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Plumatella mukaii, a new phylactolaemate bryozoan from Asia and South America

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Abstract

A new freshwater bryozoan species, *Plumatella mukaii*, is recognized from eastern Asia and western South America. Colonies and statoblasts both bear a resemblance to *P. emarginata*, and have often been confused with that species, especially in Japanese studies. Floatoblasts and sessoblasts are enclosed within a tough, wrinkled, membrane which resists removal by mechanical means. Floatoblasts are generally smaller than those of *P. emarginata*, but display unusually high variability in their overall dimensions. The species has been reported from both lentic and lotic habitats. In Asia, the range includes Japan, Korea, China, India and Indonesia. It has most recently also been found at several sites in Chile. The recognition of *P. mukaii* narrows the previously reported range of *P. emarginata* and invites a re-inspection of that species worldwide.

Introduction

Bryozoans of the Class Phylactolaemata, living exclusively in fresh water, produce encapsulated, dormant buds called statoblasts. Measuring generally under 0.5 mm, these asexual bodies are for many species the most important means of reproduction. They may also serve as effective disseminules or as place holders on favourable substrates during periods of suboptimal conditions. With their sclerotized outer shells, statoblasts have also emerged as the bearers of important morphological features for species discrimination. Good summaries of statoblast morphology are provided by Mukai (1982) and Wood (2001). This paper introduces a new Phylactolaemate species that is distinguished primarily by an unusual statoblast feature: the presence of a tough, wrinkled, enveloping membrane.

Materials and methods

To prepare statoblasts for scanning electron microscopy, I dissected them from colonies preserved in ethanol, cleaned them in a vibrating bath of 0.1 M solution of sodium hexametaphosphate (Calgon), and washed them in deionized water. To avoid distortion I freeze-dried the statoblasts at -17 ° C., then mounted them on aluminum stubs and examined them with a Philips 500 scanning electron microscope. In some specimens, the wrinked statoblast surface could also be seen with a compound light microscope using bright, reflected light. Statoblast dimensions were taken from valves that had been separated in hot potassium hydroxide. I used a compound microscope at $100\times$ with an ocular micrometer in which each unit represented 10 μm. For statistical treatment of the data, I used InStat^{TM} software (GraphPad Software, Inc).

Description

PLUMATELLA MUKAII, new species
Plumatella princeps emarginata (Kraepelin, 1887) (presumed)
Plumatella emarginata (Toriumi, 1952)
Plumatella emarginata (Mukai et al., 1990)

Table 1. Statoblast dimensions in micrometers of *Plumatella mukaii* from the holotype. Mean values show confidence limits calculated at 95%. Sessoblast dimensions do not include the lamella

Overall length	378±8
Overall width	241±3
Overall length/width	1.57±0.6
Dorsal fenestra length	118±10
Dorsal fenestra width	87±5
Dorsal fenestra length/width	1.27±0.5
Ventral fenestra length	210±20
Ventral fenestra width	171±6
Ventral fenestra length/width	1.22±0.1
Sessoblast length	345±6
Sessoblast width	254±4
Sessoblast length/width	1.35±0.2

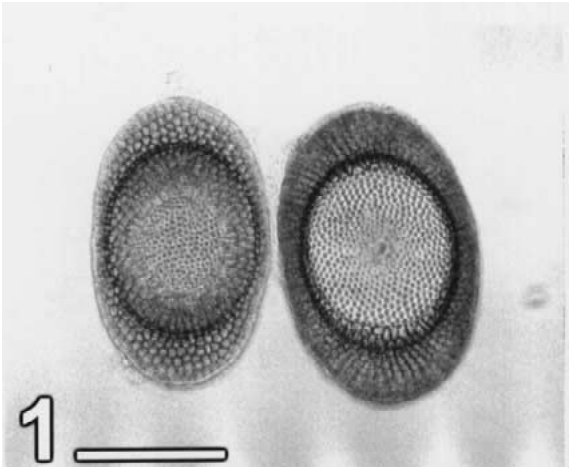

Figure 1. Floatoblast valves of *Plumatella mukaii* (holotype), the so-called dorsal valve on the left, ventral on the right. Scale bar = 200 μm.

