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Freshwater Bryozoans of Thailand (Ectoprocta and Entoprocta)

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ABSTRACT.– This paper reports on the first systematic survey of freshwater bryozoans to be conducted in Southeast Asia. The study area includes 26 of the 76 provinces in Thailand, from Chiang Mai in the north to Surat Thani in the south. Eighteen species are documented, including 14 phylactolaemates, and 3 gymnolaemates. Six of these are already widely distributed in other areas of Asia, four others are previously known from one or two other countries of Asia or Australia, two are previously known only from Thailand, and six are described as new species. The new species are: *Hislopia natans, Plumatella chulabhornae, P. siamensis, P. suwana, Swarupella divina,* and *S. kasetsartensis*.

KEY WORDS: Phylactolaemata, Gymnolaemata, Ctenostomata, Bryozoans, Thailand, taxonomy

INTRODUCTION

This paper documents 18 freshwater species from Thailand of the group commonly known as Bryozoa. These include 14 species of the Class Phylactolaemata and 3 of the Class Gymnolaemata (Order Ctenostomata). All were collected during 2001-2006 from 26 provinces in Thailand extending as far south as Surat Thani. Seven of the species are described as new.

While bryozoans are unfamiliar to many people, they are in fact common members of freshwater and marine benthic communities worldwide. In fresh water they are among the most important suspension feeding animals, along with sponges and mussels. Useful general information about freshwater bryozoans can be found in Smith (2001), Wood (2005b), and Wood and Okamura (2005).

In this paper we use the term "bryozoan" very loosely, to include both ectoprocts and entoprocts. In fact, these two groups are probably quite distant, althought their exact relationship is far from being resolved (Nielsen, 2002). Also, by tradition we are treating Gymnolaemata and Phylactolaemata as members of the same Phylum Bryozoa, despite growing evidence that each should probably be considered as separate phyla (Vinogradov, 2004; Wood and Lore, 2005).

When describing bryozoans some specialized terminology is unavoidable. A brief explanation of common terms may be useful here.

Annulus. the sclerotized band ringing the statoblast periphery, providing buoyancy

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in floatoblasts and forming a ribbon-like lamella in sessoblasts (Fig. 9A).

Ectocyst. The outer, non-living, protective layer of a bryozoan.

Fenestra. The central area of a floatoblast as seen from the exterior (Fig. 9F).

Floatoblast. A freely released statoblast capable of buoyancy (Figs 9-12).

Hibernaculum. Any dormant structure capable of initiating a new generation.

Lophophore. The feeding organ of a bryozoan bearing ciliated tentacles.

Polypide. The extendable unit of a zooid composed of lophophore and digestive system.

Raphe. A slightly raised, keel-like line along the top of a tubular bryozoan.

Sessoblast. A sessile statoblast firmly cemented to the substratum (Fig. 13).

Statoblast. A dormant resting body produced by phylactolaemate bryozoans.

Suture. The line around a statoblast periphery where two halves are joined.

Zooid. The individual repeated unit of a bryozoan colony including polypide and body wall.

Freshwater bryozoans have received little attention in Southeast Asia. The published literature is thin, and most of it dates from a time when scientific communication was slow, graphic images were imperfect, and the bryozoan taxonomy poorly understood. Therefore it is mostly of historical interest that new bryozoan species were once reported from Cambodia (*Hislopia cambodgensis* Jullien, 1880), Thailand (*Hislopia malayensis* Annandale, 1916), the Philippines (*Plumatella philippinensis* Kraepelin, 1887) and Indonesia (*Lophopodella pectinatelliformis* Lacourt, 1959). Only Annandale's species can be verified today. Reports of other bryozoans have come from Indonesia (Vorstman, 1928a, b) and Malaysia (Smedley and Dover, 1927), but these can be fully interpreted only by examining surviving specimens. The great bryozoan collection at the Zoological Survey of India in Calcutta documents a common practice through much of the 20th Century of identifying Asian bryozoans as if they had been sent over from Europe. In fact, many of the Indian species with familiar European labels are still undescribed. Much of what we now know about Asian freshwater bryozoans comes from the detailed studies of Japanese investigators: Asajiro Oka, Makoto Toriumi, Shuzitu Oda, and Hideo Mukai. From India has come the excellent work of Nelson Annandale and Kotapali S. Rao. Sadly, there has been no comparable activity elsewhere in Asia: virtually nothing from China and until now very little from the Southeast. This paper reports on the first systematic survey of freshwater bryozoans ever conducted in Southeast Asia. We hope it may provide a new starting point for additional investigations in the region.

MATERIALS AND METHODS

Bryozoans were collected from rivers, lakes and ponds throughout selected areas of Thailand with emphasis on the central region. Most specimens were taken in shallow water by examining substrata on which bryozoans were most likely to occur: floating wood, aquatic plants, plastic debris, rocks, fish culture pens, dangling rope, and other surfaces. Whenever possible, we kept the bryozoan colonies intact by removing them together with a piece of the substratum on which they were growing (Wood, 2005c).

Living colonies were taken to the laboratory for final identification. In some instances it was necessary to maintain colonies for several weeks in the lab to await statoblast development. Specimens were narcotized with menthol, then fixed and preserved in 70-100% ethanol. We measured statoblasts with a compound microscope fitted with an ocular micrometer at 100x magnification. Mean data were calculated to 95% confidence levels using statistical tests performed with Instat software (GraphPad, San Diego, USA). These data are provided here in tables for those species where they are important for identification. For scanning electron microscopy we dried

statoblasts in a household freezer, sputtered them in gold, then examined and photographed them through a JEOL JSM-5600LV microscope.

Holotype and voucher specimens have been deposited at the Chulalongkorn University Museum of Zoology, Bangkok (CUMZ). The first author is to be considered the authority for all the new taxa described here.

TAXONOMIC KEY TO SPECIES

1a Zooids composed of an erect, muscular stalk supporting an expanded "head;" less than 1 mm high, a ring of short tentacles folds towards the center when disturbed (Fig. 58).....**Phylum Entoprocta,** .....**Family Pedicellinidae,** .....***Loxosomatoides sirindhornae***

1b Zooids not as above; tentacles are withdrawn into the zooid interior when disturbe.... **Phylum Bryozoa (Ectoprocta)** **2**

2a Zooids arranged in a globular, gelatinous mass. Phylactolaemata (in part)..... .....**Family Lophopodidae**...**3**

2b Zooids arranged in a branching, linear series or a flat layer.....**4**

3a Colony seldom more than 1 cm diameter; statoblast less than 1 mm in any dimension and broadly oval, with a series of small hooked spines at each end (Fig. 45)..... .....***Lophopodella carteri***

3b Colony larger than 1 cm diameter; statoblast about 1 mm diameter and circular with minute hooks around the entire periphery (Fig. 43).....***Asajirella gelatinosa***

4a Each zooid separated from the next by an internal septum; orifice square when lophophore is retracted; statoblasts absent. .....**Class Gymnolaemata,** .....**Subclass Ctenostomata**...**5**

4b Septa either not separating every zooid or else not visible; orifice rounded when lophophore is retracted; statoblasts may be present.....**Class Phylactolaemata**...**7**

5a Tentacles numbering exactly 8 per zooid..... .....***Victorella pavida***

5b Tentacles numbering 12 or more per zooid... .....***Hislopia***...6

6a Point of contact between successive zooids wide, at least 40% maximum zooid width; 16 tentacles.....***Hislopia malayensis***

6b Point of contact between successive zooids narrow, less than 30% maximum zooid width; 12 tentacles.....***Hislopia natans***

7a Tentacles arranged in a circle around the mouth..... **Family Fredericellidae** .....***Internectella bulgarica***

7b Tentacles forming a double U or V-shaped row.....**8**

8a Colony wall thick, soft, and colorless; tubules about 1 mm diameter; floatoblasts >500 µm long.....**Family Hyalinellidae** .....***Hyalinella lendenfeldi***

8b Colony wall variable; tubules measuring less than 0.6 mm diameter, statoblasts <400 µm long.....**9**

9a Floatoblasts about 350 µm long or more...**10**

9b Floatoblasts about 330 µm long or less.....**15**

10a Floatoblast dorsal fenestra much less than half the length of the ventral fenestra. Ventral fenestra strongly reticulated..... .....***Plumatella bombayensis***

10b Floatoblast dorsal fenestra about half or more the length of the ventral fenestra....**11**

11a Floatoblast fenestrae length more than 1.5 times width.....**12**

11b Floatoblast fenestrae length less than 1.5 times width.....**14**

12a Floatoblast valves colorless and thin..... .....***Plumatella casmiana***

12b Floatoblast fenestra distinctly brown in color.....**13**

13a Floatoblast widest at the midpoint and tapering at each end..... .....***Plumatella casmiana***

13b Floatoblast sides nearly straight and parallel along the middle third, broadly rounded at the poles..... .....***Plumatella siamensis***

14a Floatoblast fenestrae reticulated..... .....***Plumatella chulabhornae***

14b Floatoblast fenestrae tuberculated..... .....***Plumatella javanica***

15a Floatoblasts laterally symmetrical, with both valves equally convex.....**16**
15b Floatoblasts laterally asymmetrical, with ventral valve much more convex, dorsal valve nearly flat.....**17**
16a Floatoblast dorsal and ventral fenestrae very similar in size, annulus uniformly narrow.....***Plumatella minuta***
16b Floatoblast dorsal and ventral fenestrae very different in size, annulus variable in width.....***Plumatella vorstmani***
17a Floatoblast fenestrae reticulated.....
.....***Plumatella chulabhornae***
17b Floatoblast fenestrae tuberculated.....**18**
18a Floatoblast dorsal fenestra ringed by fewer than 50 cells.....***Plumatella suwana***
18b Floatoblast dorsal fenestra ringed by more than 50 cells, tiny peripheral spines may be visible.....***Swarupella kasetsartensis***

SYSTEMATIC DESCRIPTIONS

Phylum Bryozoa Ehrenberg, 1831

Class Phylactolaemata Allman 1856

Species occurring exclusively in fresh water. Zooids relatively large, lophophore tentacles inflected to a U- or V-shape, except in the Family Fredericellidae where it remains circular. Mouth guarded by a flap of tissue (epistome); statoblasts produced in all species.

Family Fredericellidae Hyatt, 1868

The colony is composed of slender, branching tubules, either fully attached to the substratum or largely free and erect. Tentacles of the lophophore seldom number more than 26, arranged in a circle around the mouth. Free statoblasts are rare and known only in *Internectella* (see below). Sessile statoblasts are surrounded by a single layer of chitin, presumed to be the capsule, therefore lacking an outer periblast and a true annulus; attached to the substratum by a ring of tiny, jagged projections on the basal valve. Genera include *Fredericella* and *Internectella*. Six species are known.

Internectella bulgarica Gruncharova, 1971
Figures 1, 7, 8

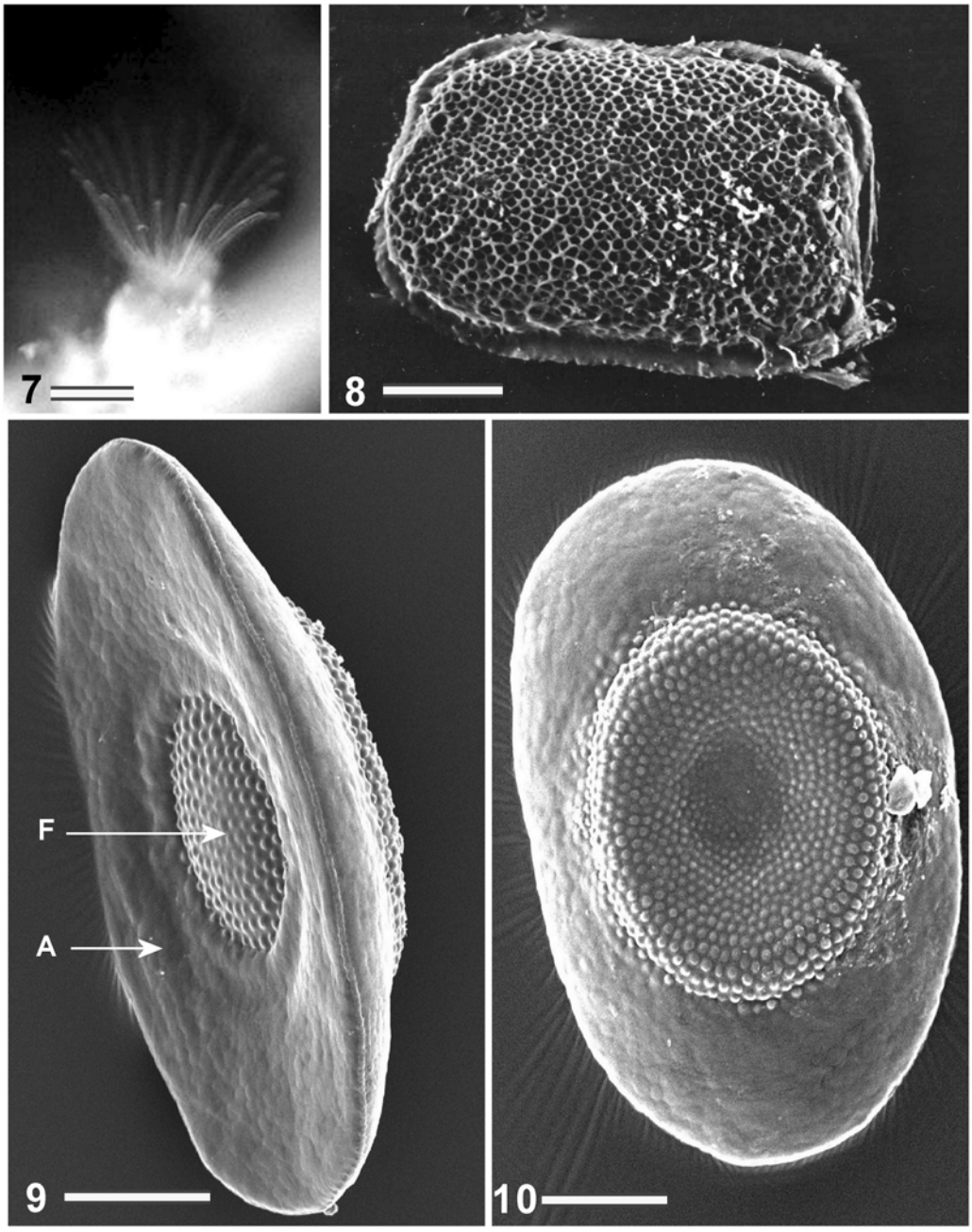
Internectella bulgarica Gruncharova, 1971: 361.

Material examined- Kanchanaburi Province: Kwai Yai River at Kanchanaburi; Nakhon Phanom Province: Mekong River at Keng Kap Pueng; Nakhon Sawan Province: Ping River at Nakhon Sawan; Prachin Buri Province: Bang Pakong River at Prachin Buri; Sakon Nakhon Province: Nam Un Reservoir; Songkhram River, Tam River; Surat Thani Province: Tapi River at Surat Thani.

