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Diversity of sessile rotifers (Gnesiotrocha, Monogononta, Rotifera) in Thale Noi Lake, Thailand

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Abstract

In response to a clear gap in knowledge on the biodiversity of sessile Gnesiotrocha rotifers at both global as well as regional Southeast Asian scales, we performed a study of free-living colonial and epiphytic rotifers attached to fifteen aquatic plant species in Thale Noi Lake, the first Ramsar site in Thailand. We identified 44 different taxa of sessile rotifers, including thirty-nine fixosessile species and three planktonic colonial species. This corresponds with about 40 % of the global sessile rotifer diversity, and is the highest alpha-diversity of the group ever recorded from a single lake. The record further includes a new genus, *Lacinularoides* **n. gen.**, containing a single species *L. coloniensis* (Colledge, 1918) **n. comb.**, which is redescribed, and several possibly new species, one of which, *Ptygura thalenoiensis* **n. spec.** is formally described here. *Ptygura noodti* (Koste, 1972) **n. comb.** is relocated from *Floscularia*, based on observations of living specimens of this species, formerly known only from preserved, contracted specimens from the Amazon region. In addition, ten of the species recorded are added to the fauna of the Oriental region, twenty-seven are new to Thailand.

Key words: aquatic macrophytes, biogeography, epiphytic rotifers, new genus, new species, taxonomy

Introduction

Sessile and colonial rotifers, belonging to four families of superorder Gnesiotrocha, are common and abundant on submerged aquatic plants and other substrata in freshwater habitats (Edmondson 1939, 1940, 1944; Koste 1975; Wallace 1980, 1987; Segers *et al*. 2011). Many are quite attractive and easily spotted organisms, so that already Anthony Van Leeuwenhoek was able to record observations on some of them in the 17th and early 18th century, and two species, *Floscularia ringens* and *Sinantherina socialis,* were named as early as 1758 by Carolus Linnaeus in his *Systema Naturae*. Nevertheless, and even though they are relatively easy to observe, there are few recent papers dealing with the animals. Most freshwater biodiversity studies treat representatives of sessile and colonial rotifers on an *ad hoc* basis at best, because classic sampling methods fail to collect them effectively (Wallace *et al*. 2006). As a consequence, there are substantial hiatuses in our knowledge on the taxonomy, biogeography and biodiversity of the organisms globally, and this holds in particular for tropical regions including Southeast Asia. This is illustrated by Segers *et al.* (2011), who report a significant number of novelties while analyzing a very limited number of samples from commonplace habitats.

To address this knowledge gap, we started a comprehensive study of the sessile and colonial rotifers of Thailand, starting with an inventory of Thale Noi Lake. This lake, a Ramsar site, is a complex ecosystem, regarding both its chemical and biological characteristics. The free-living rotifers of the lake have been documented by Segers & Pholpunthin (1997). It has diversified and patchy macrophyte stands including floating islands, and is inhabited by some sixty different aquatic plant species belonging to thirty-two families, with some twenty species dominating (Office of Environmental Policy and Planning 2000; Leingpornpan & Leingpornpan 2005). The lake can be subdivided in several zones based on depth, water chemistry, and flows (Inpang 2008), and is an important

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site for both resident and migrating populations of water birds (Office of Environmental Policy and Planning 2000). Here we present a first report on the taxonomy and diversity of the sessile and colonial rotifers of Thale Noi Lake, as a contribution to the diversity and biogeography of these peculiar micrometazoans in the Oriental region.

Material and methods

Study site. Our study was carried out in Thale Noi Lake, Phatthalung province, Southern Thailand. The lake is the first Ramsar Site designated in Thailand and a Non-Hunting Area. The lake is located at the northern end of Songkhla Lake, and is comprised between latitude 7º 45’ 44’’ N to 7º 48’ 26’’ N and longitude 100º 7’ 31’’ E to 100º 11’ 12’’ E (Leingpornpan & Leingpornpan 2005). It covers an area of about 30 km^2 (Office of Environmental Policy and Planning 2000) (Fig. 1). Songkhla Lake is a geologically complex lagoon that can be subdivided into three parts, with the southern end connected to Gulf of Thailand by an approximately 350 m wide channel (Fig. 1). As a consequence, salinity in Songkhla Lake ranges from around 0–33 ppt in the Southern part closest to the connection with the sea, 0–22 ppt in the center, and 0–7.5 ppt in the North, depending on precipitation which follows a monsoon pattern (Angsupanich & Rakkheaw 1997; Angsupanich *et al*. 2005; Ruensirikul *et al*. 2007). Thale Noi Lake itself is distinctly freshwater, relatively shallow (depth 0.7–2.3 m) and acidic (pH 5.8; range 3.2–9.9, SD1.4), the latter because of accumulation of peat in the lake and, mostly, from acidic water influx originating from peat swamp forests located near the northern shore of the lake. During the dry season influx of brackish water (0.1–0.8 ppt) can occasionally occur from Songkhla lake (Inpang 2008). Thale Noi Lake is further characterized by its high biodiversity and structural complexity (Fig. 1; Artharamas 1984). The lake is valuable not only as a habitat for important resident and migrating bird populations, but also for the livelihoods of local communities living around the lake, who benefit from the diverse ecosystem services such as, provision of clean water, and as source of revenue coming from fisheries and ecotourism (Office of Environmental Policy and Planning 2000).

Sample collection and treatment. In order to collect both fixosessile as well as free-floating colonial rotifers, we collected samples consisting of fragments of fifteen selected aquatic plants (Table 1) as well as some plankton samples. Submerged plant parts were collected qualitatively, rinsed in the field with local, filtered lake water (obtained by filtering water through a 60 µm mesh size plankton net), and placed individually in large plastic bags filled with local, filtered lake water for transport. The plankton samples were collected using a 60 µm mesh size plankton net. Both plant and plankton samples were collected in several sampling stations (Fig. 1) and occasions from March 2009 to March 2010, covering both dry and rainy season. They were transported to the laboratory of Plankton Research Unit, Department of Biology, Faculty of Science, Prince of Songkla University (PSU) immediately after collection, under slightly cool conditions. On arrival in the laboratory, the samples were immediately placed into aquariums, which were placed near a window under daylight and fitted with an air pump. Searching and identifying of sessile rotifers was performed under an Olympus SZ 51 stereomicroscope and CH 30 compound microscope. Abundant photographs of the animals were taken using an Olympus BX 51 compound microscope with DP 12 and DP 71 photographic apparatuses. Any drawings were based on these photographs and on live observations. The trophi were prepared for scanning electron microscopy (SEM) following the method of Segers (1993) and De Smet (1998).

Results and discussion

We identified a total of 44 taxa of sessile rotifers, including thirty-nine fixosessile species and three planktonic colonial species; two *Acyclus* species are predators inhabiting colonies of other Gnesiotrocha (Table 2). This inventory amounts to nearly 40% of the total global diversity of sessile rotifers (Segers 2007; Segers & Shiel 2008), and is the highest number of sessile rotifer taxa ever reported from a single lake (e.g., Edmondson 1940, 1944; Koste 1975).