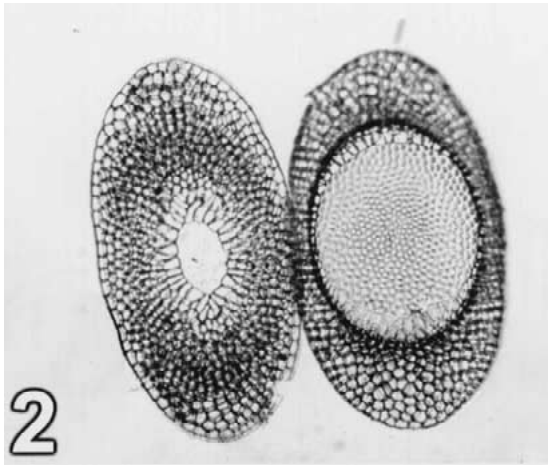

Figure 2. Floatoblast valves of *Plumatella emarginata* from Wehrle Pond, North Bass Island in Lake Erie, U.S.A. The dorsal valve is on the left. Scale is the same as in Figure 1.

Plumatella emarginata (Mukai & Kobayashi, 1988)

Plumatella emarginata (Mukai, 1999)

Plumatella emarginata (Orellana-Liebbe, 1999)

Colonies are composed of moderately branching tubules, mostly recumbent when spreading across ample substrate, becoming raggedly compact with many free branches when substrate area is limited. Crowded zooids are capable of fusing, sometimes forming long, ropey masses. The ectocyst is generally opaque and unusually thick; a prominent keel is traced by a well defined, clear line (the so-called 'furrow'), which widens to encompass each zooid tip.

The floatoblast is laterally asymmetrical, with a thin, flat dorsal valve and strongly convex ventral valve. The dorsal annulus is composed of only a single cell layer; the fenestra diameter approximately one-third total valve length. By contrast, the ventral valve has several cell layers and is slightly larger than the dorsal valve in every dimension (overall measurements in Table 1). Both fenestrae are well tubercled. The entire floatoblast is enveloped by a minutely wrinkled, roughly textured, coriaceous membrane soluble in a strong potassium hydroxide solution.

The frontal valve of the sessoblast bears small, crowded tubercles (Figure 5), themselves sometimes covered with a wrinkled membrane similar to that of floatoblasts. The lamella is faintly reticulated and appears slightly dimpled, occasionally bearing many unevenly shaped nodules (Figure 6), this being the only known case of nodules on a sessoblast.

Type Material: No. P1179/1 at the Zoological Survey of India, Calcutta, collected at Pashok, Darjiling District, India, in the Eastern Himalayas by F. H. Graveley, May 26–June 14, 1916. The designated paratypes are Nos. P1184/1 and P1560/1 at the Zoological Survey of India.

Etymology: The specific epithet honors Hideo Mukai (1939–1998), of Gunma University, Japan, a biologist of extraordinary achievement, whose own studies of this species are among his many signi-

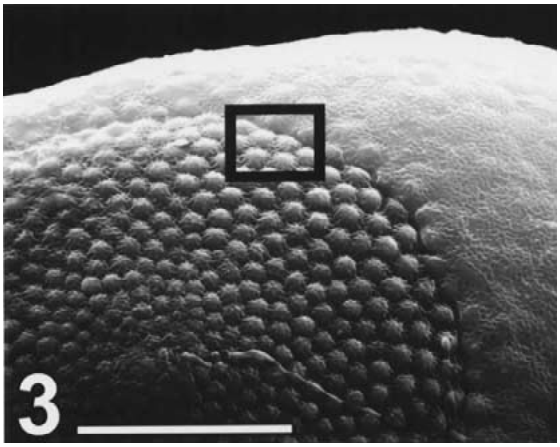

Figure 3. Scanning micrograph of a *Plumatella mukaii* floatoblast showing tubercles and wrinkled surface. Scale bar = 100 μm.

