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Vegetative and Reproductive Morphology of *Nemastoma damaecorne* (Gigartinales, Rhodophyta) from Western Australia

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Abstract

The vegetative and reproductive morphology of the red alga *Nemastoma damaecorne* Harvey (Gigartinales) have been examined. Thalli are flattened and variously branched, either foliose with marginal proliferation or deeply incised. Structurally, the thallus is multiaxial, with a filamentous medulla and cortex, the latter subdichotomously branched, anticlinally directed, and incorporating large, intercalary gland cells. Plants are monoecious, with spermatangia formed on outer cortical cells. Carpogonial branches are three-celled and borne on an inner cortical cell. Following presumed fertilization, the carpogonium fuses with nearby subsidiary auxiliary cells—the latter producing several branched connecting filaments. Generative auxiliary cells are transformed intercalary cortical cells. Connecting filaments fuse with generative auxiliary cells and continue growth. The gonimoblast initial arises from the upper surface of the generative auxiliary cell and forms a carposporophyte composed entirely of carposporangia. Tetrasporophytes are unknown, but the germination pattern of carpospores in culture suggests a crustose habit. These results indicate that the species is incorrectly placed in *Nemastoma* and conforms more closely to the genus *Platoma*. Furthermore, a comparison between *N. damaecorne* and published descriptions of *Platoma cyclocolpum* (Montagne) Schmitz suggests that the two species are conspecific, and as such the former is regarded as an heterotypic synonym of the latter.

Introduction

The mid-nineteenth century was somewhat of a watershed for Australian phycology, due principally to the activities of the Irish botanist William Henry Harvey. During this productive period, Harvey described numerous species in a variety of papers (e.g. Harvey 1855), and his ‘Phycologia Australica’ (Harvey 1858–1863)—a lavishly illustrated compendium of the Australian marine algae in five volumes—was published. In these works Harvey described over 400 new species and varieties, which, at the time, made up about half of the known Australian algal flora. Harvey’s contribution to Australian phycology cannot be overstated. Perhaps inevitably, however, changing concepts and improved techniques in algal systematics in the intervening years have led to much revision of Harvey’s species. His southern Australian taxa have received substantial attention from H. B. S. Womersley (summarised in his multi-volume flora—Womersley 1984, 1987, 1994, 1996), but there remain a handful of enigmatic taxa, mostly amongst those Harvey described from Western Australia. One of these is the subject of the present paper.

Nemastoma damaecorne was erected by Harvey (1855, p. 557, as *damaecornis*) for a gelatinous red alga collected from Fremantle and Rottnest Island in Western Australia. Curiously, Harvey did not include the species in his subsequent ‘Synopsis of all known Australian Algae’ (Harvey 1863) and the species disappeared from the literature until Huisman and Walker (1990) and Huisman (1997) reported on new collections from, respectively, Rottnest Island and the Houtman Abrolhos, Western Australia. The species is a regular component of the subtidal flora of south-western Australia, where it occurs in shaded positions on limestone reefs.

Recent revisions of the Nemastomataceae and the segregation of the Schizymeniaceae (Masuda and Guiry 1994, 1995; Womersley and Kraft 1994) have more precisely defined the

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characteristic features of the included genera, prompting a re-examination of *Nemastoma damaecorne* to confirm its generic placement. Both vegetative and reproductive features do not support its retention in *Nemastoma* and conform in virtually all respects to those described by Masuda and Guiry (1994) for *Platoma cyclocolpum* (Montagne) Schmitz.

Materials and Methods

Collections were made using SCUBA and preserved in approximately 5% formalin/seawater. Microscopic examinations were made of hand-sectioned or squashed materials stained in an aniline blue/Karo mixture (as described in Millar and Wynne 1992). Microscope slides and voucher herbarium specimens are held at Murdoch University (MURU). Herbarium abbreviations follow Holmgren *et al.* (1990). Drawings were made with a *camera lucida*.

Results and Observations

Nemastoma damaecorne Harvey 1855: 557.

Lectotype

Herb. Harvey, TCD 315 (Fig. 1).

Lectotype Locality

Fremantle, Western Australia.