Description- Colonies are composed of long, slender tubules; widely spaced zooids are often erect and producing free branches. The free portions of the colony are limp and not self-supporting when removed from the water (Fig. 1). Colony tubules bear a distinct raphe, especially those portions in direct contact with the substratum. The lophophore is circular in outline; 16-28 tentacles are short and straight (Fig. 7). Sessile statoblasts (piptoblasts) are roughened on the frontal valve by a high relief of irregular ridges, criss-crossing to produce a variable reticulum (Fig. 8). A flat, flange-like annulus rings the piptoblast close to the substratum and in the same plane. When two or three piptoblasts occur end to end in series their adjacent ends are often squared off as though pressed together, giving them a rectangular shape. An unusual floatoblast also occurs in this species, although observed in Thailand only in Sakhon Nakhon Province during November. The floatoblast has a bilateral symmetry perpendicular to the suture: one valve bears a high, keel-like crest extension while the other is gently convex; the entire free statoblast is enveloped within a continuous layer of gas-filled chambers. The floatoblast capsule has a normal oval shape.

Distribution- Described originally from the Lower Danube River basin (Bulgaria), the

FIGURES 1-6. 1) *Internectella bulgarica* colony on a twig removed from the water, showing the typical slender brown tubules. Scale bar = 0.5 cm. **2)** *Hyalinella lendenfeldi* colony on a rock removed from the water, showing typical long, gelatinous tubules. Scale bar = 1 cm. **3)** *Asajirella gelatinosa* colony removed from water. Scale bar = 20 mm. **4)** *Lophopodella carteri* colony. Scale bar = 1 mm. Photo by Shuzitu Oda. **5)** *Plumatella bombayensis* colony showing diffuse growth pattern. Scale bar = 1 cm. **6)** *Plumatella bombayensis* colony showing dense growth pattern. Scale bar = 1 cm.



FIGURES 7-10. 7) *Internectella bulgarica* zooid showing circular arrangement of tentacles. Scale bar = 0.25 mm. **8)** *Internectella bulgarica* sessoblastwith rough surface reticulum. Scale bar = 0.1 mm. **9)** *Hyalinella lendenfeldi* floatoblast showing concave dorsal valve. (F) fenstra; (A) annulus. Scale bar = 0.1 mm. **10)** *Hyalinella lendenfeldi* floatoblast, ventral side with larger fenestra. Scale bar = 0.1 mm.

species also occurs throughout Thailand and probably much of Southeast Asia, occurring in gently flowing water or in pools left by receding flood waters.

Family Hyalinellidae Vinogradov, 2004

Colonies are composed of large, branching tubules entirely adherent to the substratum and measuring 0.8 to 1.5 mm in width. The body wall is thick, soft, and transparent, rarely encrusted; raphe and emargination are absent. Zooids are arranged in a linear series along a tubular axis, retracting almost completely to leave no more than small, conical protuberances at the tubule surface. Free statoblasts are broadly oval, >500 µm in length; buoyancy chambers of the annulus may or may not be self-inflating. There are no sessile statoblasts. Historically at least 15 species have been placed in the genus *Hyalinella* at one time or another. However, the recent family definition excludes all except *Hyalinella punctata* (North America and Europe) and *Hyalinella lendenfeldi* (Australia and Southeast Asia). All other species previously attributed to the genus *Hyalinella* are placed for now the family Plumatellidae, genus *Plumatella,*

Hyalinella lendenfeldi (Ridley, 1886)
Figures 2, 9, 10

Lophopus lendenfeldi Ridley, 1886: 61.
Whitelegge, 1889: 323
Hyalinella lendenfeldi: Loppens, 1908: 143
Australella lendenfeldi: Annandale, 1910a: 37
Plumatella punctata phase *prostrata*: Vorstman, 1928a: 10

Material Examined- Chiang Mai Province: Ang Kaeo Reservoir, Chiang Mai University; Sa Kaeo Province: Tah Krabak and Huay Chan Reservoirs; Sakon Nakhon Province: Songkhram River throughout its length; Huai Leung; Udon Thani Province: Huay Louang Reservoir

Description- Colony tubules are long and sparsely branched, often growing in parallel for short distances, entirely adherent to the substratum (Fig. 2); tentacles numbering around 60. Statoblasts broadly oval, >500 µm long, the dorsal valve shallowly concave (Figs. 9-10). Statoblast fenestrae are tuberculated, most distinctly so on the ventral valve away from the central area. The annular chambers are self-inflated and slightly rounded at the statoblast surface. Despite its large, inflated annulus, the statoblast is only weakly buoyant. Floatoblast measurements are provided in Table 1

TABLE 1. Floatoblast measurements for *Hyalinella lendenfeldi* (in micrometers).

	Range	Mean	N
Overall length	522-562	544 ± 10	16
Overall width	296-320	316 ± 8	16
Overall length/width	1.60-1.84	1.73 ± 0.06	16
Dorsal fenestra length	175-203	189 ± 15	8
Dorsal fenestra width	109-199	114 ± 6	8
Dorsal fenestra length/width	1.60-1.71	1.66 ± 0.05	8
Ventral fenestra length	280-296	289 ± 8	8
Ventral fenestra width	203-234	218 ± 18	8
Ventral fenestra length/width	1.27-1.39	1.33 ± 0.06	8

Distribution- This species is common and widely distributed throughout Thailand, occurring in quiet waters of lakes and slow moving rivers. Although originally described in 1886 from a single collection at Sydney, Australia, *H. lendenfeldi* has not been reported since from that continent.

Remarks- The colony of *H. lendenfeldi* is indistinguishable from that of *Hyalinella punctata*, known only from North America and Europe. In both species the colonies have long, sparsely branched, large-diameter tubules spreading widely and often growing in parallel; completely colorless and unsclerotized; entirely recumbent. However, unlike *H. punctata*, the statoblasts of *H. lendenfeldi* are buoyant upon release; and the entire dorsal valve is shallowly concave.

Family Lophopodidae Rogick, 1935

Colony globular, body wall soft and transparent. Statoblasts relatively large, the wide annulus not inflated during development but capable of trapping air following desiccation and thus achieving buoyancy. Lophophore with arms held in parallel and bearing 65 to over 100 densely arranged tentacles. Three genera and five species are known.

Asajirella gelatinosa (Oka, 1890)
Figures 3, 42-44

Pectinatella gelatinosa Oka, 1891: 89
Pectinatella burmanica: Annandale, 1908b: 174
Asajirella gelatinosa: Oda and Mukai, 1989: 401
Lophopodella pectinatelliformis: Lacourt, 1959: 273

Material Examined- Khon Kaen Province: Lam Pao Reservoir; Sa Kaeo Province: Huay Khlai, Sakhon Nakon Province: Huay Nong Nan Chan; Surat Thani Province: Chieo Lan Reservoir, Udon Thani Province: Huay Louang Reservoir;

Description- The colony is globular, with zooids embedded within a loose, colorless, gelatinous matrix into which polypides can withdraw completely. The zooids are normally densely crowded, and tentacles of adjacent lophophores are often in contact. Individual colonies may reach a diameter of 1-2 cm; but are capable of dividing by fission without fully separating, thus forming large compound masses (Figs 1, 42). Statoblasts are large (around 1 mm diameter), bent slightly along two axes like a saddle, the outline ranging from circular to roughly quadrangular with broadly rounded corners (Fig. 43). The statoblast periphery is adorned with minute, bifid hooks (Fig. 44). As in all lophopodids, the statoblasts are nonbuoyant upon release, relying on desiccation to fill the annular chambers with air for later buoyancy in water.

Distribution- The species has been reported from Japan (Oka, 1890), Burma and India (Annandale, 1908b, 1910a); Indonesia (Vorstman, 1928a), Korea (Toriumi, 1941b; Seo, 1998), Taiwan (Toriumi, 1942), and Panama (Wood and Okamura, 1999).

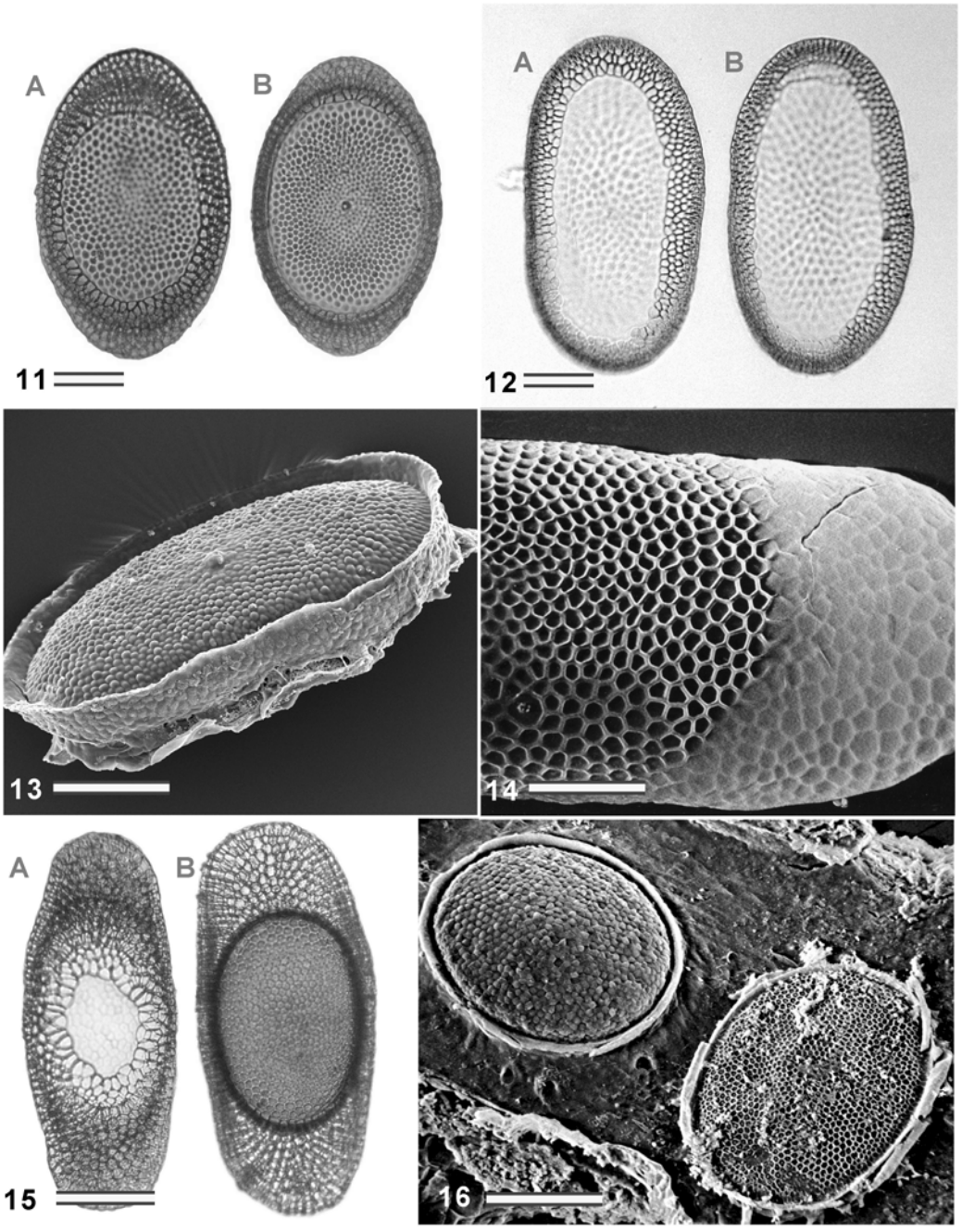
Remarks- Colonies are easily detached from the substratum, and are therefore most often seen in quiet or deep waters where they can grow undisturbed. Large lakes and reservoirs seem to be preferred. However, at the Huay Khlai site in Kabinburi many small colonies were found along the water's edge in a large concrete channel, where floatoblasts had apparently germinated.

Lophopodella carteri (Hyatt, 1868)
Figures 4, 45-46

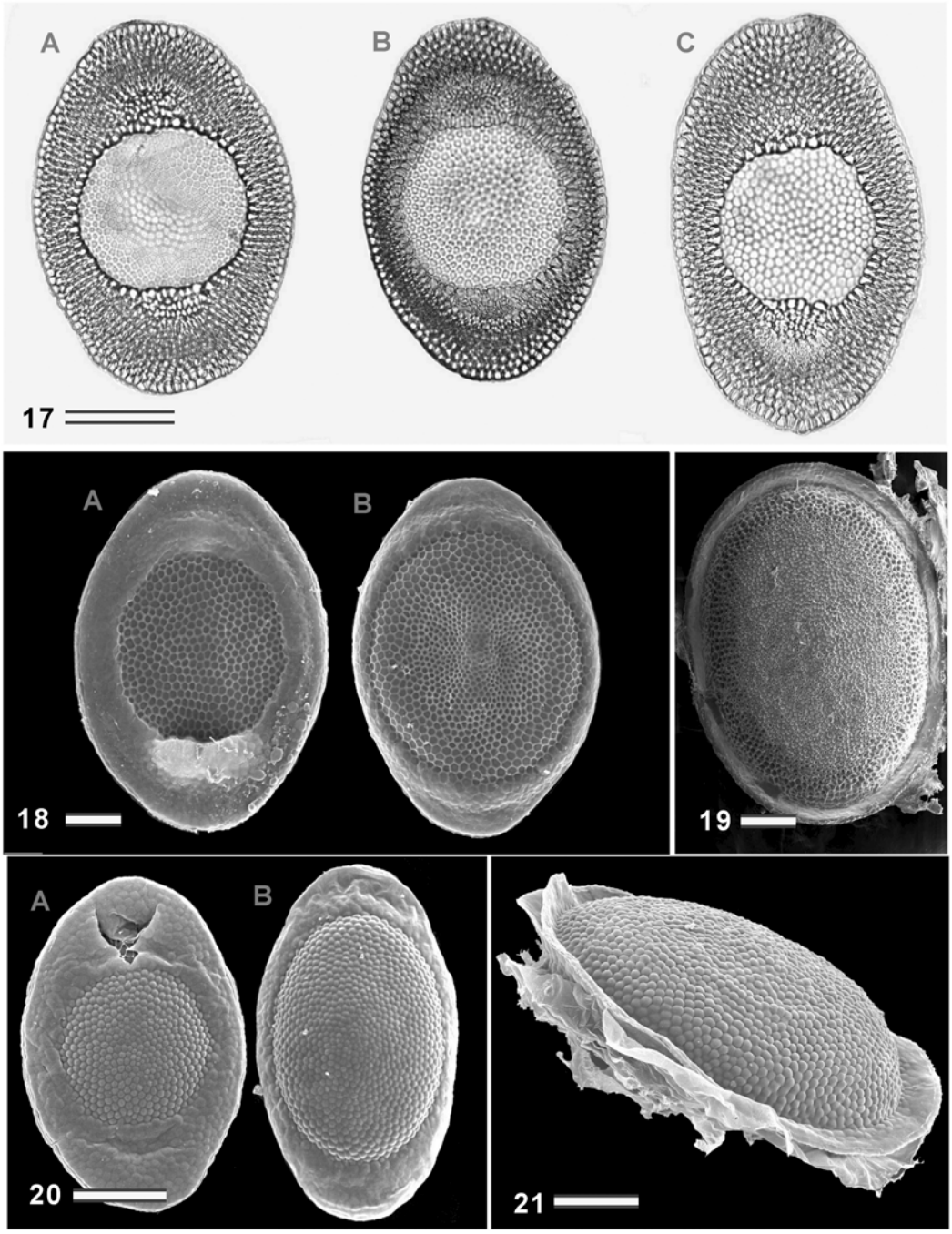
Pectinatella carteri Hyatt, 1866: 203
Lophopodella carteri: Rousselet, 1904: 47
Pectinatella davenporti: Oka, 1907: 117.
Lophopus lendenfeldi: Annandale, 1907: 92
Lophopus lendenfeldi var. *himalayanus*: Annandale, 1907: 147
Lophopus himalayanus: Annandale 1908b: 172
Lophopus brisbanensis: Colledge, 1917: 123
Lophopodella picta: Bretnall, 1920: 249
Lophopodella carteri var. *davenporti*: Hastings, 1929: 305
Lophopodella carteri var. typical: Rogick, 1934: 416.

