

Phacelocarpus neurymenioides sp. nov. (Rhodophyta, Phacelocarpaceae): A New Marine Alga from Fiji

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A new species of the red algal genus *Phacelocarpus*, of the monogeneric family Phacelocarpaceae, is reported and described for the first time from Fiji, South Pacific. *Phacelocarpus neurymenioides* differs from other members of the genus in a number of characters. It has a broad blade (up to 9 mm wide), with new blades arising irregularly from the midrib. The alae terminate in short marginal serrations that are less than ten percent of the blade width. Stalked cystocarps, and tetrasporangial and spermatangial nemathecium are borne on the center of the midrib. In its vegetative morphology, *P. neurymenioides* bears a remarkable resemblance to the genus *Neurymenia*, with which it may occur on the reef slope.

Introduction

The analysis of biogeographical and species richness patterns for the marine macro-algal flora of the tropical Pacific Ocean is impaired by the incomplete documentation of regional floras (South and Kasahara 1992, N'Yeurt 1993, South *et al.* 1993). The algal flora of Fiji and adjacent islands presently consists of 383 species. Since the publication of the first list of 79 species by Chapman (1971), an additional 304 species have been recorded (Chapman 1977, Kapraun and Bowden 1978, Garbary *et al.* 1991, Kraft 1984, Kasahara 1985, South and Kasahara 1992, South 1993, South and N'Yeurt 1993, South *et al.* 1993) and new records are continually being added (N'Yeurt, Keats and South, in preparation). We have continued studies to improve our knowledge of the marine macro-algal flora of Fiji based on more recent collections.

During the course of these investigations, an unknown species first thought to be *Neurymenia* (Rhodomelaceae, Ceramiales) was found to occur mainly in caves and shaded locations on the reef, being especially common on the outer reef slope below 35 m. Vegetative and reproductive anatomy, however, are characteristic not of *Neurymenia*, but of *Phacelocarpus*, a genus assigned to the Gigartinales. An examination of the literature revealed no presently established species of *Phacelocarpus* conforming to the material under study. This paper therefore presents the first formal description of the new species.

Materials and Methods

All material was collected by SCUBA diving to a maximum depth of 40 m from the Suva barrier reef

and its lagoon. Specimens were preserved in 4% formaldehyde (10% commercial Formalin) in seawater for storage prior to examination. For light microscopy, formalin-preserved specimens were sectioned at 10–30 µm thickness using a Reichert CO₂ freezing microtome. Each section was removed from the microtome blade using a fine sable-hair brush,

