Research note

First report of *Gelidiella ligulata* (Gelidiales, Rhodophyta) in Japan

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SUMMARY

A gelidialean red alga that was newly found in Japanese waters is referred to as *Gelidiella ligulata* Dawson. It is characterized by erect lanceolate blades developing from a creeping axis that are relatively large in the genus *Gelidiella*. Among the 22 species currently recognized in the genus, *Gelidiella indica* Sreenivasa Rao is most similar to *G. ligulata* and a further comparative study is needed to elucidate the status of *G. indica*. *Gelidiella ligulata* and the type species of the genus, *Gelidiella acerosa* (Forsskål) Feldmann et Hamel, have the unicellular independent attachments that are common to the members of *Gelidiella* investigated to date. This type of attachment is unique in the Gelidiales and this feature may be a useful taxonomic criterion in distinguishing *Gelidiella* from other genera.

Key words: Gelidiales, *Gelidiella indica*, *Gelidiella ligulata*, Japan, morphology, Pacific, Rhodophyta, secondary rhizoidal attachment.

Gelidiella ligulata Dawson 1953: p. 81, pl. 3, figs 3–5.

Holotype: Dawson 6808 (11.iii.1949) on sheet 54721 in the Herbarium of the Allan Hancock Foundation (HAHF).

Type locality: Cabeza Ballena, Baja California.

Distribution: Baja California (Dawson 1953), Solomon Islands (Womersley and Bailey 1969) and Japan (present paper).

Japanese name: Sasaba-shimatengusa.

Gelidiella ligulata Dawson is a gelidialean red alga that was established in 1953 by Dawson. Until now, there have been only two reports of this species, one from Baja California (Dawson 1953) and another from the Solomon Islands (Womersley and Bailey 1969). We report here the occurrence of this species in Japanese waters.

Plants of *Gelidiella ligulata* were collected from Miyake Island (Fig. 1) at Izu-misaki (13 July 1998) and Benkene-misaki (14 July 1998). The majority of these materials were fixed and preserved in 10% formalin–seawater and then some were dried as voucher herbarium specimens which were deposited in the Herbarium of the Graduate School of Science, Hokkaido University, Sapporo (SAP 063883–063886). Some plants were transported live to Hokkaido University for culture studies. Unialgal cultures were established from excised apical tips of creeping axes of plants collected at Izu-misaki and Benkene-misaki and were grown in Tris-buffered medium (Van Der Meer and Patwary 1991) at both 15 and 20°C, with a 16:8 h LD photoperiod and photon flux of 15–25 μE $m^{-2} s^{-1}$.

The following observations are based on field collected and cultured materials. The plants form tufts on bedrock in the middle intertidal zone of sheltered shores or in tidal pools. They are up to 4.5 cm tall (Fig. 2) and are dark red to purplish red in colour. Individual plants consist of a creeping axis and erect blades. The creeping axis attaches to the substratum by unicellular independent attachments (Figs 3,4) that are 50–240 μm in length and 10 μm in diameter. The creeping axis is subterete, 300–500 μm in diameter and is branched irregularly. Erect blades arise from the creeping axis. They are terete (250–350 μm in diameter) at the proximal portion, gradually expanding and become flattened. The blades are fan-shaped when young (Fig. 5), but become lanceolate with age (1–3 mm wide, 100–270 μm thick). They are usually simple, but are sometimes irregularly to dichotomously branched (Fig. 6). Blade margins are undulate and sometimes ruffled. Subterete to lanceolate proliferations issue from both sides of blades pinnately (Fig. 6), injured (perhaps grazed) ends of blades (Fig. 7) and blade surfaces. A dome-shaped apical cell is evident at the apices of creeping axes (Fig. 8) and erect blades, as is typical of the Gelidiales. Both creeping axes and erect blades (Fig. 9) consist of a medulla composed of 10–18 layers of cells 6–40 μm in diameter and a cortex composed of 2–3 layers of smaller cells 3–5 μm in diameter. Rhizines (slender, thick-walled, internal, hypha-like filaments) are absent throughout creeping axes and erect blades. Reproductive structures were not found in the present specimens.