Material examined- Chiang Mai Province: Ang Kaew Reservoir at Chiang Mai University; Mae Kuang Reservoir; Prachinburi Province: Huay Chan Reservoir; Sakhon Nakon Province: Nong Han at Sakhon Nakon; Songkhram River flood plain at Si Sonkhram; Huay Kat Bow Reservoir

Description- The colony is small and compact, seldom more than 5 mm diameter, roughly hemispherical (Fig 4), often dividing to form daughter colonies which slowly glide apart. Each colony has a single sac-like coelomic space which serves all the zooids. The thick body wall is soft, transparent, and



FIGURES 11-16. 11) *Plumatella casmiana* capsuled floatoblast; (A) dorsal valve; (B) ventral valve. Scale bar = 0.1 mm. **12)** *Plumatella casmiana* leptoblast valves. (A) dorsal valves; (B) ventral valves. Scale bar = 0.1 mm. **13)** *Plumatella casmiana* sessoblast. Scale bar = 0.1 mm. **14)** *Plumatella bombayensis* floatoblast, ventral valve, scanning electron (SEM) micrograph, showing the very distinctive ventral reticulum. Scale bar = 0.05 mm. **15)** *Plumatella bombayensis* floatoblast valves, slightly curled at the edges. (A) dorsal valve; (B) ventral valves. Scale bar = 0.1 mm. **16)** *Plumatella bombayensis* sessoblasts, SEM photos. Scale bar = 0.15 mm.



FIGURES 17-21. 17) *Plumatella chulabhornae* floatoblasts, dorsal view, showing a range of dimensions. (A) from Nakhon Pathom, (B) from Bangkok, (C) from Chachoengsao. Scale bar = 0.1 mm. **18)** *Plumatella chulabhornae* floatoblasts, SEM photo. (A) Dorsal valve; (B) ventral valve. Scale bar = 0.1 mm. **19)** *Plumatella chulabhornae* sessoblast, SEM photo. Scale bar = 0.1 mm. **20)** *Plumatella javanica* floatoblasts, SEM photo. showing typical dense tuberculation. (A) Dorsal valve; (B) ventral valve. Scale bar = 0.05 mm. **21)** *Plumatella javanica* sessoblast, SEM photo. Scale bar = 0.1 mm.

colorless to slightly yellow. The zooids are not densely crowded and tentacles of adjacent lophophores are seldom in contact. Statoblasts are iridescent, broadly oval, slightly truncated at the ends (Fig. 45), and curved along two axes like a saddle. A row of short 8-12 spines projects outward from each pole, each bearing pairs of minute hooks (Fig. 46). With the curvature, statoblasts measure roughly 875 µm in length and 650 µm in bredth, not including the spines.

Distribution- India, Burma (Annandale), Japan (Toriumi, 1941a), Taiwan (Toriumi, 1942), Indonesia (Vorstman, 1928a), Korea (Toriumi, 1941b), Israel (Massard et al., 1992) Australia (Colledge, 1917) East Africa (De Beauchamp, 1936), North America (Rogick, 1934), eastern Europe (Gruncharova, 1968), and United Kingdom (Wood and Okamura, 2005).

Remarks- Although uncommon in much of Thailand, *Lophopodella carteri* may be locally very abundant. At Mae Kuang Reservoir in Chiang Mai Province literally thousands of colonies were found clinging to nets in a floating fish culture framework.

Family Plumatellidae Allman, 1856

This is by far the largest family in the class Phylactolaemata. Colonies are composed of branching tubules, and the lophophore is horseshoe shaped. Two basic types of statoblasts are formed: floatoblasts (free and buoyant); and sessoblasts (permanently sessile). A single genus, *Plumatella*, is known from Thailand. A second genus, *Gelatinella*, is documented only from northeastern Asia (Toriumi 1941a, 1955a), despite reports of a wider range (Lacourt, 1968).

Genus *Plumatella*

Colonies are composed of branching tubules; ectocyst varying from thick and soft to stiff and well sclerotized, depending on species and age. Floatoblasts may germinate immediately upon release or enter an obligate period of dormancy ranging from days to months.

Plumatella bombayensis Annandale, 1908b
Figures 5, 6, 14-16

Plumatella bombayensis Annandale, 1908b: 252
Plumatella tanganyikae: Annandale, 1911a: 246
Plumatella emarginata: Hastings, 1929: 4. Vorstman, 1928a: 4
Plumatella longigemmis: Lacourt, 1968: 73

Material Examined- Bangkok Province: Fisheries Pond, Kasetsart University, Bangkhen; Chachoengsao Province: Henman River; Chiang Mai Province: Ang Kaew Reservoir, Chiang Mai University; Kanchanaburi Province: Kwai Noi River at Kanchanaburi; Kwai Yai River at many locations; Mae Khlong River at Tha Muang; Khon Kaen Province: Phong River at Nam Phong; Nakhon Nayok Province: Bang Pakong River at Nakhon Nayok; Nakhon Phanom Province: Mekong River at That Penom; Nakhon Sawan Province: Ping River; Prachin Buri Province: Bang Pakong River at Prachin Buri and at Kabin Buri; Surat Thani Province: Khlong Phom Duong.

Description- The colony is composed of branching tubules, but its appearance is otherwise highly variable, depending on water temperature, flow, turbidity, and possibly other factors. In lentic habitats colonies are usually unencrusted and darkly pigmented with a stiff, thickly sclerotized outer cuticle that extends to the tip of the zooid, enabling the polypide to retract fully within it. The raphe is clearly defined. Long branches spread across the substratum, occasionally becoming free (Fig. 5). Under crowded conditions the zooids and entire branches may grow erect, and the colony assumes a compact, ragged, shrubby appearance (Fig. 6). In flowing, turbid water colonies become heavily encrusted with silt particles, giving them a light-colored, velvety appearance. Under these conditions branches are attached to the substratum throughout their length, and the entire colony is flattened against

the substratum, with neither raphe nor emargination. Colonies transitional between these standard forms are often found.

The free statoblast is elongate with parallel sides, the length more than twice the width (Fig. 15); dorsal fenestra small and lightly tuberculated; ventral fenestra with a very prominent, lattice-like reticulation (Fig. 14). The sessile statoblast frontal valve is initially covered with crowded, tubercle-like mounds giving a pebbly appearance. These mounds later degrade to reveal a strong reticulum with a single, sharply rounded tubercle set in the center of each cell (Fig. 16). The annulus often turns under at the outer margin and thus appears thick and smooth. Floatoblast dimensions are provided in Table 2.

Distribution- The species is common throughout Thailand, occurring in a wide range of habitats, growing especially well in flowing water but tolerating both still and cascading conditions. It is often found on trees, rocks, bridges, and other hard substrata after the subsidence of flood waters. The species is also documented from India, Myanmar, Indonesia, and as far north as Afghanistan and Belarus (the latter in heated waters discharged from power plants). It is probably common throughout southern Asia.

TABLE 2. Floatoblast measurements for *Plumatella bombayensis* (in micrometers).

	Range	Mean	N
Overall length	355-420	386.12	16
Overall width	150-192	175.8	16
Overall length/width	1.87-2.53	2.22±0.01	15
Dorsal fenestra length	78-115	94.10	9
Dorsal fenestra width	60-112	71.12	9
Dorsal fenestra length/width	1.11-1.69	1.44±0.14	9
Ventral fenestra length	180-220	201.9	9
Ventral fenestra width	140-160	150.5	9
Ventral fenestra length/width	1.20-1.38	1.34±0.04	9

Remarks- As "*Plumatella tanganyikae*", this species became the type for Annandale's genus *Afrindella* (1908b). The heavily sclerotized ectocyst often extends near the zooid tip and enables the polypide to withdraw completely. To Annandale this appeared to introduce an entirely new mechanism for closure of the orifice. However, close examination of living material from Thailand does not support Annandale's interpretation.

Plumatella casmiana Oka, 1907
Figures 11-13

Plumatella casmiana: Oka, 1907: 117
Plumatella repens annulata: Hôzawa & Toriumi, 1940: 425
Plumatella repens var. *casmiana*: Toriumi, 1941a: 203.
Plumatella repens var. *flabellum* type casmiana: Toriumi, 1941b: 418.
Stolella himalayensis: Annandale, 1911a, ZEV 4813/7 from Malwa Tal, Kumaun, W. Himalayas (one of two specimens at Zoological Survey of India, both labeled "type)

Material Examined- Bangkok Province: Fisheries Pond, Kasetsart University, Bangkhen; Khon Kaen Province: Nong Khut at Khon Kaen; Nakon Pathom Province: Unnamed lake 20 km NW Ban Pong; Putthamonthon Park, Salaya; Sa Kaew Province: Tha Chan Reservoir; Sakhon Nakhon Province: Sra Pang Thong at Sakhon Nakhon and Huay Nong Nam Chan

Description- The colony appearance is variable and somewhat unreliable for species identification. Normally, the colony is flat, neat, and compact, with short branches entirely adherent to the substratum, but often growing erect when crowded. However, occasional colonies appear ragged and untidy, with crooked free branches. A raphe may be well formed and prominent or completely absent. The lophophore is relatively small, with tentacles fewer than 30.

There are two types of floatoblasts: those with an inner capsule have fenestrae that are both long, oval, and lightly tuberculated; the annulus of both valves only slightly wider at the poles than along the sides (Fig. 11). In those floatoblasts lacking an inner capsule

TABLE 3. Capsuled floatoblast measurements for *Plumatella casmiana* (in micrometers).

	Range	Mean	N
Overall length	361-379	372±9	10
Overall width	211-223	218±8	10
Overall length/width	1.51-1.63	1.58±0.07	10
Dorsal fenestra length	193-212	201±7	10
Dorsal fenestra width	125-141	132±6	10
Dorsal fenestra length/width	1.49-1.57	1.54±0.07	10
Ventral fenestra length	239-249	244±8	10
Ventral fenestra width	137-149	143±9	10
Ventral fenestra length/width	1.68-1.74	1.71±0.10	10

TABLE 4. Leptoblast measurements for *Plumatella casmiana* (in micrometers).

	Range	Mean	N
Overall length	338-386	353 ± 10	10
Overall width	177-217	195 ± 7	10
Overall length/width	1.62-1.91	1.81 ± 0.05	10
Dorsal fenestra length	241-289	264 ± 16	10
Dorsal fenestra width	122-144	132 ± 8	10
Dorsal fenestra length/width	1.89-2.21	2.00 ± 0.12	10
Ventral fenestra length	258-306	280 ± 17	10
Ventral fenestra width	122-145	132 ± 8	10
Ventral fenestra length/width	2.00-2.34	2.13 ± 0.12	10

(leptoblasts) the fenestrae are very large with small, well-spaced tubercles, reducing the annulus to a uniformly narrow band, the valves thin, fragile, colorless, and transparent (Fig. 12). Dimensions of both floatoblast types are provided in Tables 3 and 4. In sessoblasts the frontal valve tubercles range from extremely faint to well defined (Fig. 13).

Distribution- This is one of the few truly cosmopolitan phylactolaemate species, documented so far from every nonpolar continent except Australia, but almost certainly occurring there as well.

Plumatella chulabhornae Wood, new species
Figures 17-19

Type- Holotype: Collected 26 July 2005 at fish culture pond, Kasetsart University, Bangkhen, Bangkok, Thailand; deposited at Chulalongkorn University Museum of Zoology. Bangkok (CUMZ 3159).

Material Examined- Bangkok Province: Fisheries Pond, Kasetsart University, Bangkhen; Chachoengsao Province. Shrimp pond at Sanam Chai Khet; Nakhon Pathom Province Herb Garden Pond, Mahidol University, Salaya; Nakhon Sawan Province: Bung Borophet

Etymology- With kind permission from the Office of Her Royal Highness' Personal Affairs Division the species name honors Princess Chulabhorn, a tireless and effective supporter of scientific endeavors in Thailand.

Diagnosis. The colony is dendritic, with branches adhering to the substratum throughout their length. Branches are variable in length depending on the degree of zooid crowding. The body wall is mostly transparent and without any trace of a raphe. Floatoblasts are typically asymmetric laterally, the ventral valve highly convex and the dorsal valve nearly flat. Statoblasts are covered with a reticulum that is especially well defined on the floatoblast fenestrae. On the sessoblast frontal valve the reticulated relief is thickened to the point that the interstitial spaces assume a pore-like appearance.

Description- Colonies are compact, with short branches intersecting and adhering at various points, thus forming a strong lattice that may sometimes be lifted intact from certain smooth substrata. The distal half or more of each zooid angles away from the substrate at 60-80 degrees. In some instances the body wall, initially transparent, develops a dark cuticle on the frontal side only of the colony (i.e., that side opposite the substratum), giving the zooid a two-toned appearance in lateral view. The thickened cuticle is not uniform, but assumes the appearance of adjoining plates or shields. Dark lines between these plates may be internal creases or shelf-like growths. In older colonies the ectocyst becomes entirely amber and well cornified. Internal septa, while present, are infrequent. There is little to no incrustation. Raphe and emargination are absent.

Floatoblasts are distinguished by a clearly defined reticulum on dorsal and ventral

fenestrae and the absence of tubercles, at least by light microscopy (Figs. 17). The ventral fenestra is large and oval, its reticulated cells becoming progressively smaller towards center; the dorsal fenestra is smaller and nearly round, its reticulated cells a uniform size throughout. Scanning electron microscopy shows the reticulum extending across the annulus as well, and including a broad, low tubercle within each reticulated cell (Fig. 18). The length of the dorsal fenestra is <50% overall floatoblast length; ventral fenestra very large; width nearly 90% overall statoblast width; ventral annulus 3 times wider at poles than laterally. In most specimens the ventral valve is highly convex and the dorsal valve completely flat, resembling the shape of a highly domed tortoise shell. However, this striking asymmetry is much less apparent in the Kasetsart specimen. Floatoblast dimensions are provided in Table 5. The sessoblast is heavily reticulated across frontal valve, lines thickened to the point that they appear to surround pore-like holes (Fig 19). The rim of the annulus is minutely toothed.

Distribution- *Plumatella chulabhornae* is known so far in Thailand from the four sites listed above.