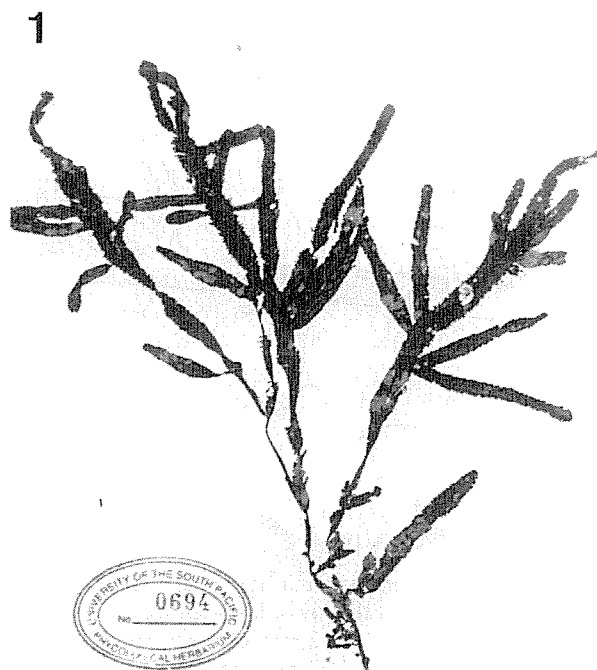
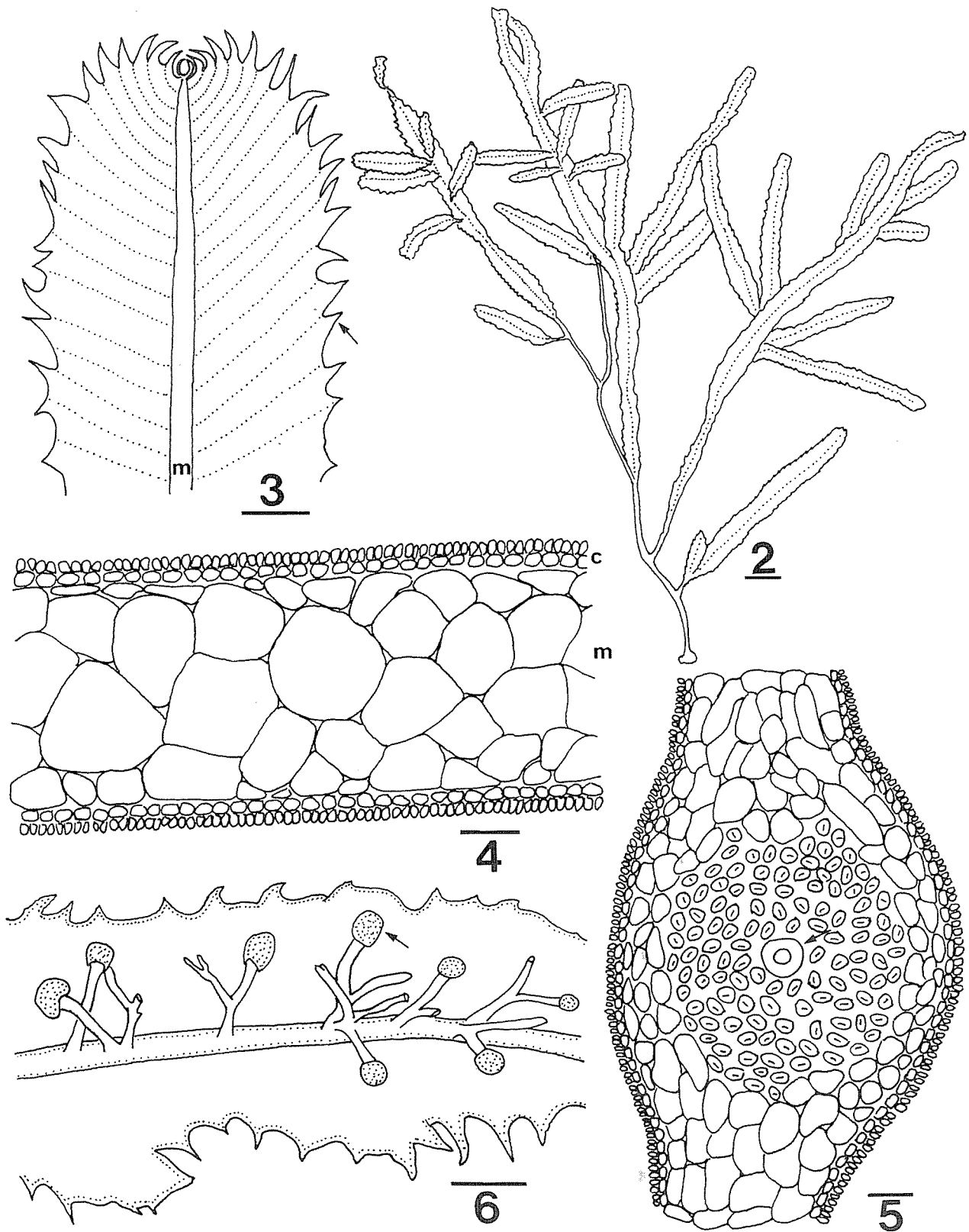


Fig. 1. Photograph of Holotype.



Figs 2–6. Habit, vegetative anatomy and reproductive structures.

Fig. 2. General habit of thallus of holotype. Scale = 1 cm. Fig. 3. Apical region of blade, showing midrib (m) and serrations (arrow) (USP 840). Scale = 2 mm. Fig. 4. Cross-section of distal part of blade, showing medulla (m) and cortex (c) (USP 840). Scale = 20 µm. Fig. 5. Cross-section of blade at the midrib, showing central axial cell (arrow) surrounded by rhizoidal mass (USP 840). Scale = 50 µm. Fig. 6. Habit of fertile blade with tetrasporangial nemathecium (arrow) borne on branched stalks (USP 840). Scale = 3 mm.

and transferred to a slide containing aniline blue in 50% Karo syrup. Drawings were made directly from prepared slides using a Zeiss microscope equipped with a drawing tube. For SEM, formalin-preserved material was subjected to critical-point drying before being examined in a Hitachi X650 scanning electron microscope. Voucher specimens of pressed material were placed in the Phycological Herbarium, South Pacific Regional Herbarium (USP). The holotype has been deposited in L, a piece of the holotype is in UC, and paratypes are in BM.