Distribution

From the Houtman Abrolhos (28°35′ S, 113°40′ E) south to Cape Bouvard (32°41′ S, 115°36′ E), Western Australia.

Selected Specimens Examined

Fremantle, *W.H. Harvey*, TCD 315 (Lectotype). Off Cape Bouvard, from 6–9 m deep, *J.M. Huisman*, 11.v.1994, MURU JH 546. Fish Hook Bay, Rottnest Island, from 12 m deep. *J.M. Huisman*, 15.iii.1997, MURU JH 1786, 1787. Green Island, off Rottnest Island, from 12–15 m deep. *J.M. Huisman*, 3.x.1990, MURU JH 1365, 1366. Ravin Reef, Rottnest Island, from 10 m deep. *J.M. Huisman*, 15.iii.1997, MURU JH 1718. Point Clune, Rottnest Island, *J.M. Huisman*, 8.viii.1988, MURU JH 866. 'Conference' wreck site, Mindarie Keys, *J.M. Huisman*, 27.ii.1993, MURU JH 938. North-east Eastern Passage, Easter Gp., Houtman Abrolhos, from 8–12 m deep, *J.M. Huisman*, 26.ix.1994, MURU HA 827. Anemone Lump, Easter Gp., Houtman Abrolhos, from 10 m deep, *J.M. Huisman*, 2.ii.1997; MURU HA 1881. Coral Patches, Pelsaert Gp., Houtman Abrolhos, from 10 m deep, *J.M. Huisman*, 31.i.1997; MURU HA 1748.

Habitat

Plants occur in subtidal positions, to depths of 20 m, generally on the sides or at the bases of limestone reefs in positions of relatively low light. At the Houtman Abrolhos plants are common amongst *Acropora* tines.

Habit

Plants are upright or partially decumbent and grow to 13 cm in height and 20 cm in width, with a small discoid holdfast. Thalli are irregularly branched and show variation in habit, commonly with foliose portions and numerous marginal proliferations (Figs 2, 3, 4), rarely with narrow axes (as in the lectotype specimen, Fig. 1). Axes are up to 10–30 mm wide and 1.4–2.2 mm thick, tapering abruptly to 0.5–2 mm wide and 0.5–1.7 mm thick near the apices. Secondary anastomoses between branches are common. Living specimens are pliable but turgid and mucilaginous to touch. Colour ranges from light pink to red–brown and pressed specimens often appear mottled.

Vegetative Structure

Thalli are multiaxial, with a diffuse, apical meristem. The medulla is filamentous (cell dimensions 80–270 μm long × 5–15.7 μm diam.) and subtends dichotomously divided, anticlinally directed, filaments that form a coherent cortex (Fig. 5). The cortex is 5–12 cells