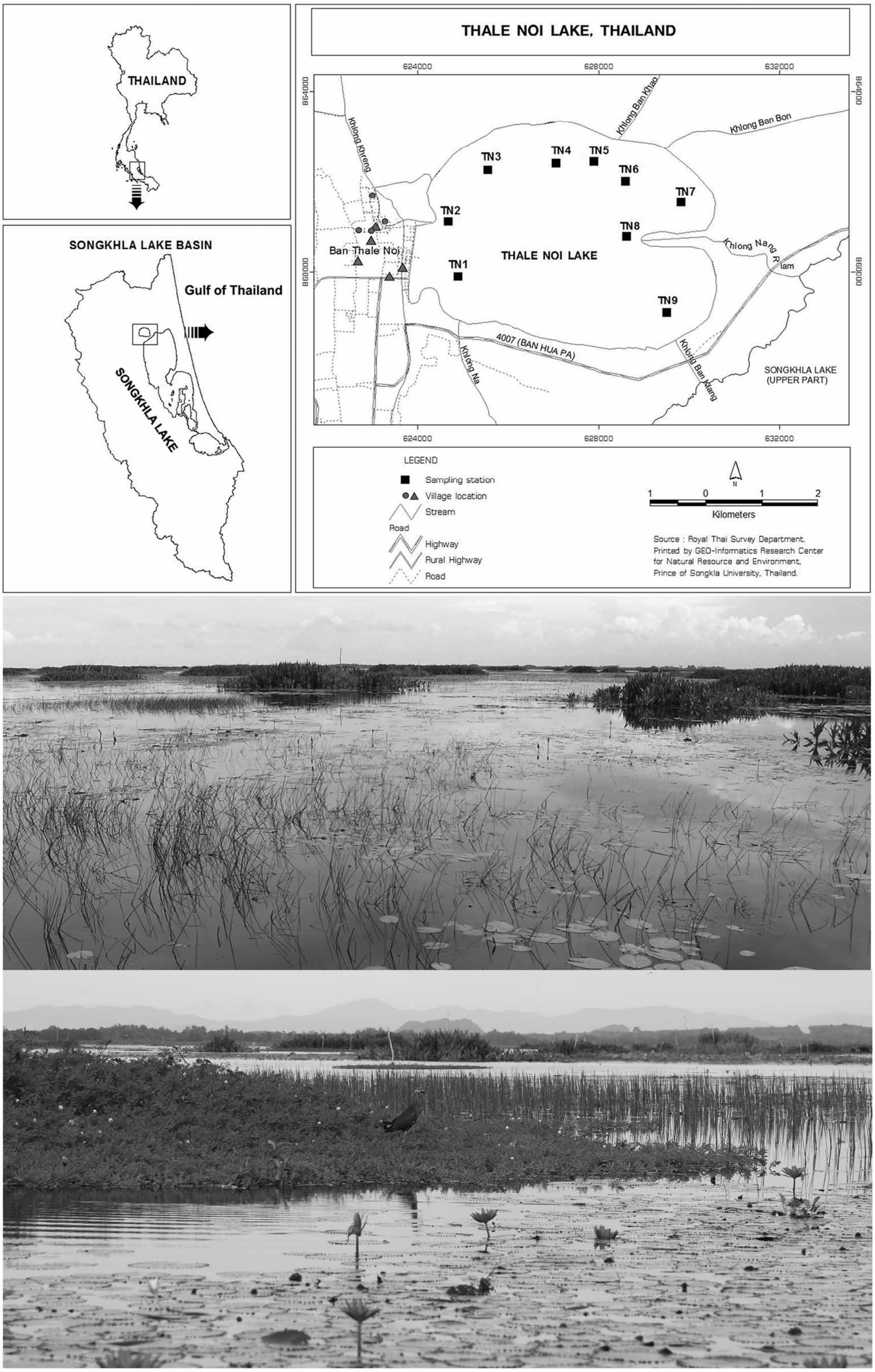


FIGURE 1. Thale Noi Lake, Thailand and the sampling stations (TN1-TN9), and Songkhla Lake (Map courtesy of GIS centre, PSU, Thailand, photographs courtesy of N. Chirapongsathonkul and K. U-taynapun).

TABLE 1. Details of the selected aquatic plant species from Thale Noi Lake.

Habitus	Family	Species name and abbreviation	
Emerged plant	Cyperaceae	1. *Eleocharis ochrostachys* Steud.	EO
	Hanguanaceae	2. *Hanguana malayana* (Jack.) Merr.	HM
	Nelumbonaceae	3. *Nelumbo nucifera* Gaertn.	NN
Floating plant	Mimosaceae	4. *Neptunia oleracea* Lour.	NO
	Onagraceae	5. *Ludwigia adscendens* (L.) H. Hara	LA
	Poaceae	6. *Hygroryza aristata* Nees	HA
	Pontederiaceae	7. *Eichhornia crassipes* (C.Mart.) Solms	EC
	Salviniaceae	8. *Salvinia cucullata* Roxb. ex Bory	SC
Root with floating leaf plant	Menyanthaceae	9. *Nymphoides indicum* (L.) Kuntze	NI
	Nymphaeaceae	10. *Nymphaea lotus* L. var. *pubescens* Hook.f. & Thomson	NL
Submerged plant	Ceratophyllaceae	11. *Ceratophyllum demersum* L.	CD
	Hydrocharitaceae	12. *Hydrilla verticillata* (L.f.) Royle	HV
		13. *Potamogeton malaianus* Miq.	PM
	Lentibulariaceae	14. *Utricularia aurea* Lour.	UA
		15. *Utricularia* sp. [flower purple]	US

TABLE 2. List of sessile rotifers in Thale Noi Lake, Thailand, and their occurrence on selected aquatic plant species (for sessile taxa), or in sampling stations (for planktonic colonial taxa) (* = new to Oriental region and Thailand; ** = new to Thailand; ^{UR} = underrepresented taxa; abbreviations of plant names see Table 1).

Subclass Monogononta
Superorder Gnesiotrocha
Order Collothecaceae
Family Atrochidae
Acyclus inquietus Leidy, 1882**: NO, LA, HA, EC, UA
Acyclus sp.: UA
Family Collothecidae
Collotheca algicola (Hudson, 1886): EC
Collotheca ambigua (Hudson, 1883): NL, UA, US
Collotheca campanulata (Dobie, 1849)**: NO, EC, SC, US
Collotheca campanulata var. *longicaudata* (Hudson, 1883)*: EC
Collotheca heptabrachiata (Schoch, 1869)*: HA
Collotheca ornata (Ehrenberg, 1832)**: NN, NO, LA, HA, EC, NL, UA, US
Collotheca stephanochaeta Edmondson, 1936*: LA, EC
Collotheca tenuilobata (Anderson, 1889)**: HM, NO, LA, HA, EC, SC, UA, US
Collotheca trilobata (Collins, 1872)**: US
Stephanoceros fimbriatus (Goldfusz, 1820)**: NO
Stephanoceros fimbriatus var. *millsii* (Kellicott, 1885)*: HM, LA, UA
Order Flosculariaceae
Family Conochilidae
Conochilus (Conochilus) hippocrepis (Schrank, 1803)**: planktonic colonial species (TN 2)
Family Flosculariidae
Beauchampia crucigera (Dutrochet, 1812): HM, NO, LA, HA, EC, CD, UA
Floscularia armata Segers, 1997**: NO, LA, HA, EC, UA, US
Floscularia bifida Segers, 1997**: HM, NO, LA, EC, CD, HV, UA, US
Floscularia conifera (Hudson, 1886): HM, NN, NO, LA, HA, EC, NL, HV, UA, US
Floscularia pedunculata (Joliet, 1883)*: HM, NN, NO, LA, EC, CD
Floscularia ringens (Linnaeus, 1758): NO, LA, HA, EC
Floscularia wallacei Segers & Shiel, 2008*: HV

continued next page

TABLE 2. (continued)