Phacelocarpus Endlicher *et* Diesing, nom. cons.

Phacelocarpus neurymenioides sp. nov.

Figures 1–21.

Holotype: Fish Patch, Suva Lagoon, reef slope, 10–15 m, caves and overhangs [Keats, 18 v 1994: deposited in L (: 989977047) with a fragment in UC].

Diagnosis: *Thalli erecti*, (7–)16–18.5 cm, *alati in partibus medianis usque ad partes distales*. *Laminae* (13–)38–80 mm *longae*, 6–9 mm *latae*. *Axis valde corticatus costam prominentem formans*. *Ramuli determinati laterales in lateribus axis oppositis et lateratim connati qui alas formant et in serraturas regulares marginales terminant, 450–580 mm longi, 416–470 mm lati basi*. *Serratura minus quam 1/10 laminae latitudine aequales*. *Venae laterales plerumque invisibiles*. *Ramificatio thalli irregularis*. *Ramuli indeterminati solum e costa*. *Nemathecia reproductiva mascula, feminea et in tetrasporangiis solum in costa, brevia usque ad longa*. *Stipites aliquando ramosi*.

Thalli upright, (7–)16–18.5 cm high, alate in middle to distal regions, blades (13–)38–80 mm long, 6–9 mm wide; strongly corticated axis forming

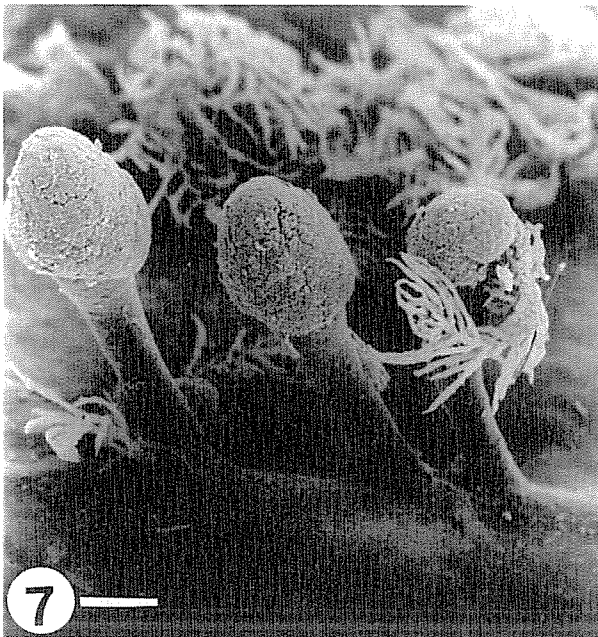


Fig. 7. SEM of tetrasporangial nemathecium (USP 840). Scale = 340 μ m.

prominent midrib; determinate lateral ramuli on opposite sides of axis, laterally fused to form alae, ending in regular marginal serrations, 450–580 μ m long, 416–470 μ m wide at base, serrations less than 10% of blade width, lateral veins usually invisible; thallus branching irregular, indeterminate branches only from midrib. Male, female and tetrasporangiate reproductive nemathecium only on midrib, terminating short to long, sometimes branched stalks.