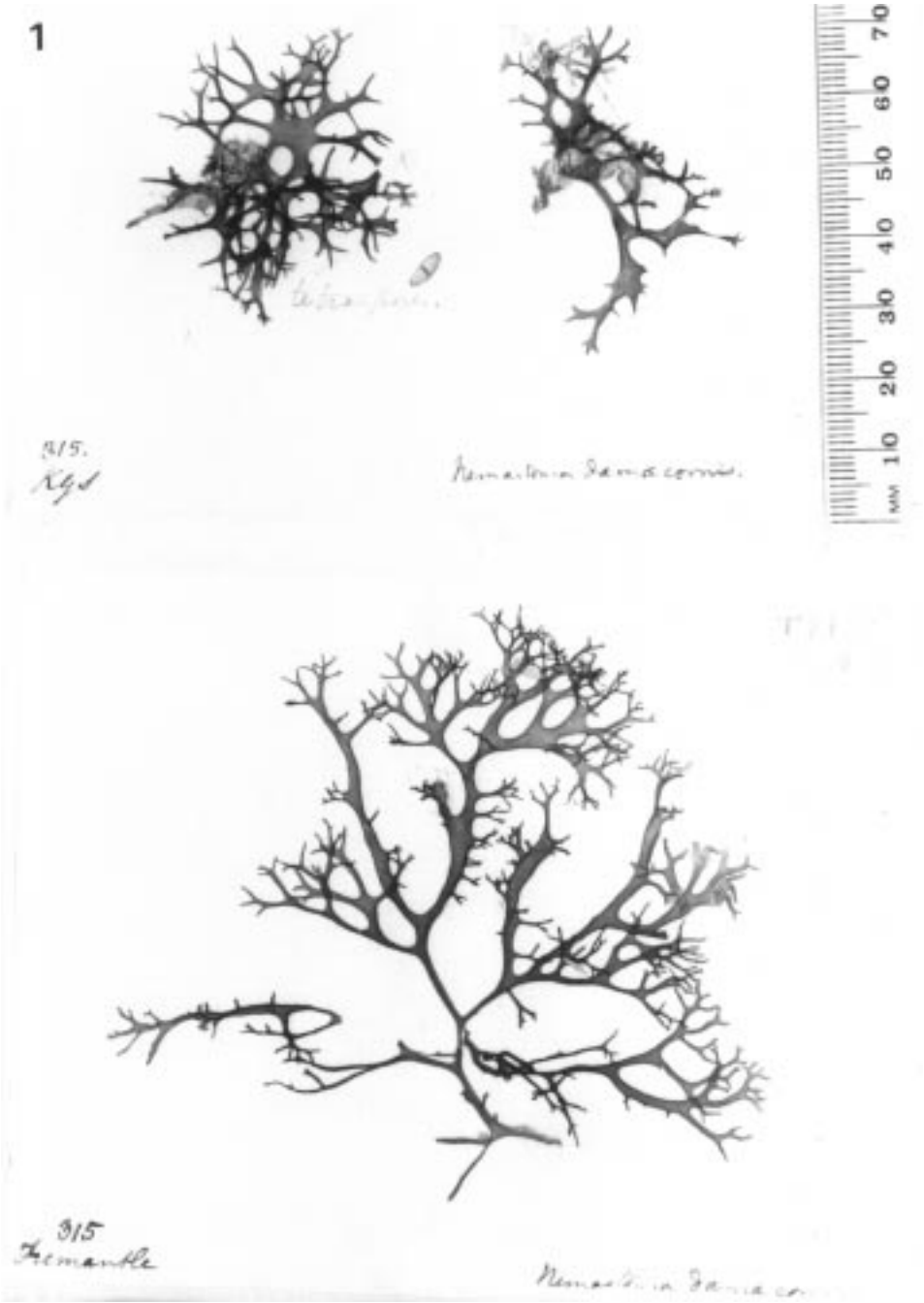