Lacinularia flosculosa (Muller, 1773)**: HM, NO, LA, HA, EC, HV, UA
Limnias ceratophylli Schrank, 1803: HM, NN, NO, LA, EC, NI, NL, HV, PM, US
Limnias melicerta Weisse, 1848: HM, NN, NO, LA, HA, EC, SC, NI, NL, CD, HV, PM
Octotrocha speciosa Thorpe, 1893**: NO, LA, HA, EC, PM, UA, US
Lacinularoides coloniensis (Colledge, 1918)* **n. gen., n. comb.**: HM, NO, LA, EC, NL, HV, UA
Pentatrocha gigantea Segers & Shiel, 2008**: LA, EC, UA
Ptygura agassizi Edmondson, 1948*[, UR]: EC
Ptygura barbata Edmondson, 1939**: EO, HM, NN, NO, LA, HA, EC, SC, NL, HV, UA, US
Ptygura beauchampi Edmondson, 1940**: UA
Ptygura crystallina (Ehrenberg, 1834)**: NO, LA, HA, EC, HV, UA, US
Ptygura ctenoida Koste & Tobias, 1990*[, UR]: EC, HV
Ptygura elsteri Koste, 1972 [UR]: CD
Ptygura furcillata (Kellicott, 1889) [UR]: CD
Ptygura longicornis (Davis, 1867)*: NO, LA, CD
Ptygura mucicola (Kellicott, 1888) [UR]: NO, HA, EC, CD, US
Ptygura noodti (Koste, 1972)* **comb. nov.**: EC, SC
Ptygura pedunculata Edmondson, 1939**: NO, HA, EC
Ptygura tacita Edmondson, 1940**: NO, LA, HA, EC, UA, US
Ptygura thalenoiensis **n. sp.**: NO, HA, EC, HV, US
Ptygura wilsonii (Anderson & Shephard, 1892)*: EC
Sinantherina semibullata (Thorpe, 1893): planktonic colonial species (TN 2, 3, 5, 6)
Sinantherina socialis (Linnaeus, 1758): NO, LA, HA, EC, CD, HV, UA, US
Sinantherina spinosa (Thorpe, 1893): planktonic colonial species (TN 2, 5, 6)

Taxonomy

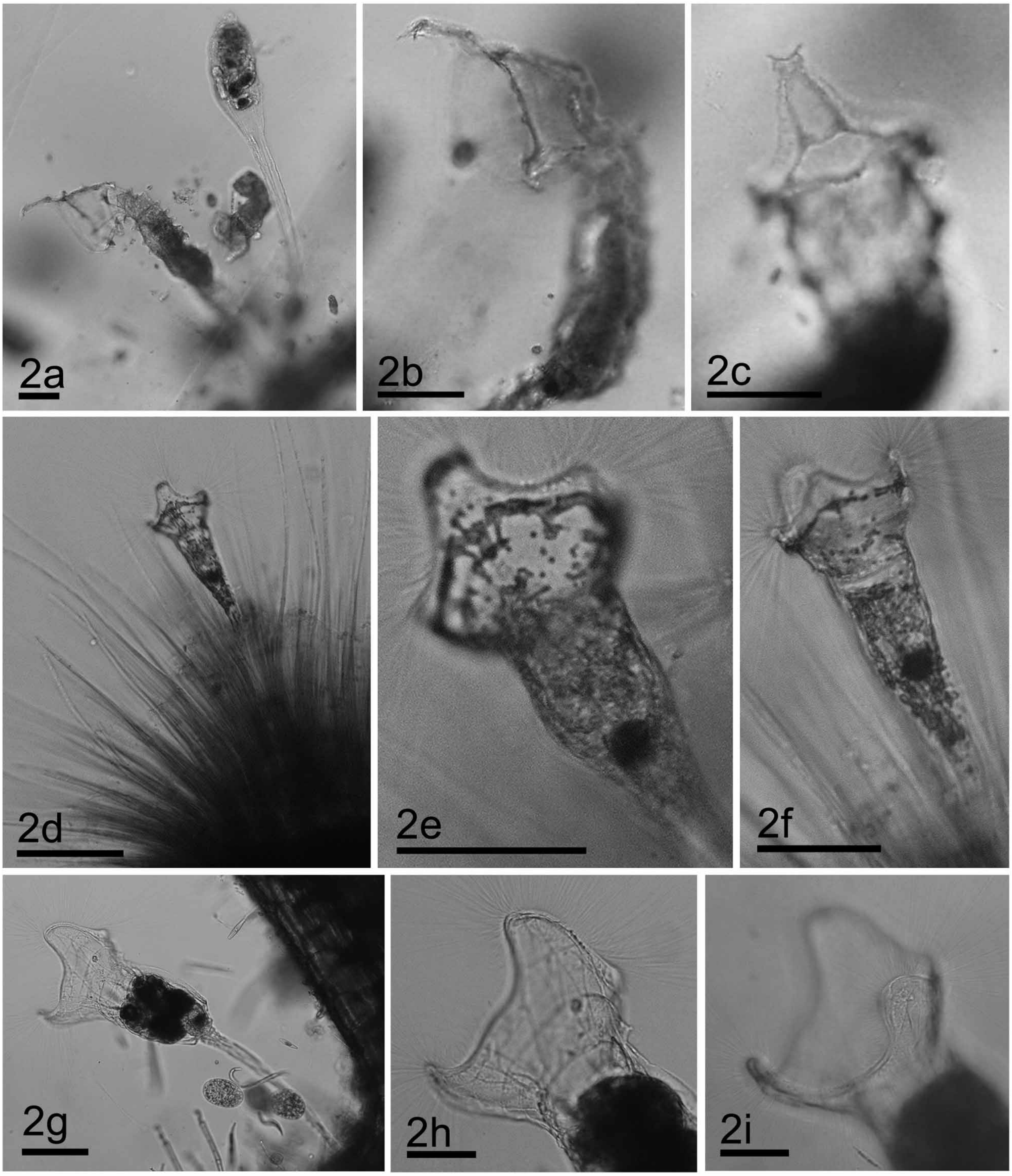
Of the taxa recorded here, one could not be attributed to a known genus, and one new species is described below. Two more, including the *Acyclus* mentioned below, are putative new species that were not encountered in sufficient numbers to warrant a formal description. Notes on these and other species of special taxonomic interest are as follows.

Genus *Acyclus* Leidy, 1882

Acyclus sp.

(Figs 2a–2c)

Although only a single specimen of this taxon was observed, we believe that it may represent an undescribed species. Morphologically, the animal is characterized by a prominent bifid anterior margin of dorsal corona lobe (Fig. 2c) which is reminiscent of *Atrochus tentaculatus* Wierzejski, 1893, the sister taxon of *Acyclus*. The single known species of *Acyclus, A. inquietus* Leidy, also occurs in Thale Noi Lake but is easily distinguished by a rounded anterior margin of dorsal corona lobe. Moreover, the specimen of *Acyclus* sp. was observed predating on a colony of *Lacinularia flosculosa* (Müller), whereas all of the specimens of *Acyclus inquietus* we observed were found in association with colonies of *Sinantherina socialis* (Linnaeus). *Acyclus inquietus* feeds on eggs and larvae of *S. socialis* whereas *Acyclus* sp. was seen to predate on adult specimens of *L. flosculosa;* the *Acyclus* sp. takes up a *Lacinularia* in its vestibulum, sucks out its content of its victim and finally releases the remains, an empty trunk and foot.