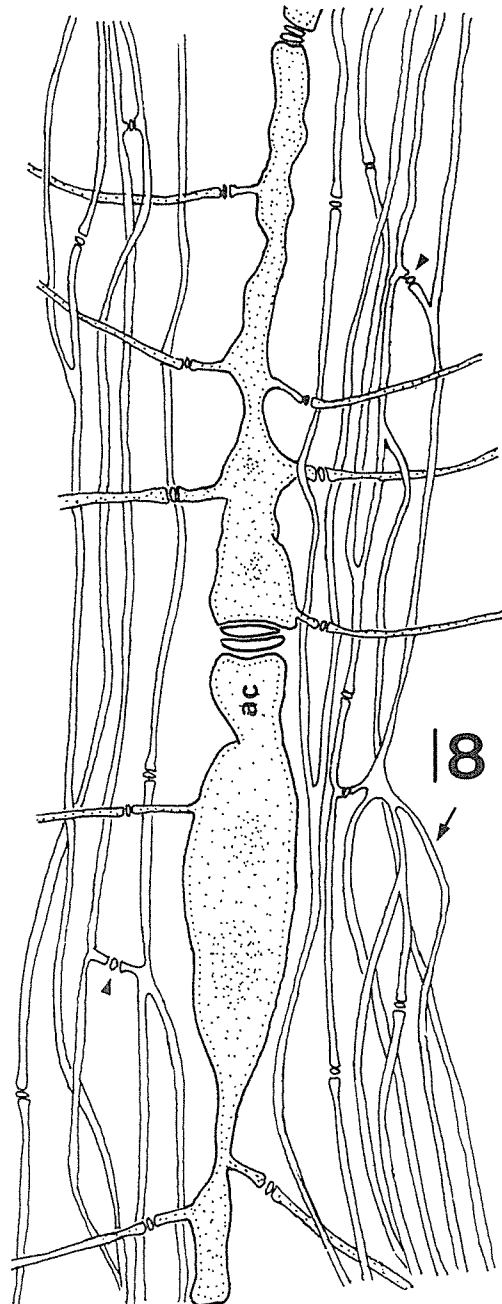


Fig. 8. Longitudinal section of blade at the midrib, showing axial cells (ac) surrounded by rhizoidal filaments (arrow) with numerous secondary pit connections (arrowheads) (USP 838). Scale = 20 μ m.

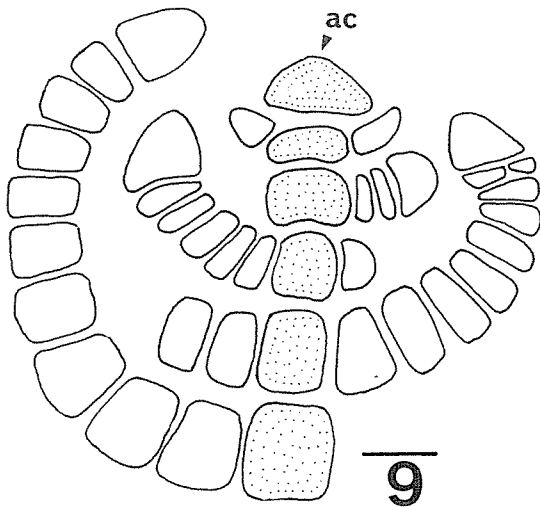


Fig. 9. Blade apex, showing apical cell (ac) (USP 838). Scale = 5 μ m.

Etymology: '*neurymenioides*' refers to the plant's morphological resemblance to a species of *Neurymenia* (Rhodomelaceae).

Representative material examined: Fish Patch, Suva Reef [Keats, 19 v 1994: USP 840 (tetrasporic); 2 xi 1994: USP 841 (spermatangial); USP 842 (cystocarpic), deposited in BM; Ballou, 24 x 1994: USP 838 (tetrasporic), deposited in US]; Nukulau Island, Suva [Carlson, 20 viii 1972: USP 680 (identified only as 'Family Delessariaceae'); Suva Reef [Kasahara, 18 ix 1985: USP 677 (as '*Neurymenia* sp.')] ; Fish Patch, Suva Reef [Keats, 10 v 1994: USP 666, 670; 18 v 1994: USP 695, 835, 836, 837; 5 x 1994: USP 806, 807]; Makaluva Island, Suva [Keats, 26 vii 1994: USP 753].

Habitat and phenology: This species is mainly found in caves and in shaded locations on the outer reef slope, between depths of 10 and 40 metres. Specimens collected from 10 to 40 metres were usually fertile, and moderately to heavily encrusted with bryozoans and smaller algal epiphytes. Plants from deeper water (30 to 40 m) were less often fertile, produced fewer reproductive structure, and were more free of epiphytes. The deeper populations also tended to occur in the open, rather than in caves and overhangs, and were often mixed with *Neurymenia fraxinifolia* (Mertens *ex* Turner) J. Agardh, which they superficially resemble. The population seems to be dominated by tetrasporophytes, with the cystocarpic and spermatangial plants being relatively rare (approximately 10–15% of the total number of plants examined).