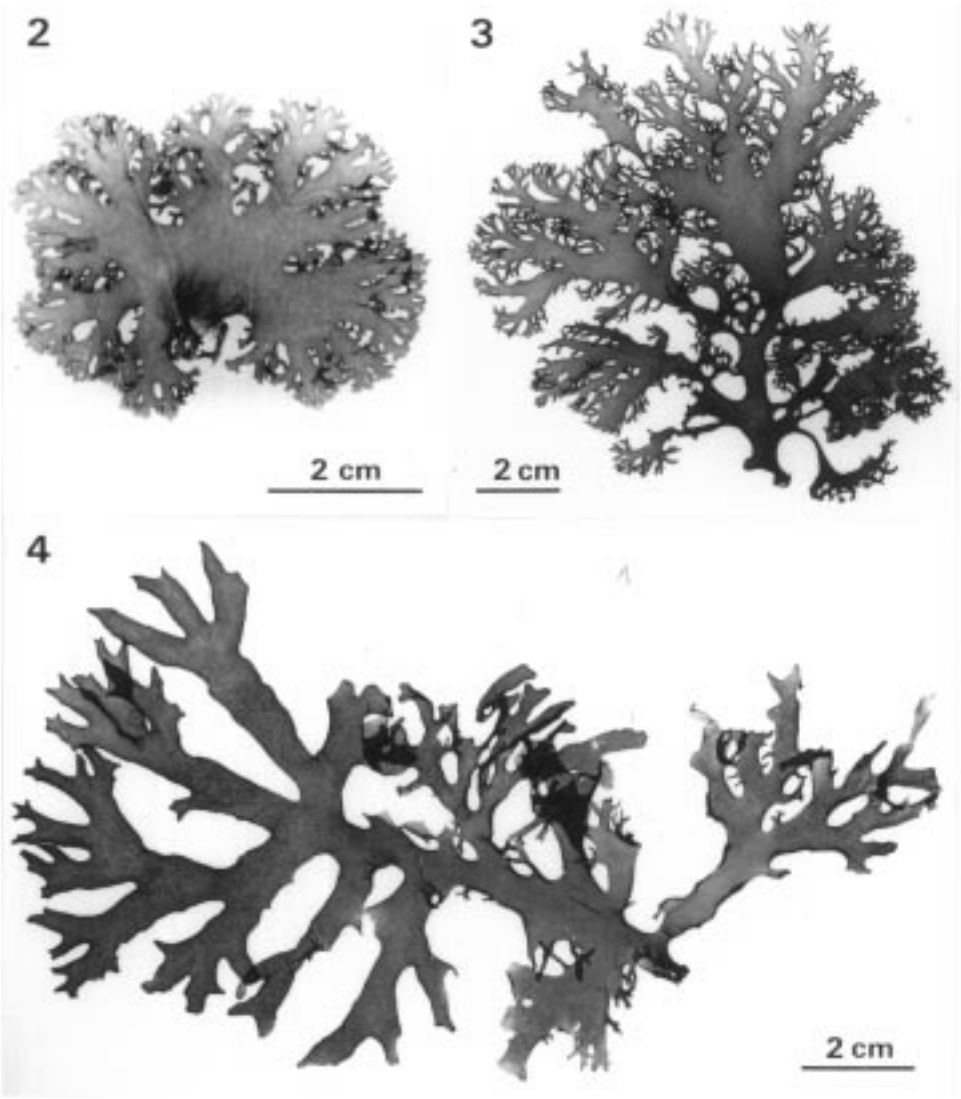