FIGURES 2A–2I. *Acyclus* sp.; *Collotheca* spp. 2a–2c: *Acyclus* sp.; 2d–2f: *Collotheca algicola* (Hudson, 1886); 2g–2i: *Collotheca ambigua* (Hudson, 1883). Scale bars: 2a–2c, 2d, 2g = 100 µm; 2e–2f, 2h–2i = 50 µm.

Genus *Collotheca* Harring, 1913

Collotheca algicola (Hudson) (Figs 2d–2f) and *Collotheca ambigua* (Hudson) (Figs 2g–2i)

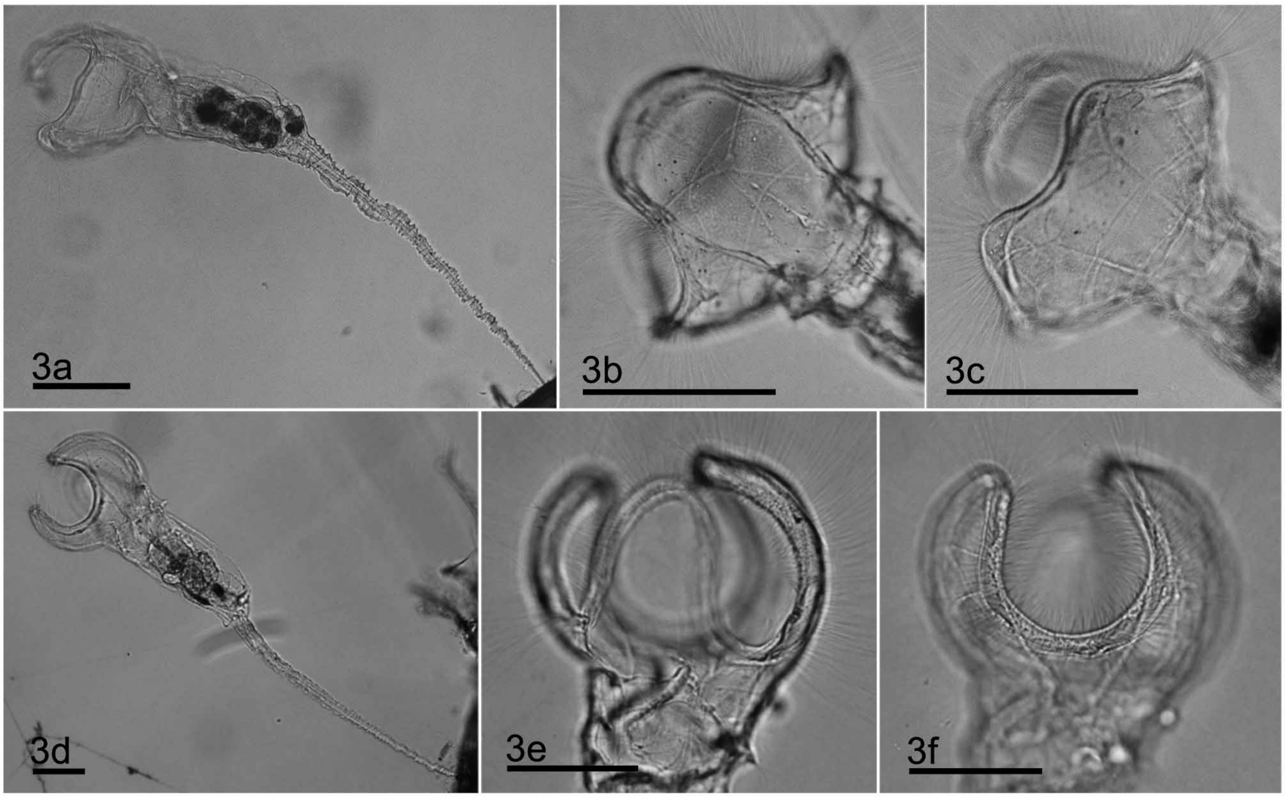
We tentatively consider these two taxa as separate species, even though the most recent checklist of the group considers *C. algicola* (Hudson) a synonym of *C. ambigua* (Hudson) (Segers 2007). Our material matches well the original description of both species (Hudson & Gosse 1886). We found three morphological characters that distinguish the two (Table 3):

- the dorso-lateral corona lobes are more prominent in *C. algicola* than in *C. ambigua*
- the separation between foot and trunk is more pronounced in *C. ambigua* than in *C. algicola*;
- they differ significantly in size, with *C. ambigua* being the larger of the two.

TABLE 3. Comparison of diagnostic features of four species of *Collotheca* (after Koste, 1978)

Species Characters	*C. algicola* (Hudson)	*C. ambigua* (Hudson)	*C. campanulata* (Dobie)	*C. trilobata* (Collins)
Corona lobes	Five	Five	Five	Three
Dorsal corona lobe	Gradually narrow onto the tip end	Gradually narrow onto the tip end	Rather parallel with rounded tip	Rather parallel with rounded tip
Dorso-lateral corona lobes	Prominent	Small	Rather prominent	Completely lacking
Corona ventral lobe sinus	Rather deep	Rather deep	Rather shallow	Very deep
Separation between foot and trunk	Less distinct	Distinct	Distinct	Distinct

That the relatively small *C. algicola* is not a young, immature and therefore not fully grown specimen is indicated by the accumulation of excretophores (Fig. 2e), a phenomenon which is commonly observed in old specimens of many species of *Collotheca*, but not in young ones (Koste 1978). We nevertheless refrain from concluding on the matter as we observed only low numbers of both of the taxa concerned. In particular, we found only a single specimen of what we identify as *C. algicola*.



FIGURES 3A–3F. *Collotheca* spp. 3a–c: *Collotheca campanulata* (Dobie, 1849); 3d–3f: *Collotheca trilobata* (Collins, 1872). Scale bars: 3a–3f = 100 µm.

Collotheca ambigua could also be confused with *C. campanulata* (Dobie) (Figs 3a–3c) or *C. trilobata* (Collins) (Figs 3d–3f). However, they can be distinguished from *C. campanulata* by having a deeper and wider sinus separating the ventral corona lobes (compare Fig. 2i and 3c), and by shape of its relatively narrower dorsal corona (compare Figs 2h–2i and 3b–3c). *C. ambigua* can further be separated from *C. trilobata* by having small dorso-lateral corona lobes (absent in *C. trilobata*) and relatively small ventro-lateral corona lobes when compared to *C. trilobata* (compare Figs 2h–2i and 3e–3f; see also Table 3).