Remarks- Distinctive features of *Plumatella chulabhornae* include the absence of a raphe and the strong reticulation on statoblast fenestra. The wide range in floatoblast shape and dimensions (Fig 17) is unusual, but not unprecedented: *Plumatella fungosa* in Europe shows a similar variation. The species has been encountered so far only in quiet lakes and ponds.

Plumatella javanica Kraepelin, 1906
Figures 20, 21, 36

Plumatella javanica Kraepelin, 1906: 143

Material Examined- Bangkok Province: Fisheries Pond, Kasetsart University, Bangkhen; Nakhon Phanom Province: Nong Yat Reservoir, 5 km southwest of Nakhon Panom; Sakon Nakhon Province: numerous small ponds west and northwest of Si Songkhram.

Description- The colony is sprawling and diffuse, its tubules attached to the substratum throughout their length and bearing a strong raphe (Fig. 36). Zooids are well spaced, recumbent, and often in line with the main tubular axes. The ectocyst is thin, brittle and easily damaged; colorless or slightly brown but not darkly pigmented. Floatoblasts are elliptical, both dorsal and ventral fenestrae covered with prominent, uniform tubercles crowded together and leaving no space between them (Fig. 20). The dorsal fenestra is rounder and 70-80% shorter than the ventral fenestra. Both valves are convex, the ventral valve more so than the dorsal. Floatoblast dimensions are provided in Table 6. In the sessoblast the fenestra has the same heavy tuberculation as in floatoblasts (Fig 21). Tubercles spill somewhat onto the base of the otherwise smooth sessoblast

TABLE 5. Floatoblast measurements for *Plumatella chulabhornae* (in micrometers).

	Range	Mean	N
Overall length	320-367	345±12	30
Overall width	210-240	223±8	30
Overall length/width	1.39-1.66	1.5±0.07	30
Dorsal fenestra length	180-190	186±7	30
Dorsal fenestra width	150-160	155±6	30
Dorsal fenestra length/width	1.13-1.27	1.20±0.07	30
Ventral fenestra length	210-230	216±8	30
Ventral fenestra width	158-180	171±9	30
Ventral fenestra length/width	1.20-1.46	1.27±0.10	30

TABLE 6. Floatoblast measurements for *Plumatella javanica* (in micrometers).

	Range	Mean	N
Overal length	360-400	374±6	20
Overall width	230-240	237±2	20
Overall length.width	1.50-1.58	1.58±0.03	20
Dorsal fenestra length	160-200	175±6	16
Dorsal fenestra width	140-150	148±4	16
Dorsal fenestra length/width	1.06-1.27	1.18±0.03	16
Ventral fenestra length	230-260	243±6	16
Ventral fenestra width	170-220	189±9	16
Ventral fenestra length/width	1.18-1.52	1.30±0.07	16

annulus, and are also found along the outside of the basal valve.

Distribution- *Plumatella javanica* is known from Indonesia (Kraepelin, 1906); also reported from India and Central Africa (Wiebach, 1967). The species appears to prefer quiet waters.

Remarks- The floatoblast has proportions similar to those of *P. vorstmani*, but is significantly larger (length 382 vs 295 micrometers). This is the first published description and illustration of the sessoblast, which has been absent from previous collections.

Like many plumatellid bryozoans, *Plumatella javanica* carries a history of confusing and often contradictory descriptions despite being represented by a good type specimen (No. B-98 at the Zoologisches Museum in Hamburg). Kraepelin's stated measurements of the floatoblast do not agree with his diagram (Smith and Wood, 1995). Specimens described as *P. javanica* by Vorstman (1928a) were determined by Toriumi (1952) to be a different species, although several of her specimens at the Leiden Museum actually are *P. javanica*. Similarly, Annandale (1910a, 1910b, 1911a) described the species several times, but his own material at the Zoological Survey of India comprises at least three different species. Lacourt (1968) included in his description of *P. javanica* material from North America later shown to be *Plumatella reticulata* (Wood, 1988). Wiebach's (1967) account of a specimen from Congo seems accurate enough, but the material is missing from his collection in Hamburg. Regardless of these historical irregularities, material from Thailand agrees closely with Kraepelin's type specimen in both colony and floatoblast morphology, even with scanning electron microscopy.

TABLE 7. Floatoblast measurements for *Plumatella minuta* (in micrometers).

	Range	Mean	N
Overall length	312-323	320 ± 22	12
Overall width	224-237	230 ± 13	12
Overall length/width	1.34-1.43	1.39 ± 0.10	12
Dorsal fenestra length	178-191	185 ±13	12
Dorsal fenestra width	153-167	160 ±14	12
Dorsal fenestra length/width	1.11-1.20	1.16 ± 0.08	12
Ventral fenestra length	187-213	200 ± 26	12
Ventral fenestra width	167-180	175 ± 13	12
Ventral fenestra length/width	1.05-1.19	1.14 ± 0.14	12

Plumatella minuta (Toriumi, 1941)
Figures 22-23

Plumatella repens minuta, Toriumi, 1941a: 202; 1941b: 417
Hyalinella minuta: Toriumi, 1955a: 137.

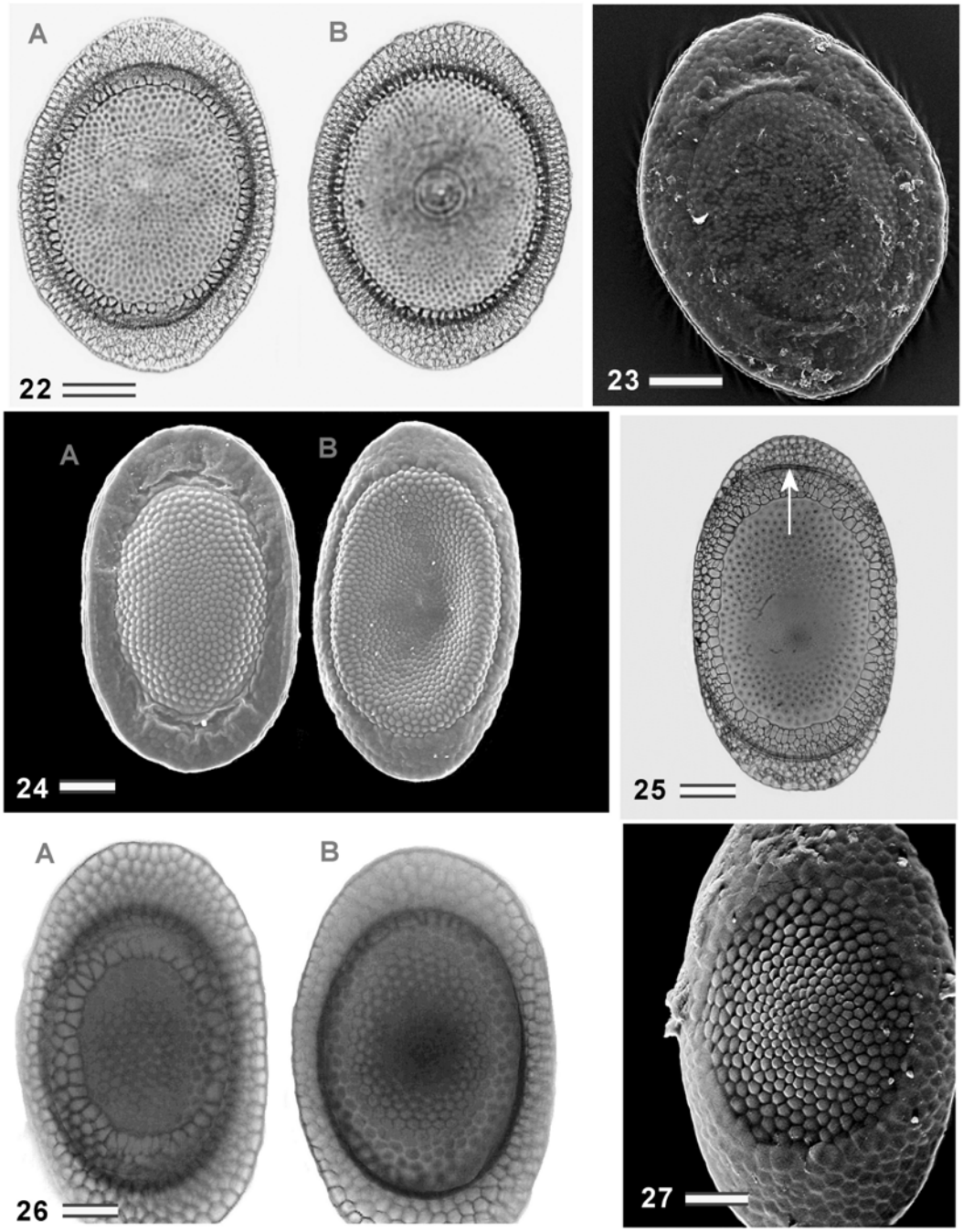
Material examined- Nakhon Sawan Province: Bung Borophet.

Description- The colony is diffuse and spreading, its branches entirely adherent to the substratum throughout their length; becoming compact with rapid growth, or no limited substratum, forming a single layer in which branches are contiguous but not fused. The distance between adjacent zooids is highly variable. The colony wall is soft and unsclerotized, with variable thickness, usually transparent but occasionally with a light encrustation. An obscure raphe is sometimes visible.

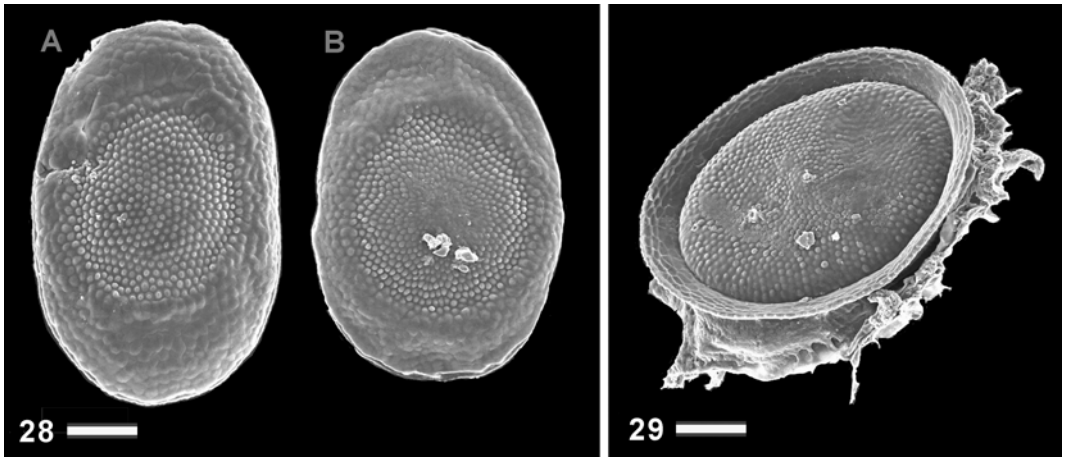
Floatoblasts are broadly oval in shape and laterally symmetrical, with a large fenestra on both dorsal and ventral valves (Fig. 22). Tuberculation across the fenestrae is weak, sometimes fading towards the center (Fig. 23). Floatoblast dimensions are provided in Table 7. Sessoblasts in this species are unknown.

Distribution- *Plumatella minuta* is known from Japan, Formosa, and Korea. In Thailand it has been found only in Bung Borophet.

Remark- This is an uncommon species in Thailand. Its presence in Bung Borophet may be due to the transport of statoblasts from elsewhere by migrating waterfowl, for which the site is well known.



FIGURES 22-27. 22) *Plumatella minuta* floatoblasts showing narrow annulus and rounded shape. (A) Dorsal valve; (B) ventral valve. Scale bar = 0.1 mm. **23)** *Plumatella minuta* floatoblast, SEM photo showing small tuberculation, dorsal valve. Scale bar = 0.1 mm. **24)** *Plumatella siamensis* floatoblasts, SEM photos. (A) Dorsal valve; (B) ventral valve. Scale bar = 0.05 mm. **25)** *Plumatella siamensis* floatoblast, dorsal valve, showing edge of the minimal capsule (arrow). Scale bar = 0.05 mm. **26)** *Plumatella suwanna* floatoblasts showing large annular cells. (A) Dorsal valve; (B) ventral valve. Scale bar = 0.05 mm. **27)** *Plumatella suwanna* floatoblast dorsal view, SEM photo. Scale bar = 0.05 mm



FIGURES 28-29. 28) *Plumatella vorstmani* floatoblasts, SEM photos. (A) dorsal side; (B) ventral side. Scale bar = 0.05 mm. **29)** *Plumatella vorstmani* sessoblasts, SEM photo, showing reticulated annulus. Scale bar = 0.05 mm.

In the early 1940's, when many bryozoan species were considered simply varieties of *Plumatella repens*, it was logical for Toriumi (1941a) to name his new species *Plumatella repens minuta*. He later placed it in the genus *Hyalinella* on the basis of the transparent, gelatinous body wall and the apparent absence of sessoblasts (Toriumi, 1955). However, the genus *Hyalinella* has become a convenient dumping ground for species solely on the basis of a transparent body wall. In addition to "*Hyalinella minuta*," for example, there have been *H. toanensis* Hôzawa and Toriumi, 1940, *H. agilis* (Marcus, 1941), *H. bigemmis* Annandale, 1919, and *H. vaihiriae* Hastings, 1929. Actually, cuticle development in plumatellids is a poor criterion by which to separate genera. Many young plumatellid colonies have a soft, transparent body wall and develop a firm cuticle only with increasing age. In species such as *P. minuta,* the formation of a cuticle may simply be delayed beyond the normal longevity of the colony. As for the genus *Hyalinella,* we propose a much more limited definition in order to recognize the distinctive features that unify *H. punctata* and *H. lendenfeldi* (see "Hyalinellidae" discussed earlier). The consequence for *H. minuta* is to return to the genus *Plumatella*.