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Fig. 1. Map showing the locations on Miyake Island where *Gelidiella ligulata* was collected.

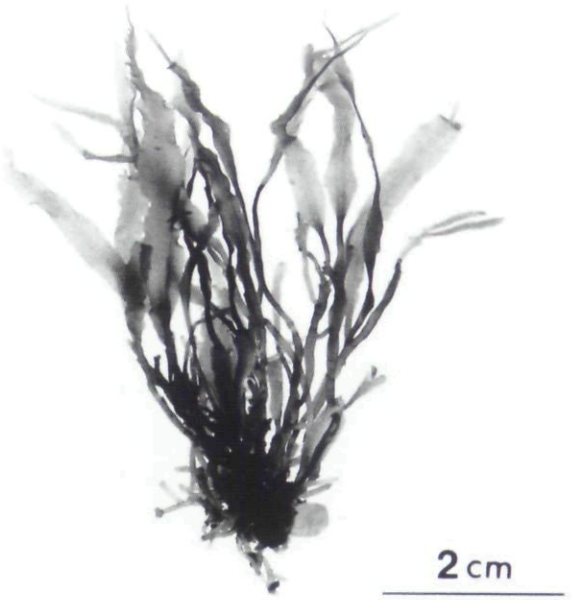
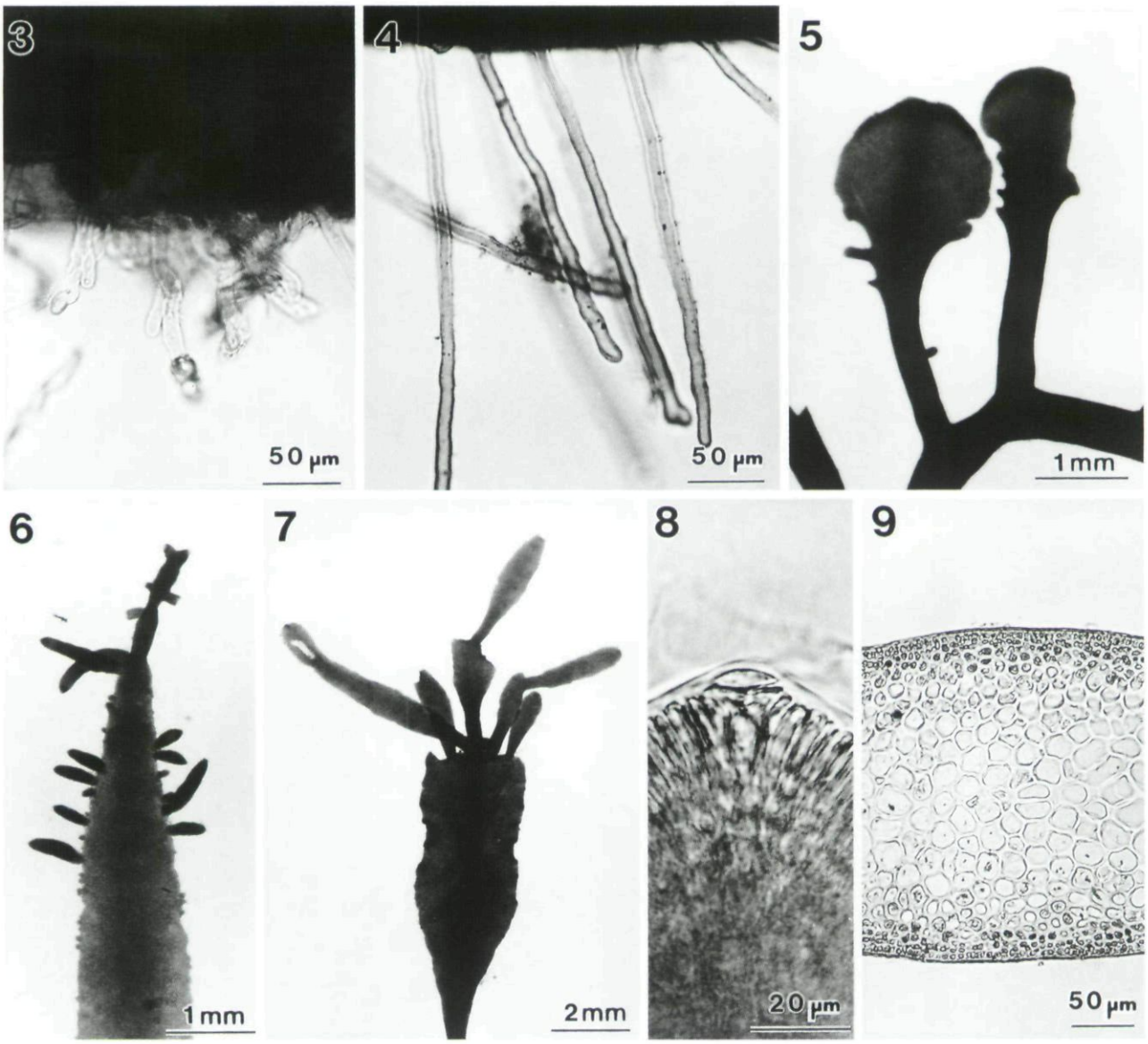