Genus *Lacinularoides*, new genus

(Figs 4–5)

Type species. *Lacinularoides coloniensis* (Colledge, 1918), new combination

Differential diagnosis. The new genus is characterized by having a corona consisting of five or seven lobes and by the absence of an oviferon (egg-carrying organ). Although the size of the animals and their corona shape both remind one of *Pentatrocha* Segers & Shiel, 2008, they are separated from this genus by the absence of an oviferon and presence of obvious gelatinous matrix formation, and by the coronal lobes being much smaller than in *Pentatrocha*. While *Pentatrocha* has never been observed other than solitary, the single constituent species of *Lacinularoides* is colonial. By lacking an oviferon, which we consider a synapomorphic feature for a [*Pentatrocha, Sinantherina* Bory de St. Vincent, 1826] clade, and by having a corona exhibiting distinct lobes, we surmise that the taxon is closest to *Octotrocha* Thorpe, 1893, which has an even more intricately lobed corona. We further believe the new genus is close to *Lacinularia* Schweigger, 1820, which has a very similar morphology but which has a corona that has, at the most, a ventral concavity giving it a heart-shaped appearance (see Table 4).

Description. Mature female large, foot long, foot peduncle tiny or almost invisible. Corona large, with five prominent and two small lobes: a large pair of ventral lobes separated by a deep ventral sinus; a pair of small or, occasionally, indistinct lateral lobes and three dorsal lobes. Single species known to date, living sessile in small to large colonies, occasionally solitary (first specimen of newly established colony?), inhabiting a clear to light-brown coloured gelatinous case. Trophi malleoramate.

Etymology. The name *Lacinularoides* (gender: masculine) is derived from that of its relative, *Lacinularia*.

Redescription of *Lacinularoides coloniensis* (Colledge, 1918), n. comb. Animal large, transparent, internal organs obvious. Trunk fusiform, tapers gradually into tapering foot, neck region slightly curved dorsally when animal expands the corona. Foot long, with abundant foot glands along upper half part, peduncle tiny. Extended corona large, five- to seven-lobed, consisting of a conspicuous pair of ventral, a pair of occasionally indistinct lateral, and three dorsal lobes. The lobes of the ventral pair are rather round, held perpendicular to the longitudinal axis of the body; the lateral lobes are relatively small and appear to be made up by an S-shaped curve of the lateral corona margins. The dorso-lateral lobes are round but with rather straight latero-dorsal sections, tilted to ca. 60 degrees versus the body axis and slightly bent to ventrad; the middorsal lobe relatively small but distinct, slightly triangular. Ventral lobes separated by a deep, U-shaped sinus, separation of dorsal and especially lateral lobes shallow. Dorsal gap tiny; apical field surface bulged by the large mastax. Small projection bearing the dorsal antenna under the dorsal corona lobe. Lateral antenna on minute conical papillae. Gelatinous matrix clear to light-brown, containing the eggs, if any. Male: see Colledge (1918).

Trophi nearly symmetrical, malleoramate; unci teeth strongly differentiated. Proximal unci teeth on both sides with three strong teeth, the first smallest in size, the first tooth on the left side bigger than on the right; distal unci teeth of both sides weak, relatively few (2–3).

Mature females total length ca. 1,300 µm. Trunk length ca. 460 µm, width ca. 130 µm. Foot length ca. 820 µm. Corona height ca. 380 µm, width ca. 360 µm. Parthenogenetic egg size ca. 160x100 µm.

Remarks. Although we recognize this taxon as representing the genus newly described herein (with the caveat that the diagnosis of genera in Flosculariidae is in urgent need of revision; see comment in Segers & Shiel 2008), the species appears to have been recorded repeatedly before. We accept that the present material is conspecific with the animal described in good detail in 1918 by W. R. Colledge, as *Melicerta coloniensis,* from a “pool at Goodna, Qld” (Colledge, 1925) Australia. The taxon had not been recorded ever since and it appears to have been overlooked. The reason for this may be historical, and lay in confusion between *L. coloniensis* and *Octotrocha speciosa*. We know from the study of W.T. Edmondson’s notebooks that this author, an authority on sessile rotifers, considered both *O. speciosa* and *L. coloniensis* as possible identity of animals before him. We now know that the two can relatively easily be distinguished, even in contracted state, by their trophi morphology, a feature that at that time

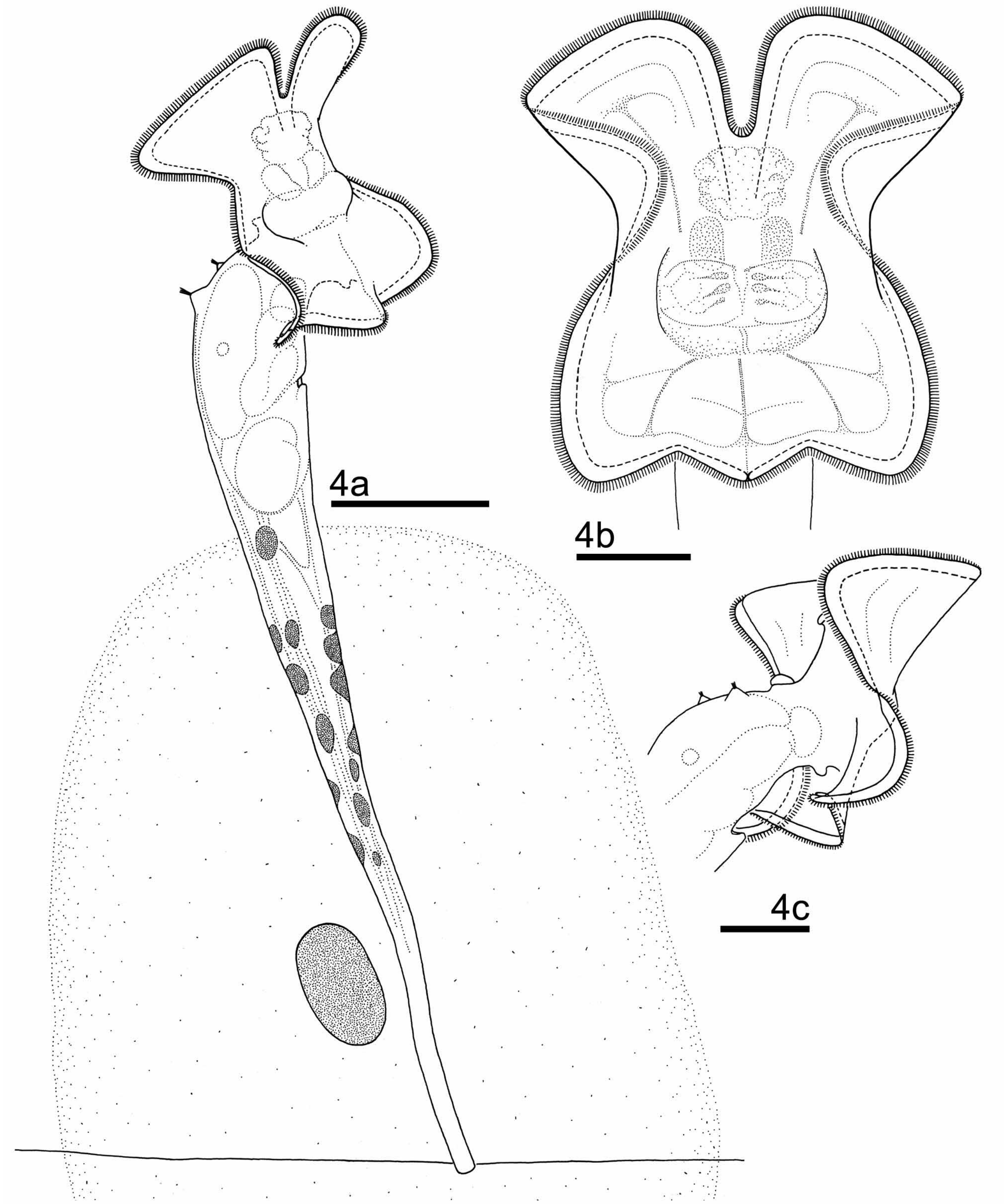


FIGURE 4. *Lacinularoides coloniensis* (Colledge, 1918) **n. comb.** 4a: adult female; 4b: corona, dorsal view, 4c: corona, ventro-lateral view. Scale bars: 4a = 200 µm; 4b–4c = 100 µm.