Plumatella siamensis Wood, new species
Figures 24, 25, 37

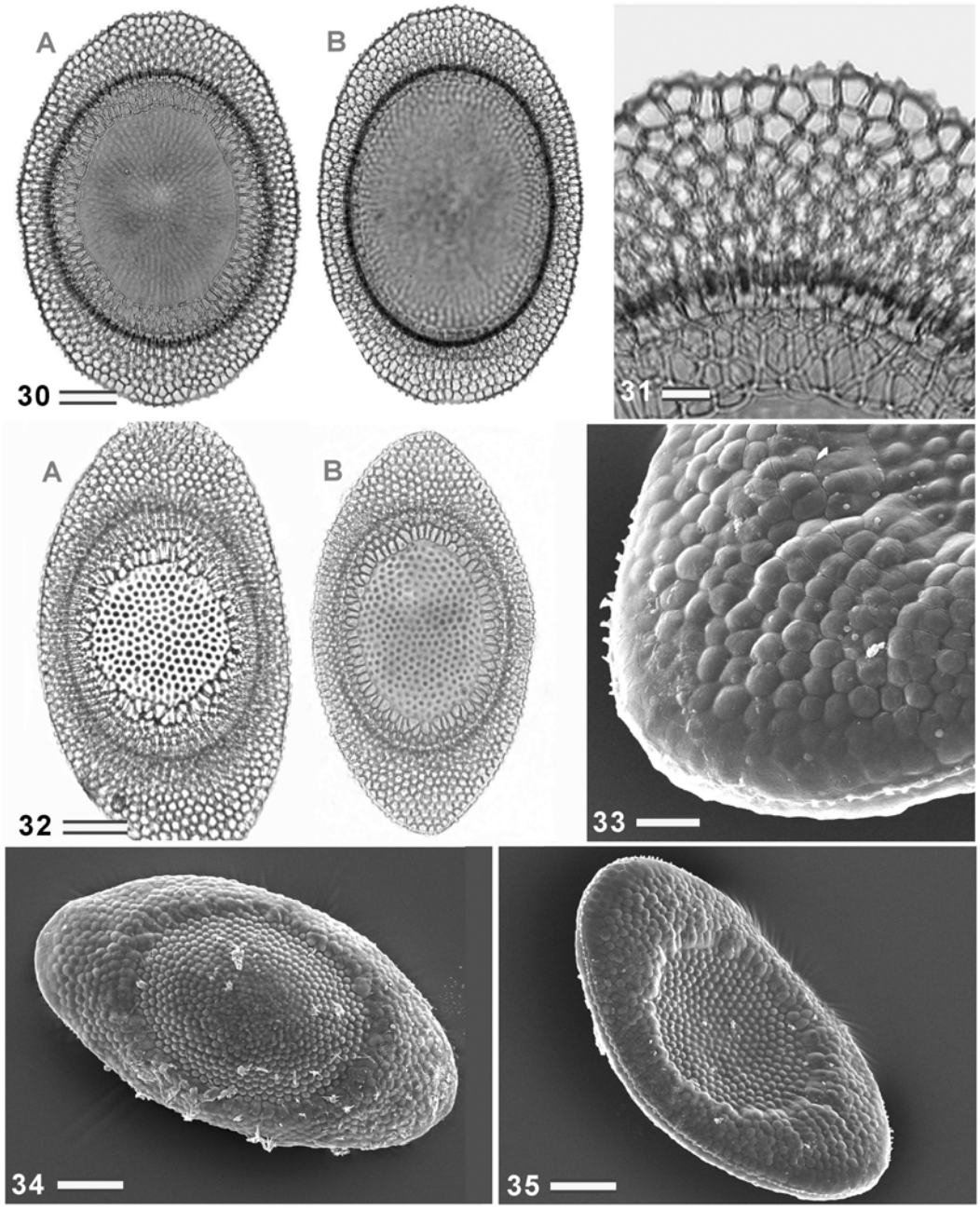
Type- Holotype: Collected 23 July 2005, Huai Nong Num Chan at Rte 2177, Sakon Nakhon Province, 23 July 2005 on polyethylene sheet, preserved in 70% ethanol, including a few leptoblasts but no sessoblasts; deposited at Chulalongkorn University Museum of Zoology, Bangkok (CUMZ 3162).

Material Examined- Nakhon Pathom Province, unnamed lake 20 km NW BanPong; Sakon Nakhon Province, Huai Nong Num Chan; Udon Thani Province, Nong Prajak Park at Udon Thani.

Etymology- The species name honors the Kingdom of Thailand, so far the only country where *Plumatella siamensis* has been found.

Diagnosis. The lophophore bears 44 to 46 tentacles. The floatoblast is elongate with a uniformly narrow annulus on both valves; the floatoblast capsule is reduced to a vestigial structure, brown in color and fused to the periblast. Colony tubules darken with age except for a prominent unpigmented stripe along the raphe.

Description- The colonies are small, sparsely branched and entirely adherent to the substrate. The ectocyst is dark reddish-brown except for a colorless stripe ("furrow")



FIGURES 30-35. 30) *Swarupella divina* floatoblasts. (A) Dorsal valve; (B) ventral valve. Scale bar 0.05 mm. **31)** *Swarupella divina* floatoblast detail showing sutural spines. Scale bar = 0.015 mm. **32)** Comparison floatoblast dorsal valves in two species: (A) *Swarupella andamanensis*; (B) *Swarupella kasetsartensis*. Scale bar = 0.05 mm. **33)** *Swarupella kasetsartensis* floatoblast, SEM photo, showing detail of sutural spines. Scale bar = 0.015 mm. **34)** *Swarupella kasetsartensis* ventral valve, SEM photo. Scale bar = 0.05 mm. **35)** *Swarupella kasetsartensis*, dorsal valve. SEM photo. Scale bar = 0.05 mm.

running longitudinally across the top of the tubules opposite the substratum (Fig. 37). Floatoblasts are about 1.6 times longer than broad, with parallel sides and rounded ends. Both dorsal and ventral fenestrae are large, with proportions similar to the overall statoblast; the dorsal fenestra is unusually large with a length around 70% of the overall statoblast length (Fig. 24). Well-formed tubercles covering both fenestrae are uniform in size and packed densely to leave no space between them. A vestigial capsule is fused to the inner side of the floatoblast valves (Fig. 25). Floatoblast dimensions are provided in Table 8. Sessoblasts in this species are not yet known.

Distribution- The species is known only from the three widely scattered locations in Thailand listed above.

Remarks- The strong raphe and floatoblast morphology make this species easily mistaken for *Plumatella casmiana*. However, *P. siamensis* has several distinguishing features: the zooecium is dark, with little or no incrustation; the colony spreads widely across the substratum and is seldom compact; the lophophore consistently bears 44-46 tentacles (but fewer in the ancestrula, as usual); the floatoblast has capsule valves fused to the periblast.

Plumatella suwana Wood, new species
Figures 26, 27, 38

Type- Holotype collected 10 December 2001 at Pran Buri Reservoir, 30 km southwest of Hua Hin, (Prachuab Khiri Khan Province), including an ample number of floatoblasts but no sessoblasts; recovered from a deep crevice of a log floating at the water's edge; preserved in 70% ethyl alcohol; deposited at Chulalongkorn University Museum of Zoology, Bangkok (CUMZ 3163).

Etymology- The species name comes from the Thai word, *suwan*, meaning "golden", and honoring the former president of Kasetsart University, Luang Suwan Wajok Kasikij.

Diagnosis- Colony wall well sclerotized; zooids erect with free branches; floatoblast fenestrae bearing unusually large tubercles;

Description- Colony is fruticose and shrubby, free branches composed of short zooids in series (Fig. 38). Zooids with distinct keel; ectocyst strong, well sclerotized, and golden brown in color although still transparent, with a series of darker rings appearing as though the growth rate were uneven. Floatoblasts are broadly oval, both fenestrae assuming proportions of the floatoblast itself, but the dorsal fenestra about 20% shorter than the ventral. Fenestra tubercles are unusually large and crowded, leaving no space between them. No more than 12 tubercles span the width of the dorsal fenestra (Fig. 26). The ventral fenestra has about 20 tubercles spanning its widest dimension, but these become smaller towards the center (Figs. 26,

TABLE 8. Statoblast measurements for *Plumatella siamensis* (in micrometers).

	Range	Mean	N
Overall length	348-381	367±7	16
Overall width	187-209	202±5	16
Overal length/width	1.57-1.67	1.62±0.04	16
Dorsal fenestra length	228-241	234±5	16
Dorsal fenestra width	133-158	150±7	16
Dorsal fenestra length/width	1.39-1.63	1.56±0.04	16
Ventral fenestra length	251-270	267±12	16
Ventral fenestra width	164-176	170±5	16
Ventral fenestra length/width	1.46-1.61	1.57±0.08	16

TABLE 9. Floatoblast measurements for *Plumatella suwana* (in micrometers).

	Range	Mean	N
Overall length	260-360	323 ± 9	20
Overall width	190-210	200 ± 3	20
Overall length/width	1.47-1.79	1.62 ± 0.04	20
Dorsal fenestra length	110-150	129 ± 4	20
Dorsal fenestra width	90-115	101 ± 4	20
Dorsal fenestra length/width	1.04-1.58	1.28 ± 0.02	20
Ventral fenestra length	160-220	189 ± 8	20
Ventral fenestra width	120-150	137 ± 4	20
Ventral fenestra length/width	1.23-1.67	1.38 ± 0.05	20

27). Floatoblast dimensions are provided in Table 9. Sessoblasts are not yet known in this species.

Distribution- *Plumatella suwana* is known only from its type locality in Prachuab Khiri Khan Province.

Plumatella vorstmani Toriumi, 1952
Figures 28, 29, 39

Plumatella javanica: Vorstman, 1928a: 6
Plumatella vorstmani Toriumi, 1952: 264

Material Examined- Bangkok Province: Fisheries Pond, Kasetsart University; Nakhon Nyok Province: Bang Pakong River at Wat Srinava; Khao Yai National Park; Nakhon Sawan Province: Bung Borophet; Prachin Buri Province: Prachin Buri River at Prachin Buri; Khlong Phra Prong at Route 33. Nakon Pathom Province: Thai House Pond, Mahidol University, Salaya; Sakhon Nakhon Province: Fish culture ponds at Sakhon Nakhon; Udon Thani Province: Issan Fish Farm, Udon Thani.

Description- Colonies growing flat along the substratum; zooids entirely prostrate, zooids in linear series, usually oriented nearly parallel to the main axis of the branch (Fig. 39). When severely crowded, zooids become erect but never fused. Raphe and furrow range from prominent to nearly inconspicuous, even in the same colony; the body wall is generally colorless and transparent or lightly incrusted, but it can also darken with age. Statoblasts are seldom abundant. Floatoblasts are irregular in outline and laterally symmetrical, or nearly so (Fig. 28); fenestrae have well-defined tubercles, many of them capped with a smaller hypertubercle, especially on the dorsal valve, although this is difficult to see without scanning electron microscopy. The ventral fenestra usually bears a prominent central protuberance. Cells of the annulus are strongly convex, often projecting above the annular plane to create irregular surface (Fig. 28), or protruding along the margin of separated valves. Dimensions of the floatoblasts are provided in Table 10. Sessoblasts are small, broadly oval, and tuberculated on the frontal valve; the annulus bears a prominent reticulum (Fig. 29) easily seen with both scanning and light microscopy.

TABLE 10. Floatoblast measurements for *Plumatella vorstmani* (in micrometers).

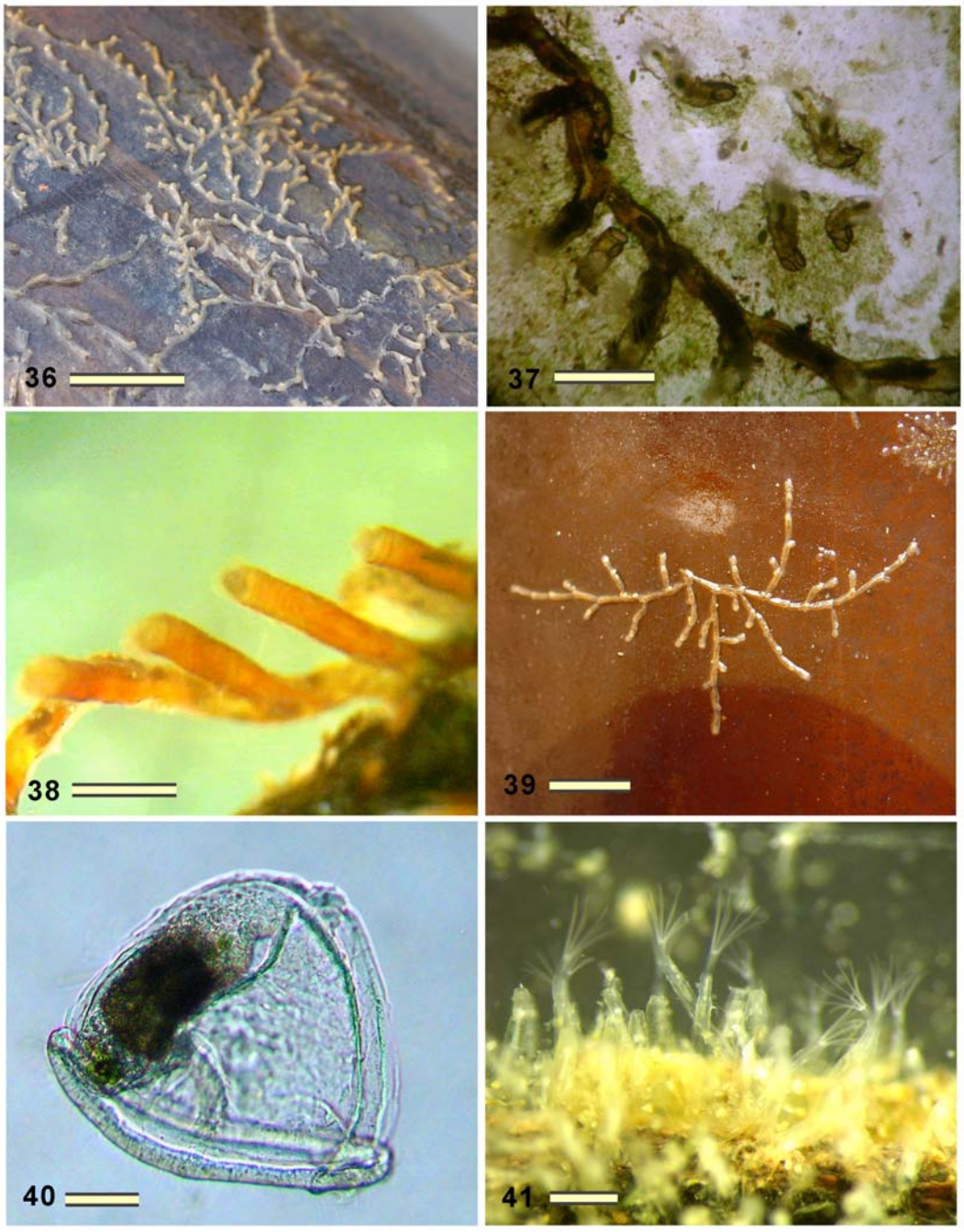
	Range	Mean	N
Overall length	260-324	295 ± 8	18
Overall width	170-200	187 ± 5	18
Overall length/width	1.44-1.70	1.58 ± 0.04	18
Dorsal f enstra length	120-164	139 ± 7	18
Dorsal fenestra width	100-122	110 ± 4	18
Dorsal fenestra length/width	1.07-1.43	1.26 ± 0.06	18
Ventral fenestra length	145-200	163 ± 8	17
Ventral fenestra width	110-140	125 ± 5	17
Ventral fenestra length/width	1.18-1.43	1.30 ± 0.03	17

Distribution- *Plumatella vorstmani* is very common and widely distributed in Thailand. It is also known from Indonesia and Japan.

Remarks- *Plumatella vorstmani* was included among the Indonesian material identified as *Plumatella javanica* by Vorstman, and now deposited at the Leiden Museum. Both species are similar in colony morphology. The most reliable difference is seen in the statoblasts. The floatoblasts of *P. vorstmani* are much smaller and almost always have hypertubercles when viewed with scanning electron microscopy. The sessoblast annulus of *P. vorstmani* has a very distinctive reticulation, which is absent in *P. javanica*.