Fig. 2. Formalin–seawater-preserved specimen of *Gelidiella ligulata* collected at Izu-misaki, Miyake Island.

The genus currently includes 22 species that are distinguished from members of other genera in the Gelidiales by the absence of rhizines. Kraft and Abbott (1998) enumerated 23 species of *Gelidiella* but included *G. calcicola* Maggs et Guiry (Maggs and Guiry 1987), which had been transferred earlier to *Gelidium* as *G. calcicola* (Maggs et Guiry) R. E. Norris (1992) on the basis of having rhizines only at the attachment points. The species of *Gelidiella* have been characterized by thallus habit, thallus size (height and diameter/width), axis symmetry, tetrasporangial location and tetrasporangial arrangement (Kraft and Abbott 1998). A few species are known to have flattened thalli: *G. bornetii* (Weber-van Bosse) Feldmann et Hamel (Feldmann and Hamel 1934), *G. feldmannii* Baardseth (1941), *G. indica* Sreenivasa Rao (1970) and *G. ligulata*. Of these species, *G. bornetii* and *G. feldmannii* differ from the Japanese material by having very narrow blades up to 300 µm wide (Weber-van Bosse 1926; as *Gelidium bornetii* Weber-van Bosse) and 500 µm wide (Baardseth 1941), respectively. *Gelidiella indica* and *G. ligulata* are more similar to the Japanese material. These two species have lanceolate erect blades. Dawson (1953) did not describe tetrasporangia, but Womersley and Bailey (1969) reported tetrasporangial lateral branches of their material from the Solomon Islands. Similarly, *G. indica* was described to have tetrasporangial lateral branches in the upper to middle part of the erect axes (Sreenivasa Rao 1970; fig. 4c). One marked difference between these two species is the presence/absence of deciduous branches. For *G. ligulata*, Dawson (1953; p. 81) described older blades becoming closely pinnately branched near the extremities and readily deciduous and apparently serving as a vegetative means of reproduction, whereas Sreenivasa Rao (1970) reported that lateral branches of *G. indica* are not generally deciduous. Pinnate branches that are very similar to those of Dawson's alga (Dawson 1953, pl. 6, fig. 5) have been found in the Japanese material (Fig. 6), but they are not deciduous. At present, the deciduous nature of Dawson's (1953) material, whether those deciduous branches function as propagules or are artefacts during preservation, has not been confirmed. *Gelidiella indica* seems to represent matured stages of *G. ligulata and* the latter (Dawson 1953) has nomenclatural priority over the former (Sreenivasa Rao 1970). However, it is prudent to maintain *G. ligulata* and *G. indica* as separate species until fully matured plants of the former alga from its type locality are collected and these two algae are thoroughly compared. We refer our material to *G. ligulata* that has nomenclatural priority over *G. indica*. In the molecular analyses of small subunit rDNA and *rbc*L sequences, *G. ligulata* from Japan clustered with *Gelidiella acerosa* (Forsskål) Feldmann et Hamel with 100% bootstrap values (Shimada *et al.* unpubl. data, 1999).