Distribution: Known only from the Suva Reef, Fiji.

Habit and vegetative structure: The *thallus* (Figs 1, 2) is medium to dark red, (7–)16–18.5 cm high, alate in middle to distal regions, with the blades (13–)38–80 mm long, 6–9 mm wide. The axis is strongly corticated, forming a prominent midrib 330–440 μ m in diameter. The determinate lateral ramuli are on op-

posite sides of axis, and are laterally fused to form the alae, ending in regular marginal serrations 450–580 μ m long and (330–)415–470 μ m wide at the base. The distance between the serrations is (250–)500–585 μ m. Branching is complanate for 2 or 3 orders with new indeterminate branches arising from the midrib. Lateral veins are usually not visible except near the blade apex, and are issued at a 45° angle from the midrib (Fig. 3).

The *blade* structure is based on an arrangement of branching filaments, with a medulla of ovoid cells that measure 22–36 μ m in diameter (Fig. 4). The inner cortex consists of ovoid cells 3.5–5.0 μ m in diameter, surrounded by a layer of obpyriform cells 1.8 \times 3.5 μ m. The blade is uniaxial, with the axial cells measuring 220–250 μ m long and 11–43 μ m in diameter. The axial filament is surrounded by densely massed rhizoidal filaments that measure 3–4 μ m in diameter, with abundant secondary pit-connections between adjacent filaments (Figs 5, 8). The apical cell (Fig. 9) measures approximately 4 μ m long \times 7 μ m in diameter, and divides transversely to give rise to segment cells, each of which in turn gives rise to an axial cell and four pericentral cells.

Tetrasporangial nemathecias are subspherical to obpyriform and measure 0.5–1.0 mm in diameter. Nemathecias terminate simple or branched stalks that measure 0.8–2.0 mm long, and that arise from the center of the midrib on both sides of the blade (Figs 6, 7, 10). Club-shaped tetrasporangial initials develop from lateral branches of the filaments that form the walls of the nemathecial channels (Fig. 11), and divide mainly oblique-zonately to give rise to ovoid tetrasporangia 7–13 μ m in diameter and 22–38 μ m long (Figs 12, 13).

Cystocarpic plants can readily be distinguished by bilabiate cystocarps bearing an ostiolar slit 100–120 μ m wide, and the dense, branched arrangement of the stalked cystocarps. Cystocarps measure 860–1000 μ m in diameter. They are bilabiate with a thick pericarp and are borne on 1–3 mm long stalks that arise either singly or in groups of up to four from the midrib (Figs 14, 15). The carposporophyte has a basal fusion cell with a thick central part and irregular lobes (Fig. 21). The fusion cell measures 40–70 μ m in diameter, and produces fan-shaped tufts of gonimoblast filaments that measure 1.2–5 μ m in diameter, with 2 or 3 terminal carposporangia that measure 6–8 μ m in diameter (Figs 16, 17). Carpogonial branches were not seen.

Male plants can be distinguished by their mostly sessile, knob-shaped and cream-colored spermatangial nemathecias borne in files along the midrib. Spermatangial nemathecias are mostly sessile, globular, and measure 850–1000 μ m in diameter. They may occur either singly or in linear groups of 2–5 along the midrib (Fig. 20). Spermatangia (Figs 18, 19) measure 1.2–2.4 μ m in diameter, and are borne on filaments