Fig. 1. *Nemastoma damaecorne* Harvey. Type sheet in Herb. Harvey (TCD 315). The lower specimen (Fremantle) is herein selected as the lectotype. The top specimens (King George Sound) are referable to *Gloiocladia halymenioides* (Harvey) R. Norris.

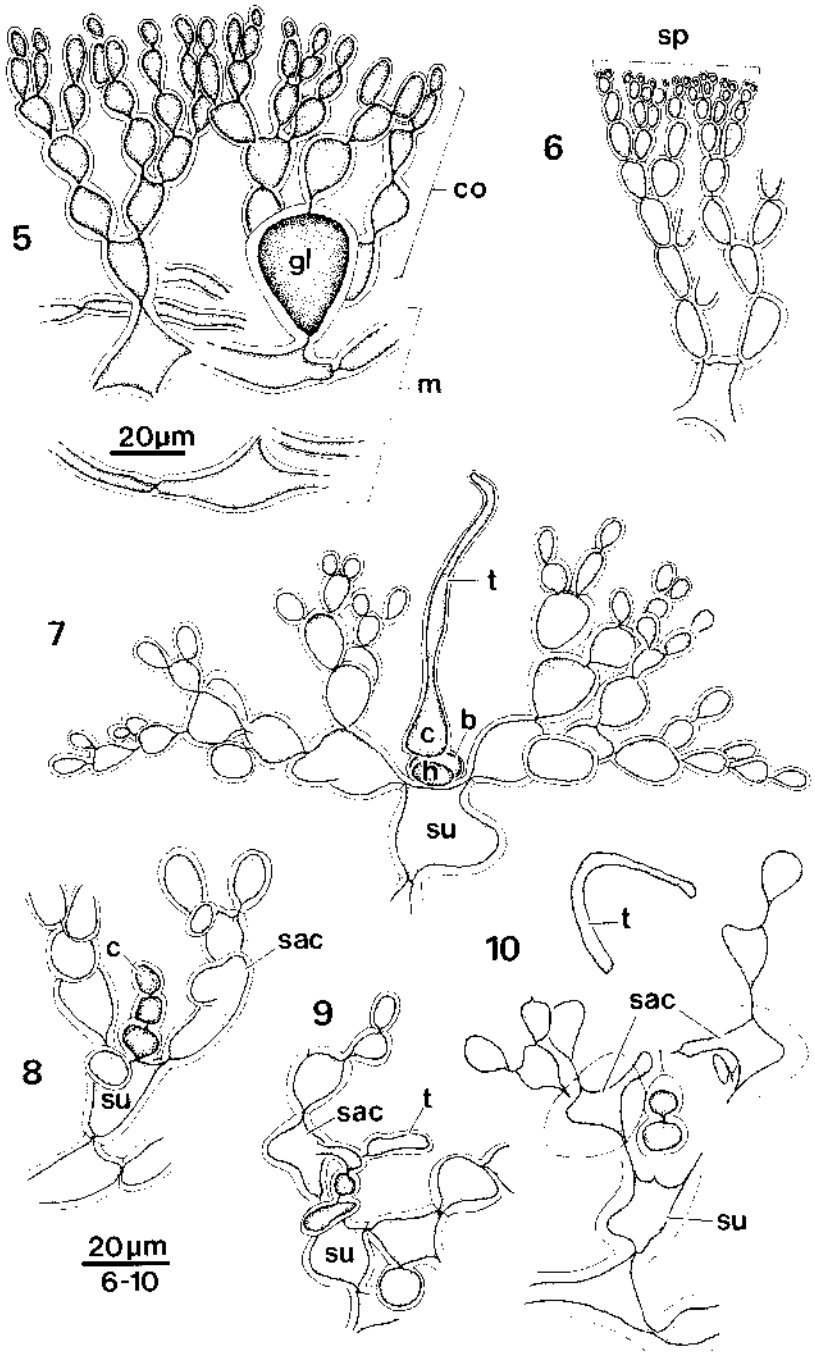


Figs 2–4. *Nemastoma damaecorne* Harvey. Habit variation in recent collections from south-western Australia. **Fig. 2.** MURU JH1365. **Fig. 3.** MURU JH1366. **Fig. 4.** MURU JH1787.

thick, with ellipsoidal inner cells 15–35 μm long × 10–15 μm diam. and subspherical surface cells 3.5–4.5 μm diam. Intercalary, obovoid gland cells (25–50 μm long × by 20–45 μm diam., Fig. 5) are common in the cortex and occasionally present in the medulla.

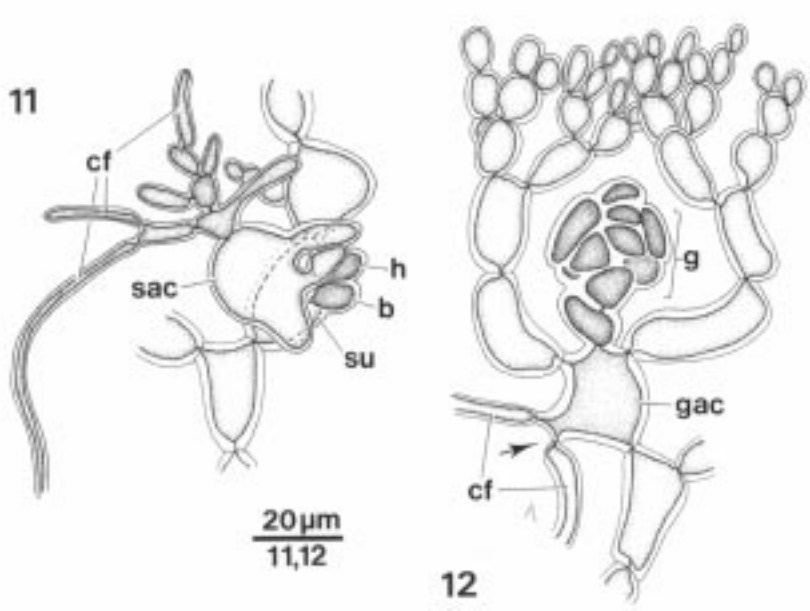
Reproductive Structures

Plants are monoecious. Spermatangia (4–6 μm long × 2.5–4 μm diam.) occur in sori and arise singly or in pairs on outer cortical cells (Fig. 6). Carpogonial branches are three-celled (basal cell, hypogynous cell and carpogonium with trichogyne) and arise on the upper surface of a mid-cortical supporting cell (Fig. 7). Cells of the cortical fascicle adjacent to the supporting cell enlarge slightly (Fig. 8) and stain darkly with aniline blue. Following presumed fertilization the carpogonium fuses with one (Fig. 9) or two (Fig. 10) of these cells, which therefore act as subsidiary auxiliary cells. Connecting filament initials are formed from the subsidiary auxiliary cell (Fig. 11), divide profusely, and course through the thallus.