was hardly considered in identification of sessile rotifers: the differentiation in development of the unci teeth is noticeably stronger in *L. coloniensis* than in *O. speciosa* (compare Figs 5a–c with Fig. 7 in Segers *et al*., 2011). Based on a re-evaluation of published drawings and photographs of trophi morphology, Segers *et al*. (2011) re-evaluated previously published and (partly) illustrated records of *Octotrocha speciosa* Thorpe, 1893 by Edmondson (1959), Koste (1974, 1978, 1989), Sarma & Elias-Gutierrez (1998), and Segers & Shiel (2008) as being

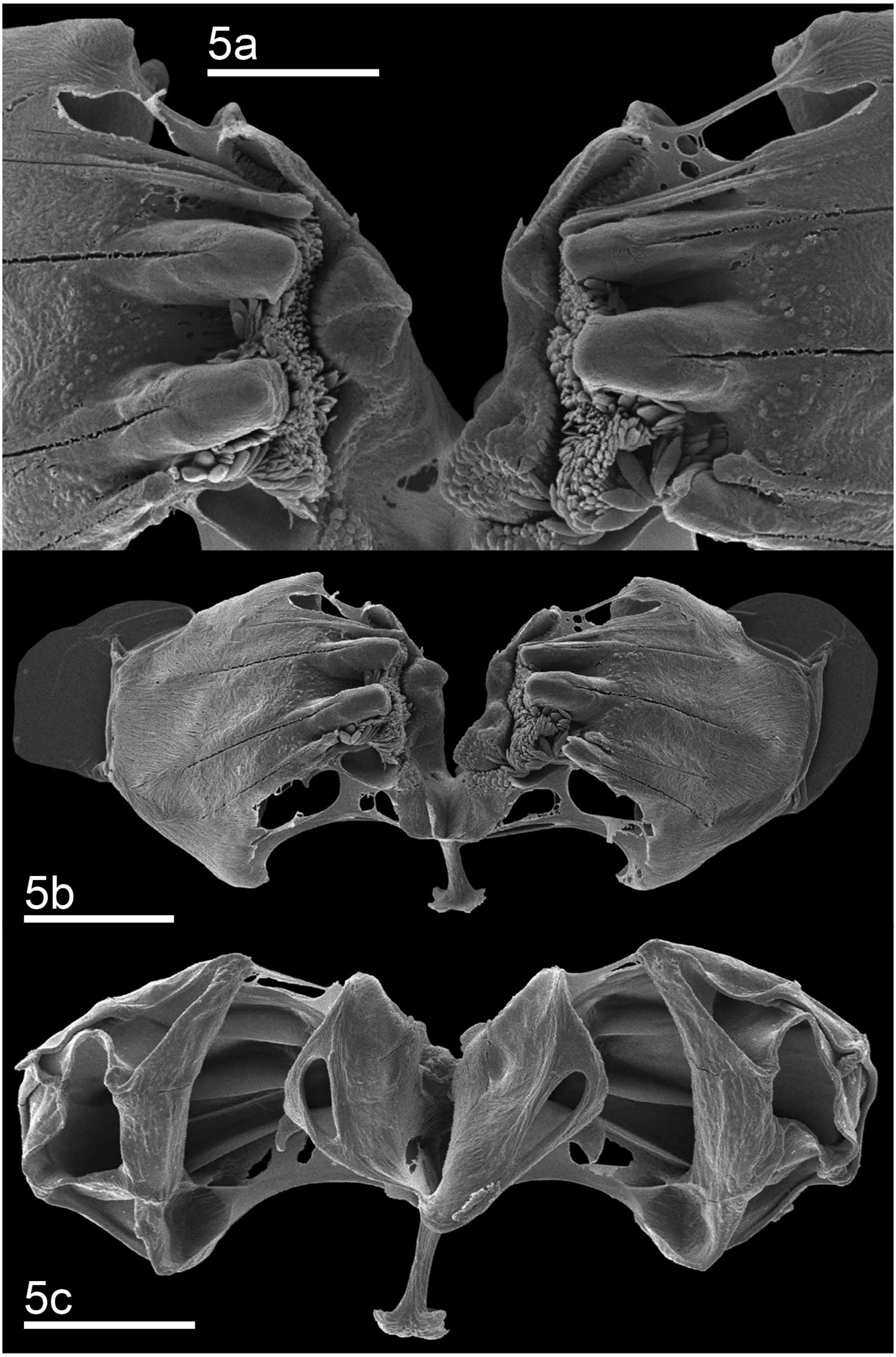


FIGURE 5. Trophi SEM photographs of *Lacinularoides coloniensis* (Colledge, 1918) **n. comb.** 5a: detail, frontal view; 5b: entire trophi, frontal view; 5c: caudal view. Scale bars: 5a = 10 µm; 5b–5c = 20 µm.

TABLE 4. Comparison of nine genera of Family Flosculariidae.

	Beauchampia	*Limnias*	*Floscularia**	*Octotrocha*	*Ptygura**	*Sinantherina*	*Pentatrocha*	*Lacinularia*	*Lacinularoides* **n. gen.**
Corona rounded or lobed	Circular	Two-lobed	Four-lobed; pair of dorsal lobes mostly larger than ventral,	Eight lobes, in complex pattern and position	Circular to kidney-shaped	Kidney-shaped	Two ventral, three dorsal lobes	Heart shaped,	Two ventral, (two intermediate, three dorsal lobes
Dorsal margin of corona	Convex, regular	Concave	Convex, regular	Concave	Convex, regular to weakly concave	Convex, regular	Convex, lobe	Convex, regular	Convex, lobe
Stiff lorica elements in neck region	Present, drawn into elongated tube around dorsal antenna	Present, a flat stiffened structure occasionally bearing protuberances	Present, a pair of variably shaped hook-like projections protecting the dorsal antenna	Absent	Absent or present as variably shaped projection(s) protecting the dorsal antenna	Absent	Absent	Absent	Absent
Modulus, submentum and mentum	Absent	Absent	Absent or present	Absent	Absent	Absent	Absent	Absent	Absent
Oviferon	Absent	Absent	Absent	Absent	Absent	Present	Present	Absent	Absent
Case	hard, thin-walled	hard, thin-walled	Gelatinous, well developed OR composed of round elements	Gelatinous, welldeveloped	Gelatinous, mostly well developed	Gelatinous, poorly developed	Absent	Gelatinous, well developed	Gelatinous, well developed
Life mode	Attached, forms pseudocolonies	Attached, form s pseudocolonies	Attached, solitary or forming pseudocolonies	Attached, solitary	Attached or free-living, solitary or (pseudo)colonial	Attached or free-living colonies	Attached, Solitary	Attached or free-living colonies	Attached, colonial

Pseudocolonies: inter-or intraspecific groups of individuals consisting of an occasionally haphazard accumulation of specimens that arises from free-swimming larvae settling in each others vicinity or near or on the case of a central (maternal?) specimen (Type 1 of Wallace, 1987).