Genus *Swarupella* Shrivastava, 1981

The genus is distinguished by small spines along the floatoblast suture, especially at the poles. While such spines are well developed in certain species of Lophopodidae and Pectinatellidae, they are unusual among plumatellids. Scanning electron micrographs suggest that the spines are derived from material of the suture (Fig. 33). Shrivastava (1981) noted that the spines of the type species, *S. andamanensis*, occur only at the poles of the floatoblasts, but "continue posteriorly as sutural frill," leaving open the possibility of more fully



FIGURES 36-41. 36) *Plumatella javanica* colony showing nearly erect zooids. Scale bar = 1 cm. **37)** *Plumatella siamensis* colonies, the four smaller ones growing from rapidly germinating flotatoblasts probably released by the larger colony. Scale bar = 1.5 mm. **38)** *Plumatella suwana*, portion of a colony. Scale bar = 1 mm. **39)** *Plumatella vorstmani*, small colony. Scale bar = 5 mm. **40)** *Hislopia malayensis* cyphonautes larva. Scale bar = 0.05 mm. **41)** *Victorella pavida* colony. Scale bar = 0.4 mm

developed spines continuing along the sides in other species.

Until now the genus *Swarupella* has been represented by a single species, *S. andamanensis* (Rao, 1961) from an unspecified location in the Andaman Islands, a group of five large and many small islands in the Bay of Bengal. The original report provides line drawings and basic measurements. The colony is described as "flat, without any erect zooecia" (Rao, 1961). The ectocyst is "constituted entirely of diatomaceous encrustations embedded in mucus" (Rao et al. 1985). These observations are borne out by holotype material. Not only is the ectocyst extremely fragile, but so also are the floatoblasts, which are so poorly sclerotized as to be practically membranous. Rao (1961) reported the floatoblast dimensions as: length 260-300 um, width 160-190 μm. These measurements are considerably smaller than those of paratype material given to the first author (see Table 13). Following the initial discovery, a specimen of *Swarupella andamanensis* was subsequently collected in Narsinghgarh, Madhya Pradesh, India, where it "conformed with the earlier descriptions of this species." (Rao et al. 1985).

Swarupella divina Wood, new species
Figures 30, 31

Type- Holotype collected 14 August 2004 at Bung Borophet, a large lake in Nakhon Sawan Province, from a leaf of *Potamogeton* sp.; colony in poor condition with floatoblasts but no sessoblasts; fixed and preserved in 70% ethyl alcohol, deposited at Chulalongkorn University Museum of Zoology, Bangkok (CUMZ 3166).

Material Examined- The holotype is the only known specimen of this species.

Etymology- The species name is from Latin, meaning "heavenly," in reference to Nakhon Sawan, the place nearest the type locality, the name of which in Thai means "Heavenly City."

Diagnosis- Compared to other members of the genus, the floatoblast is relatively large and broad, well rounded at the poles rather than tapering from the midpoint. The marginal processes are conspicuous with light microscopy and adorn the entire periphery of both valves.

Description- The holotype colony is small and sparsely branched, entirely recumbent on aquatic vegetation; ectocyst is colorless and transparent with no apparent raphe. The floatoblast is broadly oval and laterally asymmetrical with the dorsal valve only slightly convex. Dorsal and ventral fenestrae are similar in overall proportions but distinctly different in size (Fig. 30). Both bear a large number of very small tubercles. Minute spines are formed uniformly around the entire periphery of both valves, visible especially when valves are separated (Fig. 31). Dimensions of the floatoblast are provided in Table 11. Sessoblasts are not yet known in this species.

Remarks- This is a second species known in Thailand only from Bung Borophet, the first species being *Plumatella minuta* described earlier.

TABLE 11. Floatoblast measurements for *Swarupella divina* (in micrometers).

	Range	Mean	N
Overall length	350-375	356 ± 6	9
Overall width	250-260	252 ± 3	9
Overall length/width	1.35-1.50	1.42 ± 0.04	9
Dorsal fenestra length	160-185	173 ± 6	9
Dorsal fenestra width	130-143	134 ± 4	9
Dorsal fenestra length/width	1.19-1.39	1.28 ± 0.06	9
Ventral fenestra length	208-230	215 ± 7	9
Ventral fenestra width	160-170	165 ± 4	9
Ventral fenestra width/length	1.22-1.35	1.30 ± 0.03	9

Swarupella kasetsartensis Wood, new species
Figures 32-35

Type- Holotype collected 16 November 2005 at the inlet to Tha Krabak Reservoir, Prachin Buri Province; large colony on wood with floatoblasts, but no sessoblasts; fixed and preserved in 70% ethyl alcohol; deposited at

Chulalongkorn University Museum of Zoology, Bangkok (CUMZ 3167).

Material Examined- The type material constitutes the only known specimens of this species.

Etymology- The species name honors Kasetsart University and its faculty, staff, and students who have played a major role in the pioneering studies of freshwater bryozoans in Thailand.

Diagnosis- The colony is repent and diffuse, with well-spaced and erect zooids. The relatively small floatoblasts are narrow and tapering towards the ends, with minute sutural spines around the entire periphery.

Description- The colony is spindly and diffuse, with slender tubules and erect, well-spaced zooids. The overall colony morphology strongly resembles that of a robust fredericellid, except for the absence of free branches. The raphe and furrow are distinct even in young zooids; the ectocyst is lightly encrusted.

Floatoblasts are relatively small and narrow; nearly all taper from a wide midsection towards the ends (Figs 32, 34-35). Only a few floatoblasts have parallel sides and broadly rounded ends. Tiny spines occur along the suture, especially at the poles, although these are very difficult to see with light microscopy (Fig. 33). Fenestrae are strongly tuberculated, and scanning electron microscopy shows the annular chambers to be convex and distinct (Figs 34-35). Floatoblasts are normally laterally asymmetrical, with the ventral valve very convex and the dorsal valve essentially flat. Floatoblast measurements are provided in Table 12. There were no sessoblasts in our single specimen.

Remarks- The floatoblasts of *Swarupella kasetsartensis* are shaped similarly to those of *S. andamanensis*, with a distinctive tapering towards the poles (Fig. 32). However, in *S. kasetsartensis* the floatoblasts and colony ectocyst are well sclerotized compared to their membranous counterparts in *S. andamanensis*. Moreover, floatoblasts of *S. kasetsartensis* are significantly smaller and the dorsal fenestra much larger than in *S. andamanensis* (Tables 12, 13; Fig. 32). Together with the well sclerotized valves and capsule, these differences are sufficient to recognize a distinct new species.

TABLE 12. Floatoblast measurements for *Swarupella kasetsartensis* (in micrometers).

	Range	Mean	N
Overall length	290-340	313 ± 9	11
Overall width	150-190	178 ± 7	11
Overall length/width	1.63-2.00	1.77 ± 0.07	11
Dorsal fenestra length	128-150	140 ± 4	11
Dorsal fenestra width	90-115	104 ± 5	11
Dorsal fenestra length/width	1.16-1.50	1.35 ± 0.07	11
Ventral fenestra length	154-170	164 ± 4	11
Ventral fenestra width	115-142	124 ± 5	11
Ventral fenestra length/width	1.20-1.42	1.32 ± 0.04	11

Class Gymnolaemata Allman, 1856

Species overwhelmingly marine, with only a few occurring in brackish or fresh water. Zooids relatively small, tentacles arranged in a circle around the mouth and numbering fewer than 25. Mouth region lacking an epistome; statoblasts not formed although other dormant structures (hibernaculae) may occur.

Order Ctenostomata Busk, 1852

Uncalcified gymnolaemates having feeding zooids with parietal muscles attached to flexible frontal walls. Colonies are erect, encrusting, or creeping; zooids cylindrical, flask-shaped, or flattened. The terminal orifice is closed by muscular contraction giving it a squarish appearance when the polypide is withdrawn. This group includes all the known freshwater Gymnolaemata, currently comprising five genera and at least nine species.

Family Hislopiidae Jullien, 1885

Colonies are entirely recumbent, capable of forming a uniform layer across the substratum; zooids are flattened, orifice dorsal; polypide with a muscular proventriculus (“gizzard”).

TABLE 13. Floatoblast measurements for *Swarupella andamanensis* (in micrometers), taken from a paratype.

	Range	Mean	N
Overall length	340-380	366±7	7
Overal width	198-215	209±4	7
Overall length/width	1.64-1.83	1.75 ± 0.04	7
Dorsal fenestra length	100-107	102 ± 3	7
Dorsal fenestra width	93-103	100 ± 3	7
Dorsal fenestra length/width	0.98-1.11	1.02 ± 0.05	7
Ventral fenestra length	138-155	149 ± 7	7
Ventral fenestra width	112-140	129 ± 7	7
Ventral fenestra length/width	1.05-1.38	1.16 ± 0.09	7

The single genus, *Hislopia*, is known throughout southern Asia and as far north as Lake Baikal in the west to the Republic of Korea and Japan in the east; also common in parts of Central and South America. Seven species have been described, but traditional taxonomy is limited by the lack of reliable diagnostic features.

Synonymy.
Hislopia Carter, 1858, page 169.
Norodonia: Jullien, 1880, page 77.
Echinella: Korotneff, 1901, page 311.
Norodomia: Dawydoff, 1948, page 1138.

Hislopia malayensis Annandale, 1916
Figures 40, 47, 48

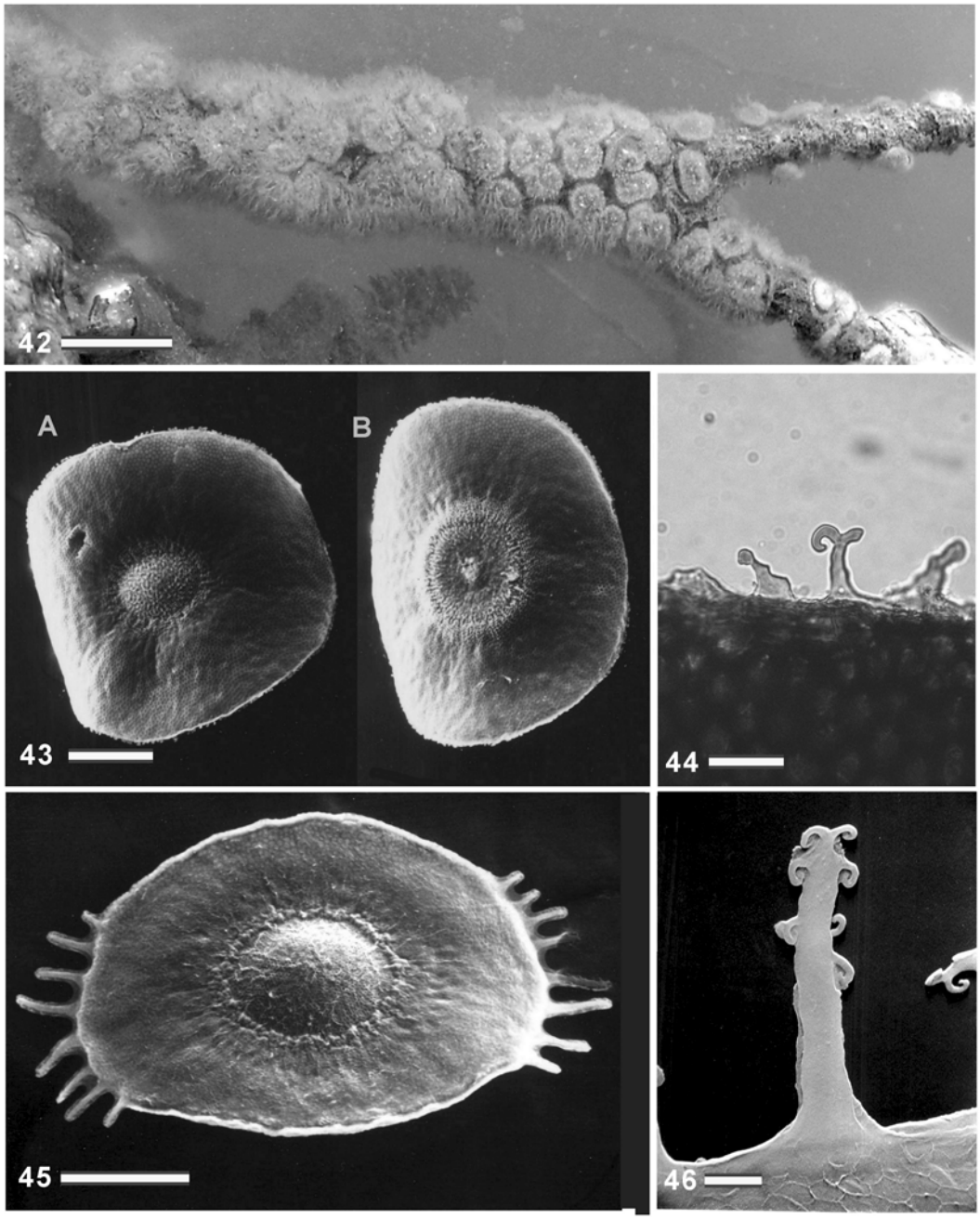
Hislopia malayensis Annandale, 1916: 35.

Material examined- Bangkok Province, Fisheries Pond at Kasetsart University, Bangkhen; Chachoengsao Province: Sanam Chai Khet; Chiang Mai Province: Ang Kaeo Reservoir, Chiang Mai University**;** Chaiyaphum Province: Kaeng Krachan Reservoir; Khon Kaen Province: Nong Khut, 5 km west of Khon Kaen; Phomg River at Nam Phong; Nakhon Nayok Province: Phra Prong River at Kabin Buri; Khlong Ban Na; Prachin Buri Province: Huay Samong, 5 km south of Na Di; Bang Pakong River at Prachin Buri; Prachuap Khirikhan Province: Pran Buri Reservoir, 30 km SW Hua Hin; Sakon Nakhon Province: Huai Nam Kam.