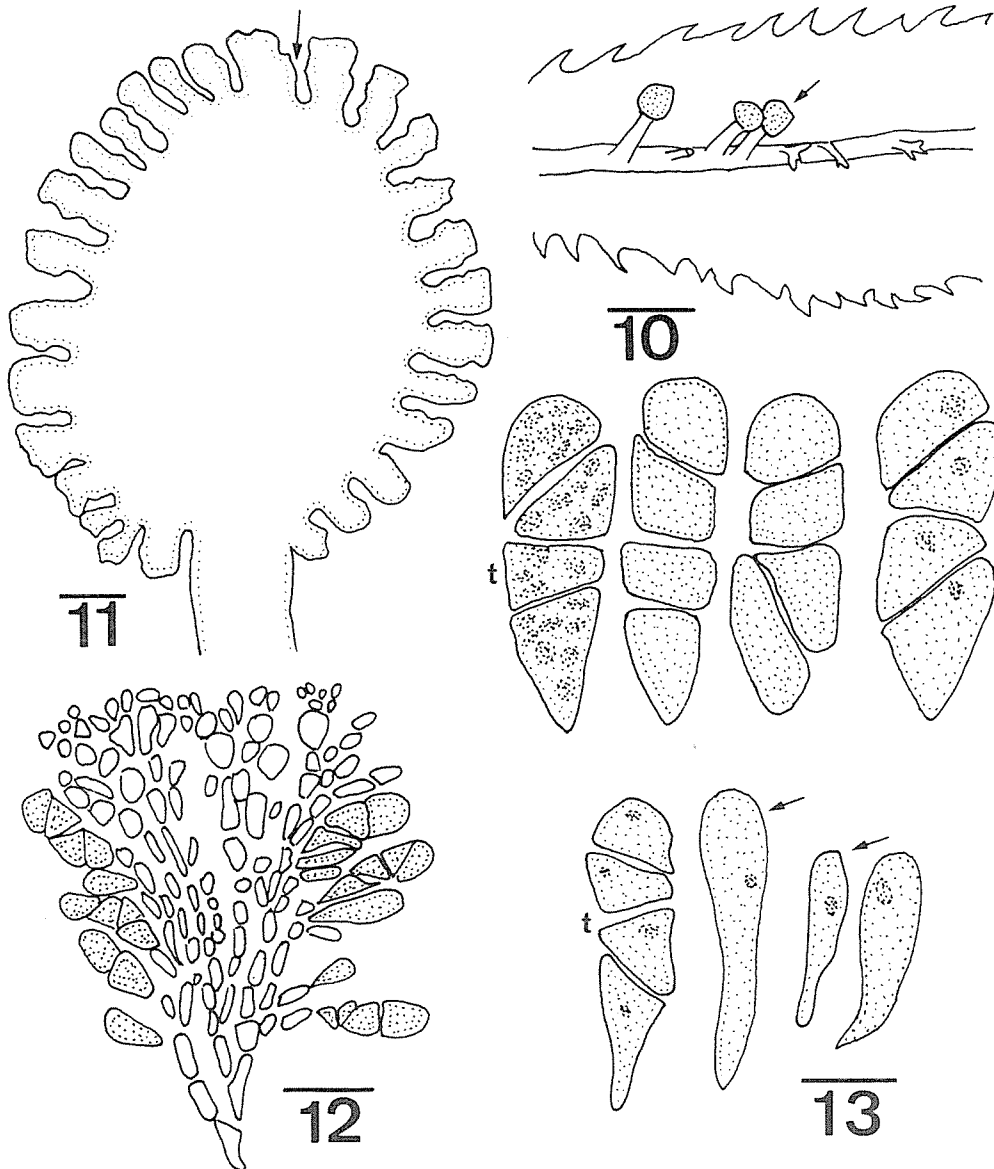
that measure 2–2.5 µm in diameter within slits in the spermagonial nemathecium.

Remarks: *Phacelocarpus neurymenioides* has been collected by earlier investigators of Fijian algae. A specimen housed in the Phycological Herbarium, South Pacific Regional Herbarium at the University of the South Pacific in Suva collected by B. Carlson from the Suva reef in 1972 and identified as belonging to the ‘family Delesseriaceae’ was ascertained to be *P. neurymenioides*. H. Kasahara in his 1985 thesis mentions a ‘*Neurymenia* sp.’ from the Suva reef (Kasahara 1995: 69, plate 13 fig. 3; plate 17 fig. D). From his description and plates, and an examination of his

specimens housed in the Phycological Herbarium, USP, there is no doubt that his plant is *P. neurymenioides*.