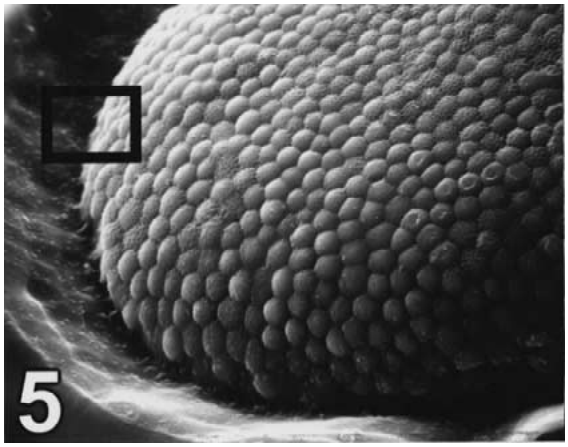

Figure 5. Scanning micrograph of a *P. mukaii* sessoblast showing wrinkled surface of tubercles and nodule-like structures on the lamella. Scale is the same as in Figure 3.

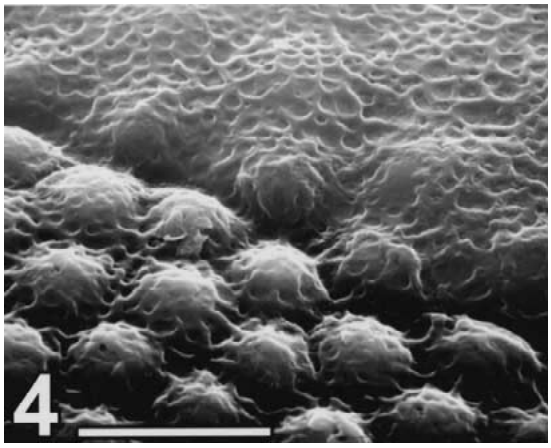

Figure 4. Detail of Figure 3. Scale bar = 25 μm.

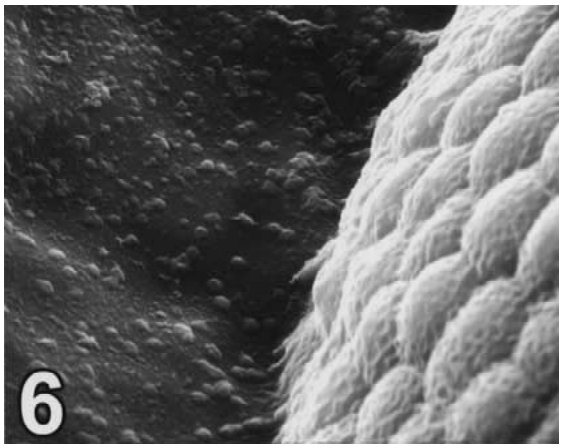

Figure 6. Detail of Figure 5. Scale is the same as in Figure 4.

ficant contributions to the knowledge of freshwater bryozoans.

Dimensions: Critical statoblast measurements of holotype statoblasts are given in Table 1; corresponding dimensions published previously by various authors in Table 2.

Distribution: Verifiable specimens of *Plumatella mukaii* are known from only a very few sites in Asia (Japan, Indonesia, India) and Chile, from both lentic and lotic habitats, and from lowland sites (Tokyo) to elevations of around 1000 m (Darjiling). Published reports of what is assumed to be the same *P. mukaii* would extend the range into Manchuria and Korea (see 'Discussion' below).

