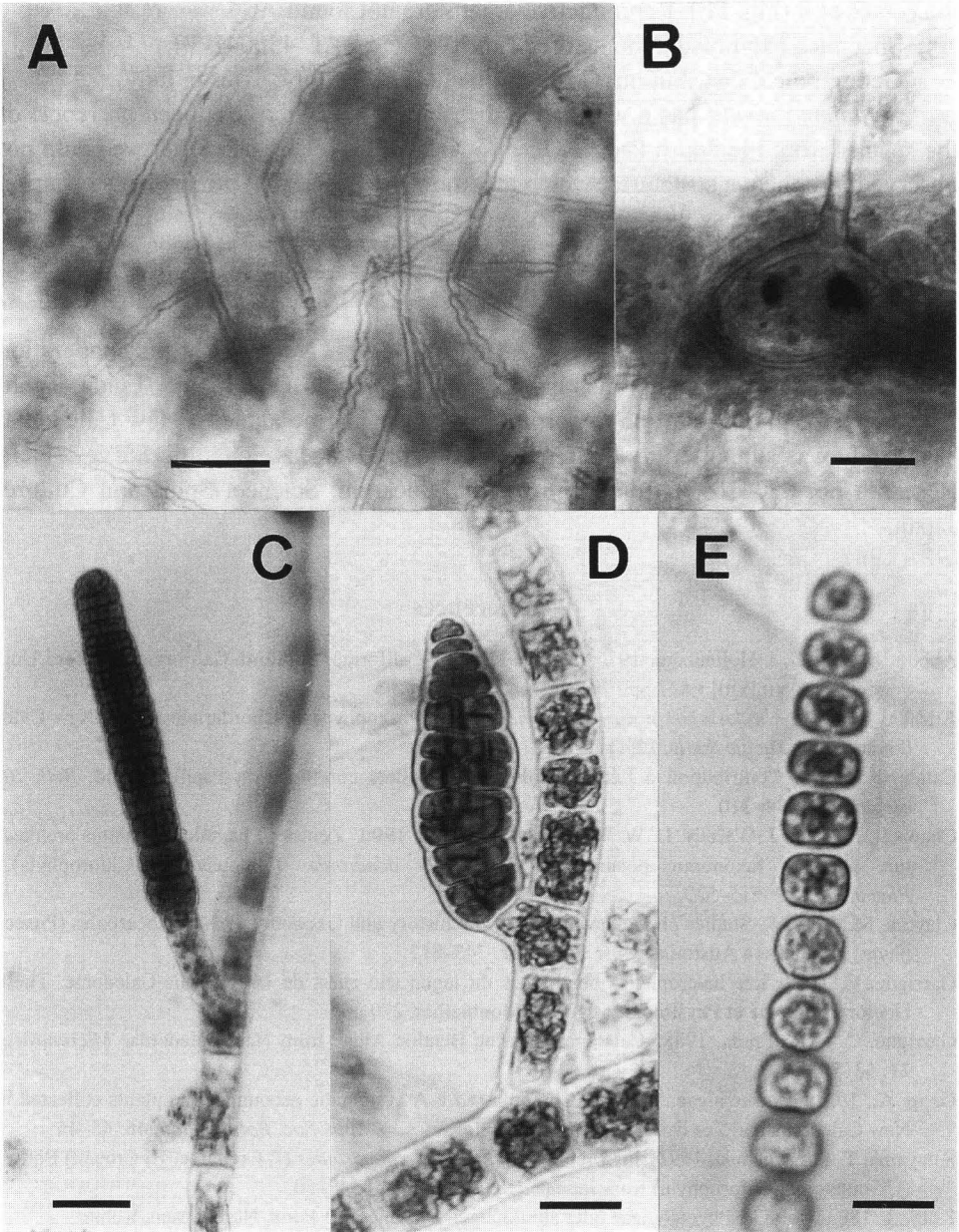


Fig. 5. A, B. *Phaeophila dendroides* (P. Crouan et H. Crouan) Batters (TNS-AL-45001). A. Setae issued from the surface of *Dictyota* spp. Scale bar=50  $\mu$ m. B. Cell projecting a seta. Scale bar=20  $\mu$ m. C. *Feldmannia indica* (Sonder) Womersley et Bailey (TNS-AL-45002). Plurilocular sporangium. Scale bar=40  $\mu$ m. D. *Feldmannia irregularis* (Kützting) G. Hamel (TNS-AL-45003). Plurilocular sporangium. Scale bar=20  $\mu$ m. E. *Stylonema alsidii* (Zanardini) K. Drew (TNS-AL-45004). Apical portion of erect filament. Scale bar=10  $\mu$ m.

the center of it (Fig. 5E). Reproductive organs are not found.

Specimen examined: Nouméa. 15 Feb. 1995 (TNS-AL-45004).