Colonies: coherent groups of individuals living in a common gelatinous matrix and sometimes attached to a common stalk, formed by larvae settling immediately into their parent colony (without free-swimming stage), by splitting of a colony, or by aggregation of larvae, (Type 2 of Wallace, 1987).

*Suspected paraphyletic taxa. In *Flosculiaria* the *F. melicerta* and *F. ringens* group only share their four-lobed corona, while the presence of a modulus (specialisation of the region ventrally and caudally of the mouth producing round elements used in the construction of the tube) is autapomorphic to the latter group; In *Ptygura* the *P. melicerta* group is characterised by a relatively small corona and presence of a stiffened tegumental plate antero-dorsally, whereas other species have an expanded corona supported by rods and lack a stiff tegumental plate. Also, the resting eggs of *P. melicerta* do not have the longitudinal ridges typical of most Flosculariacea and other *Ptygura* (for those species in which the feature is documented) and coloniality is distinctly present in the *P. melicerta* group, whereas most other *Ptygura* are solitary or occur in pseudocolonies.

misidentified, and with the information we now have available we suggest that these records all pertain to *L. coloniensis*. This would imply that, whereas both species co-occur in Southeast Asia and China, *L. coloniensis* is much more widespread and may be the only one of the two that occurs in Australia and the Americas. This precludes direct comparison of the two by zoologists working outside the area of *O. speciosa*, including W.T. Edmondson.

Based on the present considerations, we now are quite sure that the glass model of a small colony of sessile rotifers identified as *O. speciosa* Thorpe, on exhibit in the American Museum of Natural History (see Fig. 1.1. in Wallace *et al*. 2006) and whose identity had already been questioned by Segers & Shiel (2008), represents *L. coloniensis*. Similarly, as our observations confirm *Octotrocha speciosa* as a solitary animal, we assume that the autorecruitive nature of colony formation of *O. speciosa* as reported by Wallace *et al.* (2006) refers to *L. coloniensis*. Indeed, a photograph kindly supplied by R.L. Wallace of the animals he studied indeed appears to depict *L. coloniensis.*

Genus *Ptygura* Ehrenberg, 1832

Ptygura thalenoiensis new species

(Figs 6–7)

Synonym*: Ptygura* sp. near *linguata* Edmondson, 1939 *after* Segers *et al*., 2011 (Figs 9–12)

Type material. Holotype female (PSUZC-PK5PM001-01) was deposited in Princess Maha Chakri Sirindhorn Natural History Museum, Prince of Songkla University, Songkhla, Thailand; two paratype females deposited in RBINS, BRUSSELS, GI 31863 RIR 202-203.

Type locality. Thale Noi Lake, Phatthalung province, Thailand: 7º 45’ 44’’ N to 7º 48’ 26’’ N and longitude 100º 7’ 31’’ E to 100º 11’ 12’’ E, June 2009 through April 2010.

Differential diagnosis. The new species belongs to a group of congeners that are diagnosed by having elongate lateral antenna. Amongst those, *P. thalenoiensis* **n. sp.** is distinguished by the presence of a pair of apical hooks in addition to a tongue-shaped projection in between those, and of an autapomorphic ciliated projection in its mouth region.

Description. Body well separated from the elongate, retractible foot, terminating in a medium to long peduncle. Corona elliptic, twice as wide as trunk; dorsal gap minute; corona supported by relatively strong rods. Buccal area with distinct short and cylindrical projection bearing a group of elongate cilia terminally. Neck region distinct, with two sharp dorsal hooks lateral to a tongue-shaped projection, this projection protruding beyond, but less rigid than the hooks. Lateral antenna long and slender. Tube gelatinous, containing fine perpendicular lines of material radiating from the inside of the tube. Fine layers radiated from inner sheath; light to medium brown; inner sheath obvious, quite parallel along tube to. Male unkown.

Trophi nearly symmetrical, malleoramate. Unci left and right 17 teeth, these weakly differentiated into a proximal group containing 3 slightly stronger teeth and a distal group of weaker teeth (3–4 teeth); second tooth in the left group of proximal teeth small. Teeth in the distal group interdigitating with rami scleropilli (visible most in the left group). Fulcrum short, with a weakly developed basal plate.

Measurements. Females total length ca. 700 µm. Trunk length ca. 150–230 µm, width ca. 40–50 µm. Foot length ca. 200–450 µm. Foot stalk length ca. 15–60 µm. Corona height ca. 90 µm, width ca. 140 µm, width/height ratio ca. 1.6. Lateral antenna length ca. 80 µm.

Etymology. The species name *thalenoiensis* is an adjective, derived from the type locality of the species.

Distribution. In addition to the type locality, the new species is known from Cambodia (sub. *Ptygura* cf. *linguata,* Segers *et al.,* 2011). Apparently, it is endemic to Southeast Asia.