The genus *Gelidiella* has been primarily distinguished from other genera in the Gelidiales by the absence of rhizines throughout the thalli (Feldmann and Hamel 1934). It has been traditionally characterized by the lack of a sexual generation (Fan 1961; Santelices 1997). However, the discovery of a single male gametophyte in *Gelidiella acerosa* from Malaysia



Figs 3–9. *Gelidiella ligulata* collected at Izu-misaki. Formalin–seawater-preserved material unless otherwise indicated. 3. Secondary rhizoidal attachments. 4. Secondary rhizoidal attachments (cultured plant grown at 20°C, 16:8 h LD for 1 month). 5. Young fan-shaped blades issued from a creeping axis. 6. Uppermost portion of an erect blade forming branches irregularly to pinnately. 7. Proliferations from an injured (perhaps grazed) end of a blade. 8. Dome-shaped apical cell at the apex of a creeping axis. 9. Transverse section of a blade showing the absence of rhizines in the cortex and medulla.

(Santelices 1997) requires reexamination of previous collections and further research on the presence of gametophytic stages in the genus. Furthermore, the genus can be characterized by the exclusive production of the unicellular independent type of secondary rhizoidal attachment (Perrone 1994). Three types of secondary attachments are known in the Gelidiales: (i) unicellular independent type; (ii) peg type; and (iii) brush type. Of these types, only the unicellular independent type has been reported for *Gelidiella* in *G. lubrica* (Kützing) Feldmann et Hamel, *G. nigrescens* (Feldmann) Feldmann et Hamel, *G. ramellosa* (Kützing) Feldmann et Hamel, *G. pannosa* (Feldmann) Feldmann et Hamel and *G. antipai* Celan (De Gregorio and Perrone 1994). The peg type of secondary rhizoidal attachments has been found in *Pterocladia lucida* (Brown et Turner) J. Agardh (Shimada and Masuda, unpubl. obs. based on material from Scarborough, Perth, 7 December 1997) and *Pterocladiella* (Perrone 1994; for *P. capillacea* (Gmelin) Santelices et Hommersand and *P. melanoidea* (Schousboe ex Bornet) Santelices et Hommersand). The brush type occurs in other genera, such as *Gelidium* (Perrone 1994; for *G. latifolium* (Greville) Bornet et Thuret and *G. pusillum* (Stackhouse) Le Jolis; Shimada and Masuda. unpubl. obs. for *G. vagum* Okamura from Jodogahama, Iwate Prefecture, 11 June 1997 and *G. elegans* Kützing from Awaji Island, Hyogo Prefecture, 16 May 1996), *Acanthopeltis japon-*

ica Okamura (Shimada and Masuda unpubl. obs. from material from Shimoda, Shizuoka Prefecture, 25 September 1996) and *Ptilophora subcostata* (Okamura) Norris (Shimada and Masuda, unpubl. obs., material from Naminoura, Wakayama Prefecture, 29 November 1996). Perrone (1994) suggested that the unicellular independent attachments can be used as a diagnostic feature at the generic level of *Gelidiella*, *Pterocladia* and *Gelidium*. This is confirmed for *Gelidiella ligulata* in this study and the type species in this genus, *Gelidiella acerosa* (Shimada and Masuda, unpubl. obs. based on materials from Pulau Gulisaan, Sandakan, Sabah, Malaysia, 16 May 1998 and Ginowan, Okinawa Prefecture, 14 June 1998). Thus, the members of *Gelidiella* investigated so far have the unicellular independent attachments that are unique in the Gelidiales. Kraft and Abbott (1998, figs 4,6,7), however, describe and illustrate the attachment of *Gelidiella womersleyana* Kraft et Abbott as rhizoids issuing as consolidated cables on prostrate axes that look like the peg type. *Gelidiella womersleyana* has erect axes of unique morphology, which are composed of a slender polystromatic central region surrounded on both sides by monostromatic wings and shows no clear affinities to any other *Gelidiella* (Kraft and Abbott 1998). There is a strong possibility that this species is actually not a member of *Gelidiella*. As the genus *Gelidiella* is believed to not be a natural taxon and requires taxonomic revision (Kraft and Abbott 1998), molecular analyses of the members of the genus is apparently needed.

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