Figs 5–10. *Nemastoma damaecorne* Harvey. b = basal cell; c = carpogonium; co = cortex; gl = gland cell; h = hypogynous cell; m = medulla; sac = subsidiary auxiliary cell; sp = spermatangia, su = supporting cell; t = trichogyne. **Fig. 5.** Section of filamentous medulla and cortex with dichotomously divided filaments and intercalary gland cell (MURU HA 827). **Fig. 6.** Spermatangia borne at the apices of cortical filaments (MURU JH 1786). **Fig. 7.** Three-celled carpogonial branch borne on an inner cortical cell (MURU HA 1881). **Fig. 8.** Apparently post-fertilization stage in which a bulbous growth on a nearby cell (potentially a subsidiary auxiliary cell) appears to be preparing to fuse with the carpogonium (MURU JH 1718). **Fig. 9.** Fusion of carpogonium with nearby subsidiary auxiliary cell (MURU JH 1786). **Fig. 10.** Fusion of carpogonium with two subsidiary auxiliary cells (MURU JH 1786).

Generative auxilary cells are transformed mid-cortical cells—the connecting filament fuses with a surface of the generative auxiliary cell, forms a pit-connection, then continues growth (presumably onto additional generative auxiliary cells) (Fig. 12). The gonimoblast arises from the upper surface of the generative auxiliary cell (Fig. 12) and eventually produces a spherical carposporophyte (140–200 μm diam.) composed entirely of angular or spherical carposporangia (12–20 μm diam.). Cells of adjacent cortical fascicles elongate somewhat to accommodate the enlarging carposporophyte, but subsidiary involucral or pericarp filaments are not produced. Mature carposporophytes are largely immersed in the thallus, although a slight protuberance and rudimentary ostiole are visible from the surface. Tetrasporangia were not observed, but early stages of the germination of carpospores in culture (Huisman, unpublished observations) were identical to those observed by Masuda and Guiry (1994) for *Platoma cyclocolpum*, suggesting a crustose tetrasporophyte.



Figs 11–12. *Nemastoma damaecorne* Harvey. cf = connecting filament; g = gonimoblast; gac = generative auxiliary cell. Other abbreviations as for Figs 5–10. **Fig. 11.** Production of connecting filaments from subsidiary auxiliary cell. Note the apparent double fusion between the carpogonium and subsidiary auxiliary cell (MURU HA 1881). **Fig. 12.** Young carposporophyte borne on a generative auxiliary cell. The attachment of the connecting filament to the generative auxiliary can be seen (arrow) (MURU HA 1881).

Discussion

Mounted on the type sheet (TCD 315) of *Nemastoma damaecorne* are three specimens, a large, cystocarpic plant from Fremantle and two smaller plants from King George Sound, one of which is tetrasporangial (Fig. 1). These are the only specimens of *Nemastoma damaecorne* in TCD. The author has examined the Fremantle specimen and one of the King George Sound specimens. The former is vegetatively and reproductively identical to recent collections attributed to *Nemastoma damaecorne* (Huisman and Walker 1990; Huisman 1997) and as described above, whilst the latter has a large-celled medulla and filamentous cortex and is referable to *Gloiocladia halymenioides* (Harvey) R. Norris. Unfortunately, Harvey based the protologue of *Nemastoma damaecorne* on both elements—the locality is given as 'At Fremantle and Rottnest', but the description, which includes cruciately divided tetrasporangia and makes no mention of gland cells nor cystocarps, appears to be based largely on the King George Sound specimen. Since there are no 'Rottnest' specimens in

TCD, it is likely that Harvey (1855) erred in citing that locality. As the only specimen definitely associated with the protologue—and to preserve current usage—the Fremantle specimen is herein selected as the lectotype. In habit, the thallus of this specimen is more deeply incised with axes of similar width than generally occurs in the species, but this form is also displayed by several recent collections.