Discussion

At present the monogeneric family Phacelocarpaceae comprises nine mostly Southern Hemisphere species (Searles 1968: 8; Womersley 1994: 391; Table I). The genera *Stenocladia* and *Nizymenia* (originally included in the Phacelocarpaceae by Searles) were placed in a separate family by Womersley (1971). The genus *Phacelocarpus* was erected by Endlicher and

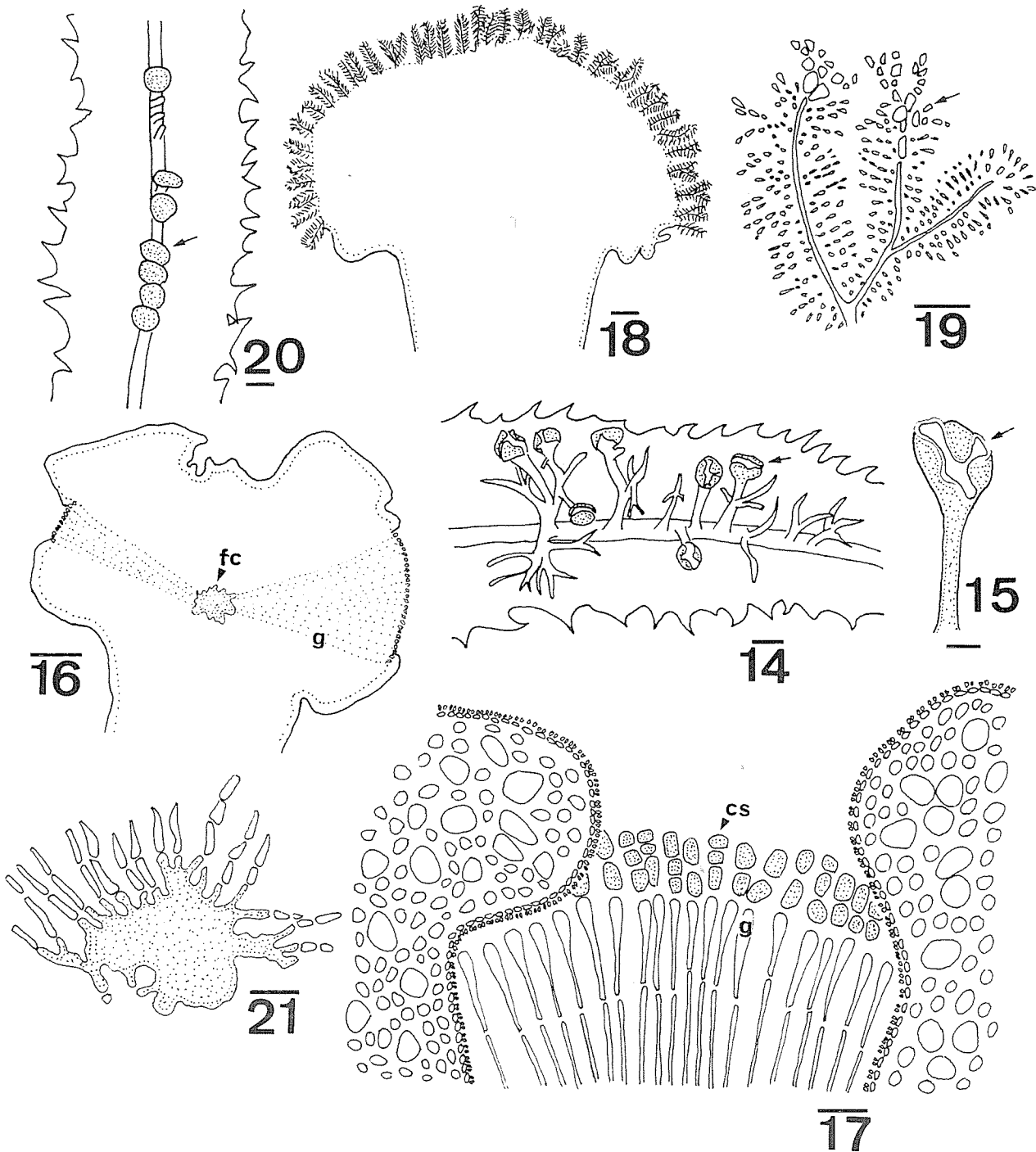


Figs 10–13. Tetrasporic reproductive anatomy.

Fig. 10. Habit of fertile blade with tetrasporangial nemathecium (arrow) borne on unbranched stalks. Scale = 2 mm. Fig. 11. Diagrammatic drawing of a longitudinal section of a tetrasporangial nemathecium, showing nemathecial channels (arrow) (USP 840). Scale = 100 µm. Fig. 12. Single filament from nemathecial channel, bearing tetrasporangial initials and zonately divided tetrasporangia (USP 840). Scale = 20 µm. Fig. 13. Zonately divided tetrasporangia (t) and club-shaped tetrasporangial initials (arrow). Scale = 10 µm.