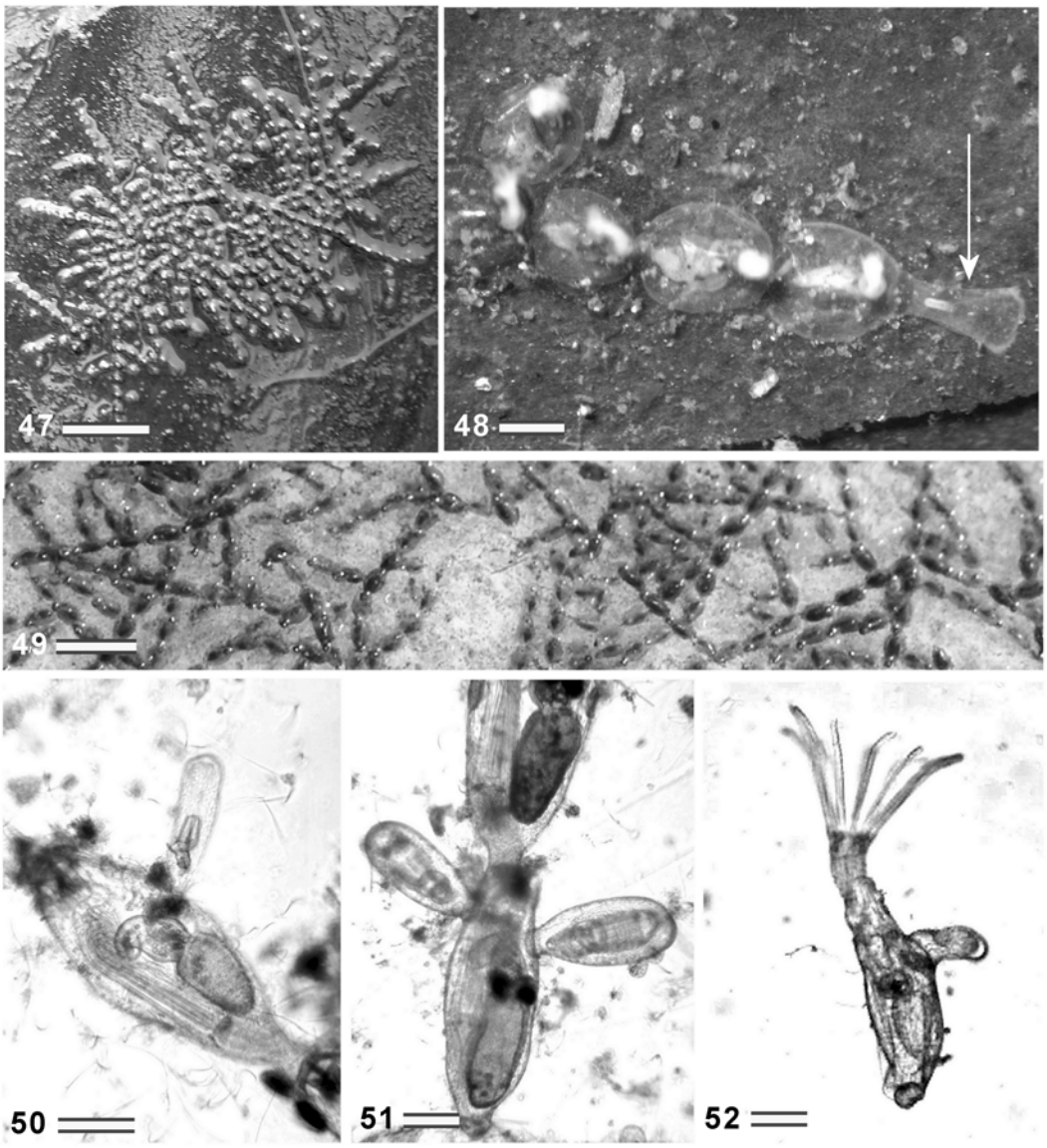
Description- The colony is flat and centrally compact, with richly branched lines of zooids radiating in all directions (Fig. 47). On a uniform, unobstructed substratum the young colony quickly becomes roughly circular in outline and expands outwards. Zooids are broadly rounded and joined to each other along a relatively wide line of contact. The ectocyst is sufficiently transparent to allow a clear view of the internal anatomy. The first zooid of the colony (ancestrula) measures only 315 micrometers in diameter; dimensions for all other zooids are: length 860 ± 40 µm, micrometers, width 620 ± 50 µm, ratio of length to width 1.20 ± 0.08 µm (N=30). There are no spines around the orifice. Tentacles number 16 to 18. Budding morphology is distinctive and diagnostic for this species: a new bud elongates as a straight, slender, bluntly pointed extension that expands broadly at the distal end. The expansion works its way back towards the adult zooid as the new zooid gradually assumes a broad, oval shape (Fig. 48). Many older zooids eventually develop thickened walls and become packed with yolk granules to form hibernaculae. Colonies release gametes throughout the year, the fertilized eggs developing into planktotrophic cyphonautes larvae (Fig. 40).

Distribution- *Hislopia malayensis* is known so far only within the borders of Thailand.

Remarks- *Hislopia malayensis* is probably the most frequently encountered bryozoan in Thailand. It was initially described by Annandale (1916) from a small lake near Yala in Patani Province, where collections were made in 1901 and again in 1916. The cyphonautes larva has previously been associated only with marine bryozoans, but a recent study of *H. malayensis* revealed its presence in fresh water for the first time. Hibernaculae in the genus *Hislopia* also have not been previously described. Preliminary studies suggest that these dormant bodies survive cool temperatures and low oxygen levels, but not prolonged desiccation.



FIGURES 42-46. 42) *Asajirella gelatinosa* colony immersed in water. Scale bar = 20 mm. **43)** *Asajirella gelatinella* statoblasts, SEM photo. (A) Dorsal side; (B) ventral side. Scale bar = 0.25 mm. **44)** *Asajirella gelatinella* statoblast spines. Scale bar = 25 µm. **45)** *Lophopodella carteri* statoblast, SEM photo, showing polar spines. Scale bar = 0.2 mm. **46)** *Lophopodella carteri* statoblast spine. Scale bar = 25 µm.



FIGURES 47-52. 47) *Hislopia malayensis* colony. Scale bar = 6 mm. **48)** *Hislopia malayensis* stages of bud formation showing the expansion at the tip, which is characteristic of this species. Scale bar = 0.5 mm. **49)** *Hislopia natans* colony showing diffuse growth pattern. Scale bar = 4 mm. **50)** *Hislopia natans* zooid with a normal adventitious bud. Scale bar = 0.25 mm. **51)** *Hislopia natans* zooid with two unique nautizooid buds. Scale bar = 0.25 mm. **52)** *Hislopia natans* nautizooid, free swimming. Scale bar = 0.2 mm.

Hislopia natans Wood, new species
Figures 49-52

Types- Holotype collected 6 March 2005 at Huai Chan Reservoir, 26 km N. Aranyaprathet, 35 km NE Sa Kaeo, Sa Kaeo Province, 13°59.2'N, 102°26.8'E., colony fragments on several pieces of high density polyethylene substrata; fixed and preserved in 70% ethyl alcohol; deposited at Chulalongkorn University Museum of Zoology (CUMZ 3152).

Material examined- Sa Kaeo Province: Huay Chan Reservoir and Tah Krabak Reservoir.

Etymology- The species name is from the Latin, *natare*, meaning "to swim," in reference to the unusual free-swimming nautizooids.

Diagnosis- The colony is diffuse, forming straight lines of zooids branching at nearly 90-degree angles when unobstructed. The zooids are slender and generally fusiform, about 2.5 to 3 times longer than wide. The minutely textured surface develops a dark gold color with age. Tentacles number 11-12. In addition to producing one or sometimes two daughter zooids, each zooid is also capable of forming up to five "nautizooids," which detach from the colony and swim away.

Description- The colony is diffuse and spreading, with straight series of elongate zooids producing well spaced, nearly perpendicular branches (Fig. 49). Slender zooids are irregularly shaped, but usually widest near the middle and tapering to a narrow septum at each end. The zooids measure about 1 mm between proximal and distal septa, and 0.3-0.4 mm wide. A flat, cornified membrane sometimes extends as much as 0.2 mm further along each side. The lophophore bears 11-12 tentacles. Each zooid produces one distal zooid and somewhat later perhaps one or (rarely) two lateral daughter zooids. The zooid buds are always recumbent, growing as elongate, uniformly narrow cylinders, extending to a full zooid length before filling out from a point near the distal third to assume an adult shape (Fig. 50). Lateral zooids always form at a specific point proximal to the orifice and near the widest part of the parental zooid. A unique second type of bud may also be formed, appearing as a bulbous outgrowth from any dorsolateral point of the parental zooid, growing obliquely away from the substratum (Fig. 51) (Wood et al. 2006b). The bud develops rapidly into a fully formed zooid about 20% smaller than the parent, from which it detaches spontaneously and becomes free-swimming, using the extended lophophore for propulsion (Fig. 52). A zooid may form as many as five of these bulbous buds in rapid succession. The unusual motile zooid, or "nautizooid," bears two adhesive stubs, one proximal and one ventral, capable of adhering to a new substratum, at which point they elongate to form large daughter zooids of a new colony.

Distribution- The species is known so far only from two small irrigation reservoirs cited above.

Remarks- Two other *Hislopia* species with proximally tapering zooids have been described from southern Asia by Jullien (1880). His *Norodonia (= Hislopia) cambodgiensis* was collected from the Mekong River at the far northeastern boundary of Thailand and also in the interior of Cambodia. The zooids are described as 0.85 mm long and 0.65 mm wide, thick-walled and pear-shaped. Jullien's *Norodonia sinensis* was named from a dry specimen found on a mussel shell at the Museum of Paris, originally collected from Anhui Province west of Shanghai, China. The zooid shape and dimensions are similar to those of *H. natans*. A dorsal keel described and figured by Jullien is almost certainly an artifact resulting from desiccation. Jullien's (1885) paper distinguished *Norodonia* from *Hislopia*, suggesting that *Norodonia* colonies had identifiable lines of serial zooids while *Hislopia* colonies were more often lacking a defined structure. Loppens (1908, 1909) retained this distinction between genera. However, when Annandale (1916) visited the Taihu Lake area of China, not far from the type locality of *N. sinensis*, he encountered specimens of Hislopiidae with a variable morphology which he believed was related to colony age. Since this material seemed to combine the essential features of Jullien's two *Norodonia* species, Annandale called it *Hislopia cambodgiensis,* and made it synonymous with *Norodonia* (*Hislopia) sinensis*. Distinguishing this new species from India's *H. lacustris* with which he was more familiar, Annandale noted that *H. cambodgiensis* was composed of more visibly separate branches owing to sparse lateral budding; also that zooids of *H. cambodgiensis* were invariably tapered proximally, while those of *H. lacustris* were only occasionally so. These are also features of *H. natans*, although

Annandale's sketch shows zooids far more angular than those we have just described.

If any of Jullien's or Annandale's material were the same as *H. natans* it seems odd that neither of these keen observers noticed the distinctive globular nautizooid buds. Unfortunately, Jullien's specimens are now missing, and Annandale's material yields no useful information. For now it seems prudent to consider *H. natans* a wholly new species, distinct from any previously described. Further bryozoan surveys in Southeast Asia and in China should help clarify the distribution and relationships of *Hislopia* species in eastern Asia.

Family Victorellidae Hincks, 1880

The colony is composed of creeping, successive zooids in direct continuity, every zooid attached to previous one only in its proximal zone, budding directly from other autozooids, the aperture quadrangular, zooids capable of forming hibernaculae, lophophore campylonemidan (bilaterally symmetrical with 8 tentatacles, the abanal pair best outwards), zooids capable of becoming erect and elongate, occurring in fresh or brackish water.

Genus *Victorella*

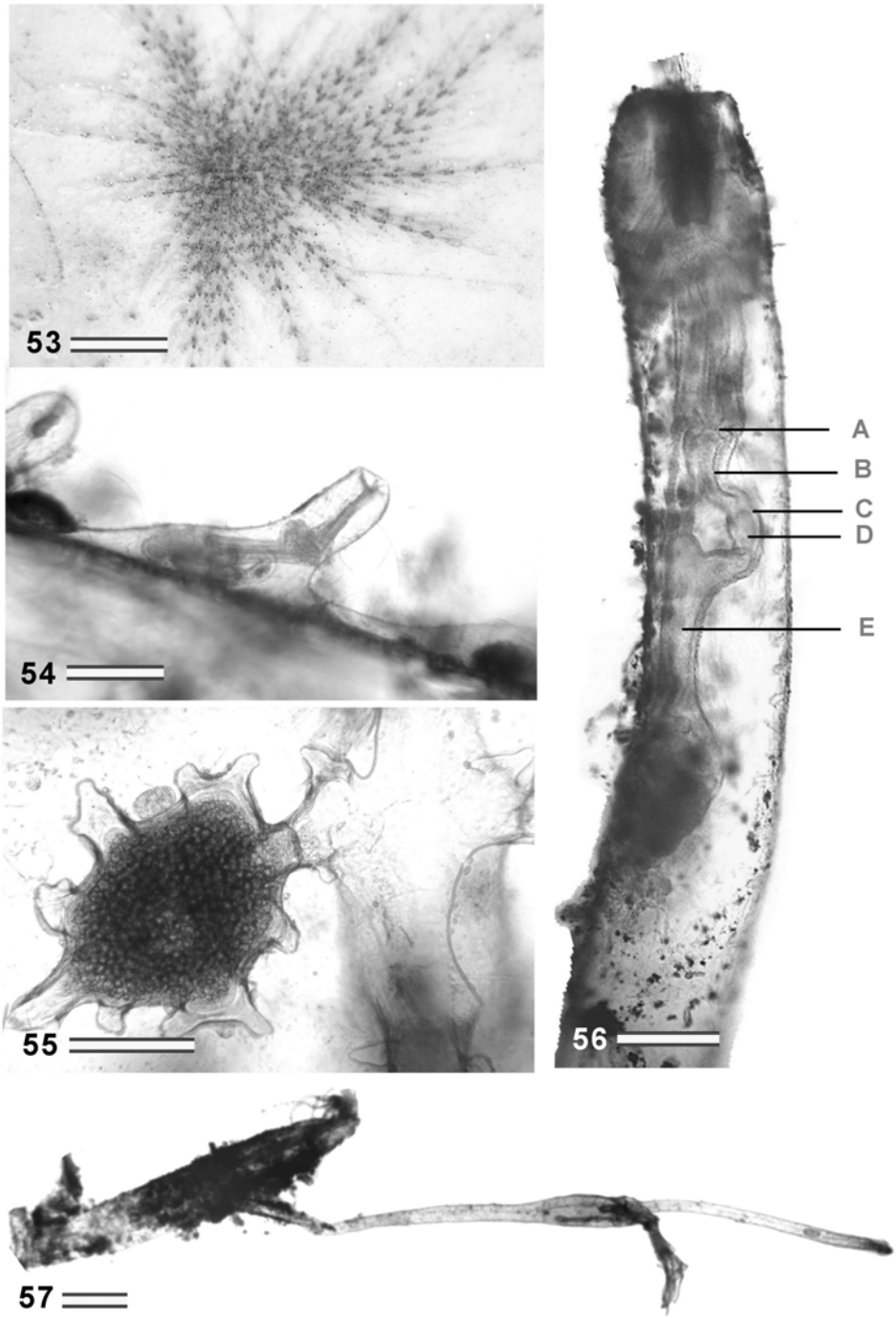
Diagnostic features of the genus are based on the digestive tract: the stomach cardia is divided by a distinct sphincter into roughly equal fore and aft sections; the caecal lobe of the stomach is similar in length to the esophagus, pharynx, and cardia combined; the gut lacks a muscular proventriculus (gizzard) with distinct teeth,

Victorella pavida Saville Kent, 1870
Figures 41, 53-57

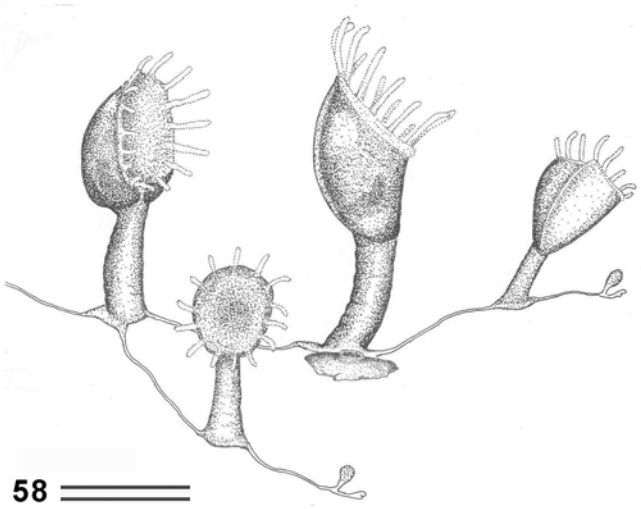
Victorella pavida Saville Kent, 1870: 34.
Victorella bengalensis: Annandale, 1908a: 11.