Geographical distribution: Cosmopolitan (Type locality: Trieste, Italy).

*Stylonema alsidii* has a worldwide distribution, but there has been no report of the species from the South Pacific Ocean. Our plants are so young that we could not observe reproductive structures, which are known to be asexual monospores occurring on the tip of filaments.

### Acknowledgments

We are grateful to Prof. Tanguy Jaffre, ORSTOM, Nouméa for his cooperation in this study. The first author also expresses his thanks to Dr. Mitsuya Tsuda, Kyoto University for giving him the opportunity to study marine algae of New Caledonia. This study was supported by the Grant-in-Aid for Overseas Scientific Survey (Field Research no. 05041093) from Ministry of Education, Science, Sport and Culture, Japan.

### References

- Abbott, I. A. & G. J. Hollenberg, 1976. Marine algae of California. Stanford, California: Stanford University Press. xii [xiii]+827 pp., 701 figs.
- Ajisaka, T., 1991. *Cladosiphon novae-caledoniae* Kylin (Phaeophyceae, Chordariales) from New Caledonia. *South Pacific Study*, **12**(1): 1–6.
- Catala, R., 1950. Contribution à l'étude écologique des îlots coralliens du Pacifique Sud. *Bull. Biologique*, **3**: 234–310.
- Chappell, D. F., C. J. O'Kelly, L. W. Wilox & G. L. Floyd, 1990. Zoospore flagellar apparatus architecture and the taxonomic position of *Phaeophila dendroides* (Ulvophyceae, Chlorophyta). *Phycologia*, **29**: 515–523.
- Clayton, M.N., 1974. Studies on the development, life history and taxonomy of the Ectocarpales (Phaeophyta) in Southern Australia. *Aust. J. Bot.* **22**: 743–813.
- Garrigue, C. 1987. Les macrophytes benthiques du lagon sud-ouest de la Nouvelle-Calédonie. Thèse Doctorat Biologie et Physiologie végétale. Montpellier, 270 pp.
- Garrigue, C. & R. Tsuda, 1988. Catalog of Marine Benthic Algae from New Caledonia. *Micronesica*, **21**: 53–70.
- Gepp, A., 1922. Marine algae. In R. H. Compton (ed.): A systematic account of the plants collected in New Caledonia and Iles des Pins. Part 3, Cryptogames. *J. Linn. Soc. Bot. London*, **46**: 45–46.
- Kitayama, T. & T. Yoshida, 1992. First report of *Phaeophila dendroides* (P. Crouan et H. Crouan) Batters (Ulvophyceae, Chlorophyta) from Japan. *Jpn. J. Phycol.*, **40**: 47–50.
- Kützing, 1863. *Tabulae Phycologicae oder abbildungen der tange*. 13 Band, Nordhausen, Kohne.
- Mattox, K. R. & K. D. Stewart, 1984. Classification of the green algae: A concept based on comparative cytology. In D. E. G. Irvine & D. E. John (eds.), *Systematics of the Green Algae*. pp. 29–72. Academic Press, London.
- May, V., 1953. Some marine algae from New Caledonia collected by Mrs. R. Catala. *Contr. from the N. S. W. National Herbarium*, **2**(1): 38–66.
- May, V., 1966. Further records of algae from New Caledonia collected by Mrs. R. Catala. *Contr. from*



*the N. S. W. National Herbarium*, **4**(1): 17–18.

- O'Kelly, C. J. & C. Yarish, 1980. Observations on marine Chaetophoraceae (Chlorophyta). I. Sporangial ontogeny in the type species of *Entocladia* and *Phaeophila*. *J. Phycology*, **16**: 549–558.
- Silva, P. C., P. W. Basson & R. L. Moe, 1997. Catalogue of the Benthic Marine Algae of the Indian Ocean. University of California publications in botany 79. pp. 1259+xiv.
- Silva, P. C., E. G. Meñez & R. L. Moe, 1987. Catalog of the benthic marine algae of the Philippines. *Smithonian Contributions to the Marine Sciences*, **27**. iv+179 pp., 2 figs., 1 table.
- Tanaka, J., 1990. Brown algae from the Amami Islands. *Mem. Natn. Sci., Mus., Tokyo*, **23**: 23–32.
- Tanaka, T., 1967. Some marine algae from Batan and Camiguin islands, Northern Philippines-I. *Mem. Fac. Fish., Kagoshima Univ.*, **16**: 13–27.
- Womersley, H. B. S., 1987. The marine benthic flora of southern Australia. Part II. Adelaide: South Australian Government Printing Division. 484 pp., 169 figs., 8 pls., 4 maps, 1 table.
- Yoshida, T., K. Yoshinaga & Y. Nakajima, 1995. Check list of marine algae of Japan (revised in 1995). *Jpn. J. Phycology*, **43**: 115–171.