Diesing (1845: 289), and includes uniaxial plants with irregular long and short branches bearing distichous (or tristichous) tooth-like ramuli, with the reproduct-

ive structures borne on short shoots which are branchlets produced in addition to the teeth (Searles 1968).



Figs 14–21. Cystocarpic and spermatangial reproductive anatomy.

Fig. 14. Habit of fertile blade bearing stalked cystocarps (arrow). Scale = 1 mm. Fig. 15. Detail of bilabiate cystocarp with ostiolar slit (arrow). Scale = 500 μ m. Fig. 16. Semi-diagrammatic drawing of a longitudinal section of a cystocarp, showing fan-shaped gonimoblast filaments (g) and fusion cell (fc) (USP 842). Scale = 100 μ m. Fig. 17. Longitudinal section through ostiolar slit of a cystocarp, showing gonimoblast filaments (g) terminated by carposporangia (cs). Scale = 20 μ m. Fig. 18. Semi-diagrammatic drawing of a longitudinal section of a spermatangial nemathecium. Scale = 100 μ m. Fig. 19. Single spermatangial filament bearing spermatangial systems (arrow) (USP 841). Scale = 20 μ m. Fig. 20. Habit of fertile blade bearing knob-shaped spermatangial nemathecia (arrow) (USP 841). Scale = 1 mm. Fig. 21. Detail of fusion cell. Scale = 20 μ m.

Table I. Comparison of selected characters of *P. neurymenioides* with those of other *Phacelocarpus* species.

Species	Tetrasporangial/ spermatangial nemathecia, cystocarps stalked or sessile	Tetrasporangial/ spermatangial nemathecia, cystocarp position	Ramuli/serration length in relation to blade width
<i>P. neurymenioides</i>	stalked	borne on midrib	less than 10% of blade width
<i>P. alatus</i>	stalked	borne on periphery of rachis	60–70% of blade width
<i>P. apodus</i>	sessile	borne on periphery of rachis	240–350% of blade width
<i>P. complanatus</i>	sessile	borne on the ramuli	100–150% of blade width
<i>P. japonicus</i>	stalked	borne on periphery of rachis	100–150% of blade width
<i>P. oligocanthus</i>	sessile	borne on the ramuli	240–350% of blade width
<i>P. peperocarpus</i> ¹	stalked	borne on periphery of rachis	240–350% of blade width
<i>P. sessilis</i>	sessile	borne on periphery of rachis	400–420% of blade width
<i>P. tortuosus</i>	stalked	borne on the ramuli	100–150% of blade width
<i>P. tristichus</i>	sessile	borne on periphery of rachis	100–150% of blade width

Sources: Searles (1968); Womersley (1944)

¹ = *P. labillardieri* (Turner) J. Agardh (see Wynne *et al.* 1993).

The internal anatomy and reproductive structures of *P. neurymenioides* confirm its placement in *Phacelocarpus*. Of particular significance are:

1) the presence of abundant secondary pit-connections between adjacent rhizoidal filaments surrounding the axial cells of the midrib, and

2) the production of bilabiate, stalked cystocarps with fan-shaped gonimoblast filaments terminating in one to three-celled chains of carposporangia.

A comparison of selected characters between *P. neurymenioides* and the other nine species in the genus *Phacelocarpus* is given in Table I.

The new species has broader blades than other members of the genus. It has indeterminate branches that arise irregularly rather than regularly from the midrib. Determinate branchlets, which form the alae, terminate in serrations that occupy less than ten percent of the width of the blade. The stalked nemathecia are borne on the center of the midrib, whereas in all other nine species they are borne laterally within the inter-ramular spaces (as additional teeth), or on the ramuli themselves. *Phacelocarpus neurymenioides* bears a remarkable superficial resemblance to the genus *Neurymenia*, and to other Rhodomelaceae of the tribe Amansieae.

The deep-water and cryptic distribution of *P. neurymenioides* partly explains why it has eluded examina-

tion until now, and its superficial resemblance to such genera as *Amansia* and *Neurymenia* has led to misidentification in the past. It is hoped that this study will stimulate investigations in other parts of the world into the habitats favoured by the new species, as well as a re-examination of previous collections in the light of the Fijian discoveries.

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