Specimens: I have examined material from the following locations: INDIA - Pashak, Darjiling District (see type). INDONESIA Botanical Gardens of Buitenzorg (Bogor), 21 September 1926 leg. A. G. Vorstman (Nationaal Natuurhistorisch Museum, Leiden, No. 808); Meer Van Sindanglaja, Java 19 October 1927 leg. A. G. Vorstman (Institut voor Taxonomische Zoölogie, Amsterdam, ZMA V. Br. 804). JAPAN – Small pond, Sendei, 29 August 1949, coll. M. Toriumi (Nationaal Natuurhistorisch Museum, Leiden, No. 1291); Tokyo (no date), leg. Hilgendorf (Humboldt Museum für Naturkunde, Berlin, ZMB 366); Tamagawa River at Tokyo, coll. August 9, 1999, Gen-yu Sasaki (Tokyo Metropolitan Johnan High School).

Discussion

The first complete description of *Plumatella mukai* was made by Toriumi (1952), who compared Japan-

Table 2. Floatoblast dimensions of *Plumatella mukaii* from various published sources. Mean values are followed by the standard deviation

Overall length	Overall width	Length of dorsal fenestra	Length of ventral fenestra	Location	Reference
402±14	237±15	- - -	- - -	Japan	Kraepelin (1887)
397±20	234±12	132	231	Japan	Toriumi (1955)
406±21	224±11	117	212	Taiwan	Toriumi (1955)
380±21	237±10	110±14	203±10	Japan	Mukai (1990)
407±23	227±14	118±14	206±15	Chile	Orellana-Liebe (1999)

ese material with *P. emarginata* from Europe and North America, concluding that the morphological differences were due to 'seasonal and local variations.'

Toriumi's identification of the material may have been influenced by the great monograph of Kraepelin (1887) which makes the first published reference to a Japanese freshwater bryozoan, *'Plumatella princeps emarginata'* from Yoda (Tokyo). Kraepelin noted that floatoblasts from the Japanese material were distinctly smaller than those from Germany, and he provided several measurements (Table 2). Unfortunately, Kraepelin's source material cannot be positively identified. However, among the three public collections of phylactolaemate bryozoans in Germany (in Hamburg, Berlin, and Frankfurt) only the Humboldt Museum in Berlin has material from Japan, a single specimen from Tokyo labeled *Plumatella princeps emarginata*, No. ZMB 366 (no date), which is, in fact, *P. mukaii*.

Hideo Mukai retained the assumption that the Japanese species was *P. emarginata*, and he used it as the subject of several important studies (e.g., Mukai et al. 1984, 1987, 1988, 1990; Mukai, 1996, 1997, 1999). His published photographs (Mukai et al., 1990) show Japanese floatoblasts distinctly smaller than those from either Europe or North America. Similarly, in 1927 Vorstman preserved colonies of *P. mukaii* from a lake at Sindanglaja (Java, Indonesia), and labeled them, '*Plumatella emarginata* Allman (small form)' with 'small statoblasts' (Zoological Museum, Amsterdam, V. Br. 804).

It was in his final paper, published posthumously, that Mukai (1999) noted for the first time the membranous 'basophilic layer' covering his *P. emarginata* floatoblasts. This alerted me to the possibility that Mukai's species was not the *P. emarginata* commonly recognized in Europe and North America. An examination of Toriumi's material from Sendei (Leiden Museum, No. 1291) confirmed that it was not *P. emarginata* at all. In fact, it matched unknown specimens I had seen recently from India and Indonesia (listed above). Living colonies from Japan, reared in my laboratory, retain all the features of the species described here.

The reports of *P. mukaii* from Chile come as a surprise. However, the excellent photos and statoblast measurements of Orellana-Liebbe (1999) leave little doubt on identity of the species she collected at four sites in central Chile. Several other people have reported plumatellid species from South America that could conceivably be *P. mukaii*. These include Meissner's (1893) brief reference to *P. princeps* from southern Brazil; and *'Plumatella emarginata'* also from Brazil (Lange De Morretes, 1940) and Argentina (Cordiviola De Yuan, 1977). In none of these instances can *P. mukaii* be ruled out as the actual species observed, although the mean floatoblast length calculated by Cordiviola de Yuan (1977) (411 μm) is indeed closer to the expected value in *P. emarginata*. Wiebach's studies from the Amazon include a brief description of *Plumatella javanica* (1970a), which could be *P. mukaii*, although there appears to be more than a single cell layer comprising the dorsal annulus.