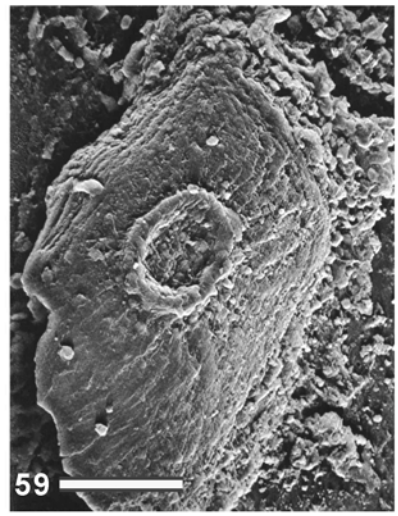
Material Examined- Chachoengsao Province: Wat Ban Kao; Nakhon Pathom Province: Herb Garden Pond, Mahidol University, Salaya.

Description- Zooids occur in three forms: adnate (lying close to the substratum), erect, and adventitious (free). On unrestricted substrata colonies form straight, radiating lines of adnate zooids, with secondary and tertiary branches developing from pairs of lateral buds (Fig. 53). Adnate autozooid length 400-430 µm, maximum width 150-160 µm, zooids tapering proximally to 50-60 µm; peristomial tube length 180-220 µm; peristomial tube containing only the setigerous collar when polypide is fully retracted (Fig. 54). New zooids develop first distally and then bilaterally; all buds formed from the basal portion only; free, adventitious zooids occurring at the abrupt edge of a substratum. Under crowded conditions all zooids become erect, with the cylindrical peristomial tube and basal element together lengthening to 1-1.2 mm (Fig. 41). Erect zooids are joined by their proximal tubules which are short and narrow, much like little stolons. Peristomial budding may also occur, in which new zooids are formed around the midpoint of erect zooids, producing a free chain of adventitious zooids. Each adventious zooid is composed mostly of a long, proximal tubule (50-60 µm in diameter, extending up to 1.5 mm) (Fig. 57). This enlarges at the distal end to a shorter region (100-150 µm in diameter, 450-500 µm long) where the polypide is housed. Here the peristomial tube is around 160 µm long. In all three forms of zooids the stomach cardia is long and thin-walled from esophagus to the cardia muscle and thereafter thick-walled like the rest of the stomach (Fig. 56). Both adnate and erect zooids may form dark colored hibernaculae, which are circular and slightly dome-shaped, the diameter measuring 160-210 µm not including short, bifurcating radial processes (Fig. 55). We have not observed any sign of sexual reproduction, including the appearance of an intertentacular organ. The species flourishes in permanent bodies of water with no measurable salinity, but has also been found in an area intermittently



FIGURES 53-57. 53) *Victorella pavida* colony on unobstructed substratum, showing radiating branches. Scale bar = 7 mm. **54)** *Victorella pavida* adnate zooid. Scale bar = 0.15 mm. **55)** *Victorella pavida* hibernaculum. Scale bar = 0.1 mm. **56)** *Victorella pavida* erect zooid showing digestive system. (A) pharynx. (B) esophagus; (C) cardia muscle; (D) stomach cardia; (E) stomach caecum. Scale bar = 0.075 mm. **57)** *Victorella pavida* adventitious zooid. Scale bar = 0.5 mm.





FIGURES 58-59. 58) *Loxosomatoides sirindhornae* zooids. Scale bar = 0.2 mm. **59)** *Loxosomatoides sirindhornae* hibernaculum Scale bar = 75 µm.

salinized to as high as 3% (30 psu) from the discharge of commercial shrimp farms.

Distribution- Brackish coastal regions of northern Europe, Mediterranean and Black Seas, eastern North America, Brazil, Japan and Thailand (Thalé Sap); also entirely freshwater ponds in India and Thailand.

Discussion- Living colonies from Chacheongsao Province were easily maintained for five months in the laboratory according to the methods of Wood (1996). At a pH of 8.4 and conductivity of 280-320 mmhos they produced both adnate and erect zooids, formed hibernaculae, and spread thickly across nearly a dozen microscope slides.

Victorella pavida was described from brackish water around London, first by Saville Kent (1870) and later by Hincks (1880), Bousfield (1885), and Rousselet (1907). Since then published descriptions have appeared of at least six additional species and several look-alike genera. The differences among these appear slight, and there have been numerous reports of intermediate forms. As summarized by d'Hondt (1983) the main taxonomic points are these: At the generic level, *Tanganella* (Braem, 1951) has the cardial sphincter located at the entry to the digestive caecum rather than at the midpoint of the cardia; in *Bulbella* (Braem, 1951) the zooids are never erect and brooding is external. The six species classified as *Victorella* differ in zooid size; the number, frequency, and position of buds, and details of gut anatomy.

While these generic differences may be real, their taxonomic value is untested. Zooid size can be highly variable (Soule, 1957) and gut anatomy can be difficult to interpret (Braem, 1951). Seasonal and other environmental factors also play an undetermined role, and some morphological features may be recognizable only in living material (Jebram and Everitt, 1982). Certainly a wide variation of zooid morphology and budding patterns are clearly evident in the Thai material.

The significance of a freshwater habitat should not be overestimated. *Victorella pavida* has been reported from a wide range of salinities (Carrada and Sacchi, 1964), including entirely fresh water (Hayward, 1985). Two victorellid species are known only from single collections in fresh water: *V. symbiotica* Rousselet, 1907 and *V. pseudoarachnida* Jebram and Everitt, 1982.

The only victorellid previously reported from southeast Asia has been *V. bengalensis*

Annandale, 1908a. Nelson Annandale initially described his species from brackish and freshwater ponds in India around Port Canning and Bombay. Further details were published in 1916 after Annandale had collected identical material in the brackish waters of Thalé Sap, Thailand. The only features distinguishing this species from *V. pavida* were its "more luxuriant and irregular growth" and the circular cross-section of the distal end of the adult zooid (Annandale, 1911b). Neither Menon (1972) nor d'Hondt (1983) considered these sufficient to justify a distinct species, so *V. bengalensis* has become a junior synonym for *V. pavida*.

The present material from Thailand reveals the full range of morphological variation in this species. It is almost certainly the same as Annandale's *V. bengalensis*, and it meets every morphological criterion of the more firmly established *V. pavida*.

Phylum Entoprocta

Family Pedicellinidae (Johnston, 1847)

Colonial, stolonate entoprocts having a continuous longitudinal muscles in the stalk and a stack of star-shaped cells ("star complex") at the transition between the body and stalk.

Loxosomatoides sirindhornae Wood, 2005
Figures 58, 59

Loxosomatoides sirindhornae Wood, 2005a: 27.

Material examined- Mae Khlong River at Kanchanaburi, Kanchanaburi Province; Prachin Buri River at Prachin Buri, Prachin Buri Province.

Description- Zooids are small and erect, generally less than 450 µm in height, joined at their base in linear series by narrow, creeping stolons about 30 µm in diameter (Fig. 58). Each zooid has a muscular, unsegmented stalk that tapers slightly towards the calyx and appears mostly smooth. The calyx is nearly the same length as the stalk but tilted obliquely, deploying 12-16 tentacles. A rigid shield encloses the calyx, with a roughened surface texture and a prominent medial carina on the aboral side. Small particles and debris usually cover the shield and render it opaque. The base of the stalk may generate up to four radiating stolons and may also produce a sessile hibernaculum. The hibernaculum is darkly colored and shaped like a low, conical mound very close to the stalk. It measures about 300 µm by 180 µm, with a central orifice about 75 µm diameter plugged with undefined granules (Fig. 59). It is through this orifice that a new zooid eventually appears.

Distribution- *Loxosomatoides sirindhornae* is known so far only from two rivers draining into the Gulf of Thailand.

Remarks- Annandale (1908a) created the genus *Loxosomatoides* for an entoproct occurring in brackish water at Port Canning, India. That species, *L. colonialis*, is similar to *L. sirindhornae* but lacks the carina and has differently formed hibernaculae. Three additional species have also been described from brackish waters of India, Brazil, and Thalé Sap in Thailand (see review by Wasson et al., 2000). Only *L. sirindhornae*, is known from entirely fresh waters

The known distribution so far suggests the species prefers a lotic habitat. The largest populations have been collected from old, synthetic rope dangling from floating restaurants, guest houses, and fish culture pens.

The only other entoproct species reported from entirely fresh water is *Urnatella gracilis*, with a branching, segmented stalk, but not seen so far in Thailand.

DISCUSSION

Among the 18 species documented here from Thailand 10 have been previously described from other parts of Asia or Australia. Seven species are shared with Japan, six with India (Table 14).

There is growing evidence that waterfowl are important agents in the dispersal of freshwater bryozoans (Wood, 2002). Migrating

TABLE 14. Known distribution of Thai freshwater ectoproct bryozoans in Asia and Australia. Numerals within the table refer to the following useful references regarding the local occurrence of each species: a) Current paper; b) Annandale 1916; c) Annandale, 1911a; d) Annandale, 1908a; e) Annandale, 1908b; f) Rao et al., 1985; g) Toriumi, 1941a; h) Toriumi, 1956a; i) Toriumi, 1956b; j) Valkanov, 1943; k) Toriumi, 1952; l) Toriumi, 1955a; m) Vorstman, 1928a; n) Bretnall, 1920; o) Ridley, 1886.

Species	Thailand	India	Japan	Other Asia	Australia
Asajirella gelatinosa	**a**	**c**	**g, h**	**m**	
Lophopodella carteri	**a**	**c**	**g, i**	**m**	**n**
Plumatella casmiana	**a**	**f**	**g**	**m**	
Victorella pavida	**b**	**d**	**j**		
Plumatella javanica	**a**	**e**		**m**	
Plumatella bombayensis	**a**	**c**			
Plumatella vorstmani	**a**		**k**		
Plumatella minuta	**a**		**l**		
Hyalinella lendenfeldi	**a**				**o**
Hislopia malayensis	**b**				
Hislopia natans	**a**				
Internectella bulgarica	**a**				
Loxosomatoides sirindhornae	**a**				
Plumatella chulabhornae	**a**				
Plumatella siamensis	**a**				
Plumatella suwana	**a**				
Swarupella divina	**a**				
Swarupella kasetsarti	**a**				

birds carry viable bryozoan statoblasts on their feathers, feet and even in their digestive tracts (Brown, 1933), and therefore the well-established migratory routes serve as corridors of statoblast dispersal. Thailand sits on the western edge of a network of ancient bird migration routes known collectively as the East Asian/Australasian Flyway (Fig. 60). These corridors link all of Southeast Asia and the Western Pacific with eastern China, Japan, Korea, Australia, and beyond. They could certainly explain how seven bryozoan species are shared between Thailand and Japan, and how a northeast Asian bryozoan, *Plumatella minuta* could become established in Bung Borophet, a stopover site in Thailand for migratory waterfowl. Although virtually nothing is known of freshwater bryozoans in southern China, the flyway suggests that we should expect to find there a close correspondence with Thai species.

Further west of Thailand the avian migratory routes are increasingly oriented towards Western Asia and Europe. This could be why Thailand and India share only six bryozoan species, even though Thailand sits only on the other side of the Bay of Bengal well within the latitudes of southern India and Sri Lanka. At least 20 species of freshwater bryozoans have been documented from central and northern India alone (Rao et al., 1985), not including 8 species yet to be described from the Zoological Survey in Calcutta.

However, with so much of southern Asia yet to be examined for freshwater bryozoans the actual distribution patterns remain unclear; nor is it certain that much new knowledge will be acquired any time soon. Sadly, Asia has recently lost three of its most active freshwater bryozoologists (Rao, Mukai, and Oda), leaving fewer than a half dozen worldwide. Moreover, heavy predation on bryozoans by the introduced apple snail, *Pomacea canaliculata* Lamarck, 1822 is having a dramatic impact on many species (Wood et al., 2006a). The continued degradation of freshwater habitats combined with the chronic shortage of information, funding, and biodiversity conservation are worrisome (Dudgeon, 2003). Nevertheless, even the modest effort reflected in this paper

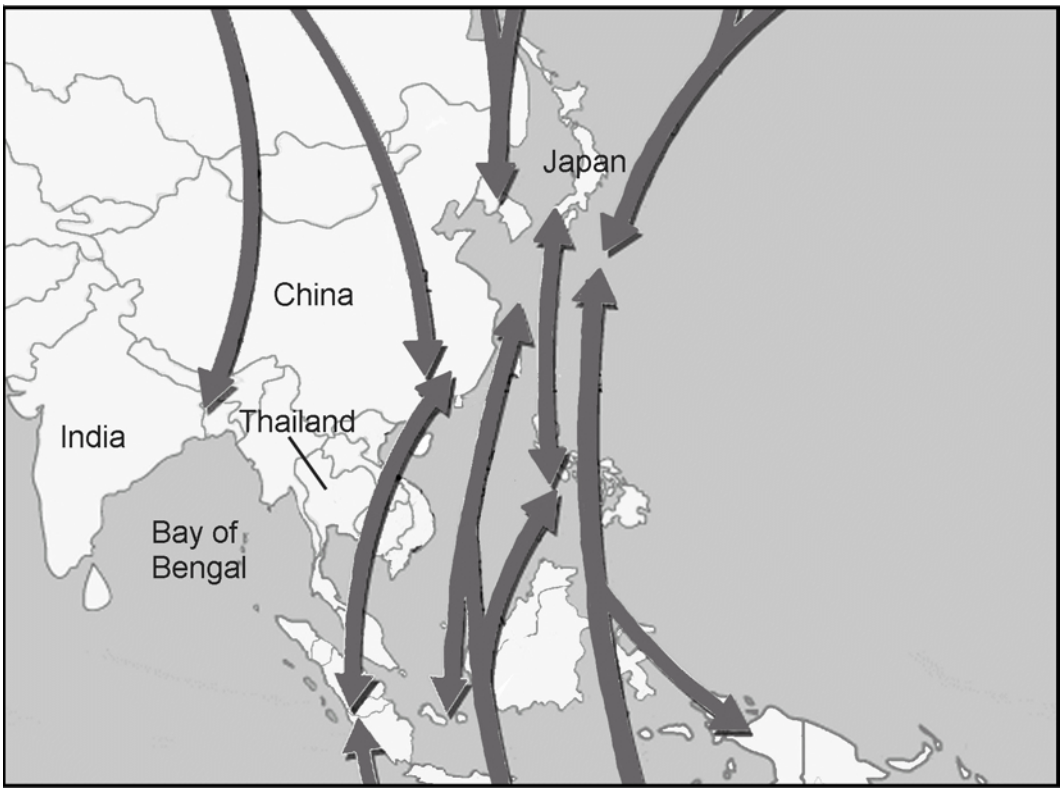


FIGURE 60. Bird migration routes in the East Asian/Australasian flyway, showing links between Thailand and other regions (based on a map prepared by the Australian Wader Study Group, Birds of Australia).

reveals a surprising diversity of freshwater bryozoans in Thailand, and we are optimistic that even more species will eventually be revealed in this region.

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