According to Masuda and Guiry (1994), defining features of *Nemastoma* include terminal gland cells, supporting cells and auxiliary cells in adventitious filaments, no subsidiary auxiliary cells, and the gonimoblast arising from the connecting filament. None of these features is found in *Nemastoma damaecorne* and its generic placement is clearly incorrect. The species is entirely compatible with *Platoma*, however, with which it shares intercalary gland cells, supporting cells and auxiliary cells in cortical filaments, the presence of subsidiary auxiliary cells, and the gonimoblast arising from the auxiliary cell. In fact, a comparison between *N. damaecorne* and Masuda and Guiry's (1994) description of *Platoma cyclocolpum* (the generitype) suggests that the two are conspecific (see Table 1). The only difference appears to be that *N. damaecorne* can grow to a larger size than *P. cyclocolpum*, but many of the smaller specimens in Western Australian collections are indistinguishable

Table 1. Comparison of vegetative and reproductive features of *Platoma cyclocolpum* and *Nemastoma damaecorne*
Details for *Platoma cyclocolpum* from Masuda and Guiry (1994). Cell sizes are given as length (L) by diameter (D)

Feature	*Platoma cyclocolpum*	*Nemastoma damaecorne*
General		
Habitat	Lower intertidal pools	Subtidal, 3–20 m depths
Light	Low	Low
Substratum	Rock	Rock
Thallus length (max.)	50 mm	130 mm
Thallus width (max.)	60 mm	200 mm
Stipe	Absent	Absent
Blade thickness (distal)	0.3–0.7 mm	0.5–1.7 mm
Blade thickness (proximal)	1.2–2.8 mm	1.4–2.2 mm
Branching	Irregular	Irregular
Holdfast	Discoid	Discoid
Secondary anastomoses	Present	Present
Cortex		
Inner cell size (L×D)	25–40 × 10–25 μm	15–35 × 10–15 μm
Surface cell size (D)	3.0–4.5 μm	3.5–4.5 μm
Depth	10–14 cells	5–12 cells
Branching	Dichotomous	Dichotomous
Medulla		
Cell size (L×D)	100–450 × 7.5–12.5 μm	80–270 × 5–15.7 μm
Gland cells		
Shape	Spherical, ellipsoidal or ovoid	Spherical, ellipsoidal or obovoid
Position	Intercalary, mostly in cortex	Intercalary, mostly in cortex
Size (L×D)	25–50 × 25–40μm	25–50 × 20–45 μm
Reproduction		
Mono/dioecious	Monoecious	Monoecious
Spermatangia size (LxB)	4–5 × 3–4 μm	4–6 × 2.5–4 μm
Spermatangia position	Paired on outer cortical cells	Paired on outer cortical cells
Carpogonial branch	Three-celled	Three-celled
Carposporophyte	150–200 μm diam.	140–200 μm diam.
Carposporangia	Spherical 15–20 μm diam.	Angular/spherical 12–20 μm

from those described by Masuda and Guiry (1994). In all structural and reproductive features the two are comparable. Thus, *Nemastoma damaecorne* is considered to be conspecific with *Platoma cyclocolpum* and the former is relegated to a synonym of the latter. The type locality of *P. cyclocolpum* (Tenerife, Canary Islands) is some distance from the known range of *Nemastoma damaecorne*, but such disjunct distributions are not without precedence. *Predaea huismanii* (Kraft 1984), known in Australia only from two collections from Rottnest Island (the type locality) and Pearson Island in South Australia, was recently recorded from the Canary Islands by Sanson *et al.* (1991). Whether these disjunct distributions are the result of chance introductions or are a reflection of our imperfect knowledge of the real distribution of the taxon remains to be seen. Comparative molecular studies of these disjunct populations might demonstrate genotypic variation and give some indication of possible avenues of distribution.

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