It is not unusual for new statoblasts to be enveloped by a thin membrane, which probably derives from the outer epidermal layer seen during their development (Mukai, 1982). This membrane eventually disintegrates some time after the statoblast is exposed directly to water. In my laboratory, when we prepare freshly dissected statoblasts for scanning electron microscopy, we routinely remove this membrane using fine instruments. In *P. mukaii*, the persistent statoblast covering may be an elaboration of the membrane, but in this case mechanical tools are completely inadequate for its removal. A strong potassium hydroxide solution

will soften and loosen the enveloping material and eventually dissolve it entirely without affecting the underlying chitin.

Another plumatellid species with a thickened statoblast covering is *Gelatinella toanensis* (Hozawa & Toriumi, 1940). In this species, the enveloping membrane is thrown into deep, convoluted folds and villi that give the floatoblast surface a velvety appearance (see, for example, Specimen No. 1278, Sendei, Japan, August 5, 1941 at the Zoology Museum, Leiden, Netherlands). *Gelatinella toanensis* is known only from Western Asia, including Manchuria (Hozawa & Toriumi, 1940), Japan (Toriumi, 1941a, 1942a), Korea (Toriumi, 1941b) and Taiwan (Toriumi, 1942b), but not from Africa, Australia or Central and South America, as claimed by Lacourt (1968). Thus, its range overlaps that of *P. mukaii*, and in fact both species have been reported from 'a pond in Sendei' (Toriumi, 1952, 1955). Aside from its unusual floatoblast, *G. toanensis* is also characterized by a remarkably thick, gelatinous ectocyst, prompting Toriumi (1955) to erect for it the genus, *Gelatinella*. By contrast, the thick, leathery ectocyst of *P. mukaii* argues against combining these species in a single genus, at least for now. Despite their geographical proximity, it is not inconceivable that these statoblast coverings arose independently in the two species. After all, a persistent membrane also occurs around the statoblasts of *Fredericella browni* (Rogick, 1945), which is set firmly within an entirely different family.

While the minutely wrinkled statoblast surface is certainly distinctive in this species, *P. mukaii* can also be recognized by the dorsal floatoblast annulus, composed of only a single cell layer. This is an unusual feature among plumatellid bryozoans, previously seen only in *Hyalinella africana* (Wiebach, 1970b). It clearly defines the borders of individual annular cells when the valve is seen with standard light microscopy (compare, for example the dorsal annulus in Fig. 1 with the multiple cell layered one of *P. emarginata* in Fig. 2).

The apparent nodules on the sessoblast lamella (Fig. 6) may not be analogous to those on floatoblasts of other plumatellids (Wood, 2001). In fact, they were seen only in the holotype, and not in other specimens. There is indirect evidence that the distinctive surface features of *P. mukaii* sessoblasts disappear more quickly than those of floatoblasts upon exposure to water.

Floatoblast measurements of *P. mukaii* from various regions are reasonably consistent (Table 2). Nevertheless, within a single colony floatoblast length may vary by more than 30% (Toriumi, 1952), far more than in other species. In a comparison of wild vs. laboratory-reared colonies, Mukai et al. (1990) found his laboratory floatoblasts 10% longer, with the length/width ratio varying by 11%. By contrast, the same study found differences for European and North American *P. emarginata* to be only 3% and $<1\%$, respectively. My own work with other species has shown little difference between laboratory-reared and naturally occurring statoblasts, but with *P. mukaii*, at least, the size of individual floatoblasts alone would be an insufficient criterion for species identification.

Acknowledgements

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