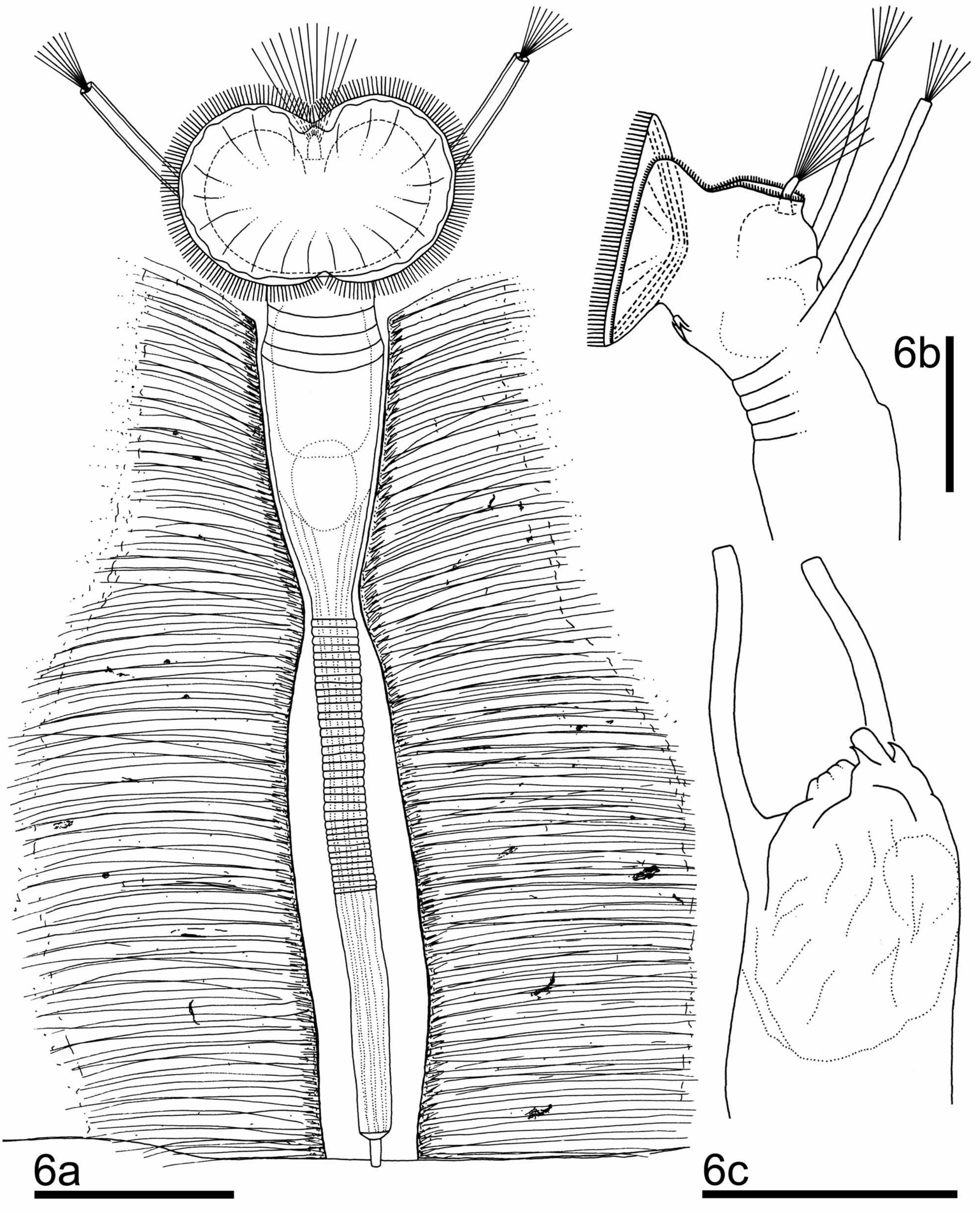


FIGURE 6. *Ptygura thalenoiensis* **n. sp.** 6a: adult female; 6b: apical region, showing the mouth and ciliated cylindrical process; 6c: contracted specimen, apical region, showing the dorsal hooks. Scale bars: 6a = 100 µm; 6b, 6c = 50 µm.

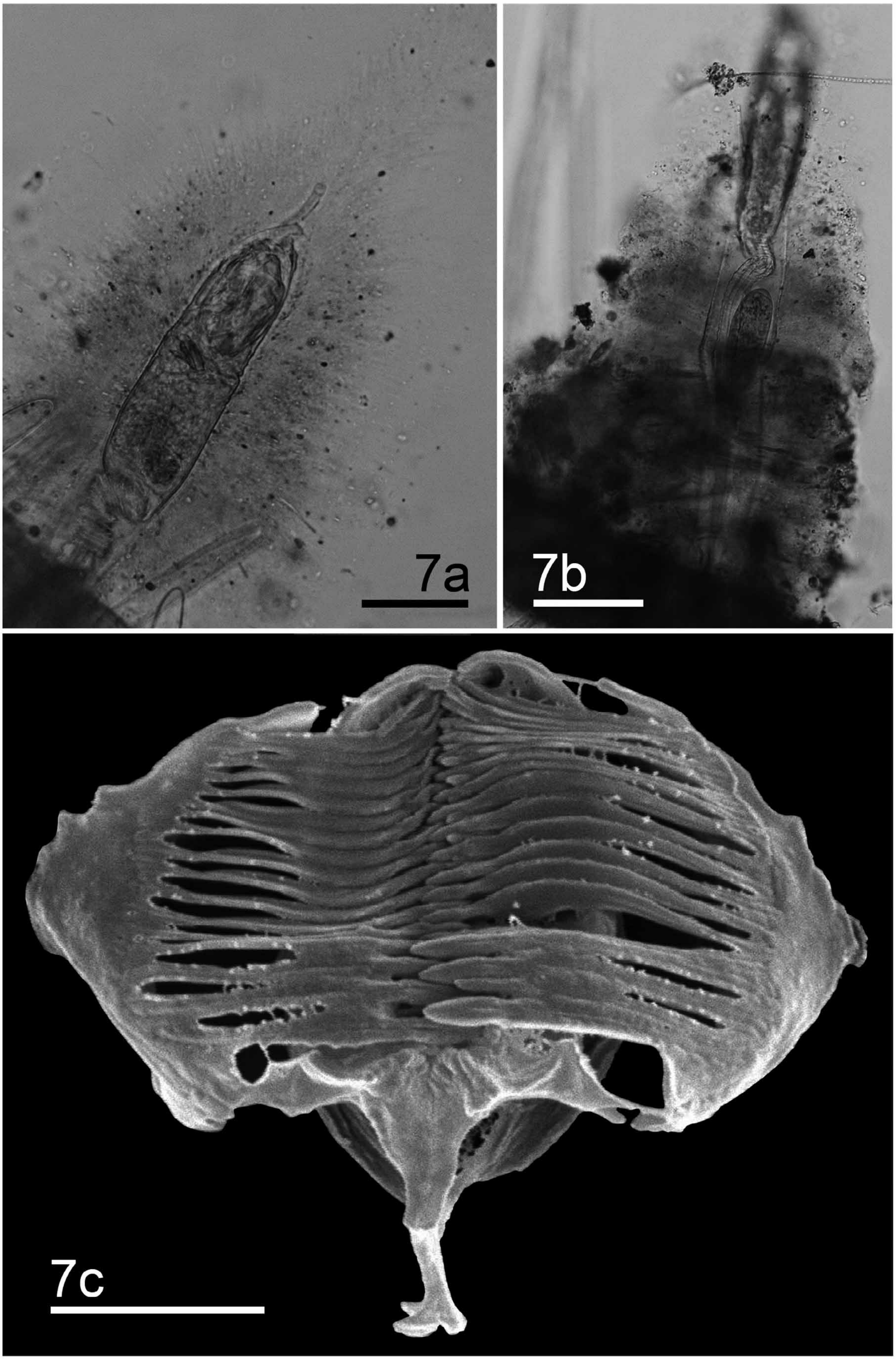


FIGURE 7. *Ptygura thalenoiensis* **n. sp.** 7a, 7b: tube structure in different specimens, 7c: Trophi SEM photograph, frontal view. Scale bars: 7a, 7b = 100 µm, 7c = 5 µm.

Ptygura noodti (Koste, 1972) new combination
(Figs 8–9)

Synonym: *Floscularia noodti* Koste, 1972: 534–540

Comments. We identified our material as being conspecific with *Floscularia noodti* Koste, 1972 based on complete concordance of the tube and of the morphology of the contracted body and trophi of the specimens with Koste's (1972) description, notwithstanding the incompleteness of the original description. Our examination of living specimens reveals that this species does not belong to *Floscularia* Cuvier, 1798 but, rather, to *Ptygura* Ehrenberg, 1832. Indeed, the corona of the species is bilobed and more or less elliptical, as in *Ptygura*, not four-lobed as in *Floscularia.* Koste (1972) based his description of the species exclusively on preserved, contracted material, and allocated the animal to *Floscularia* based on a superficial similarity of the tube it inhabits with that of species of the *F. ringens* group, in particular, *F. janus*. The generic assignment of the specimens we observed is unequivocal, given the present generic diagnosis in family Flosculariidae. Actually, its tube morphology is not unique in *Ptygura:* also *Ptygura pilula* (Cubitt, 1872) inhabits a tube constructed of loose pellets of mucus and detritus, albeit that in the latter species these pellets are round, not elongate.

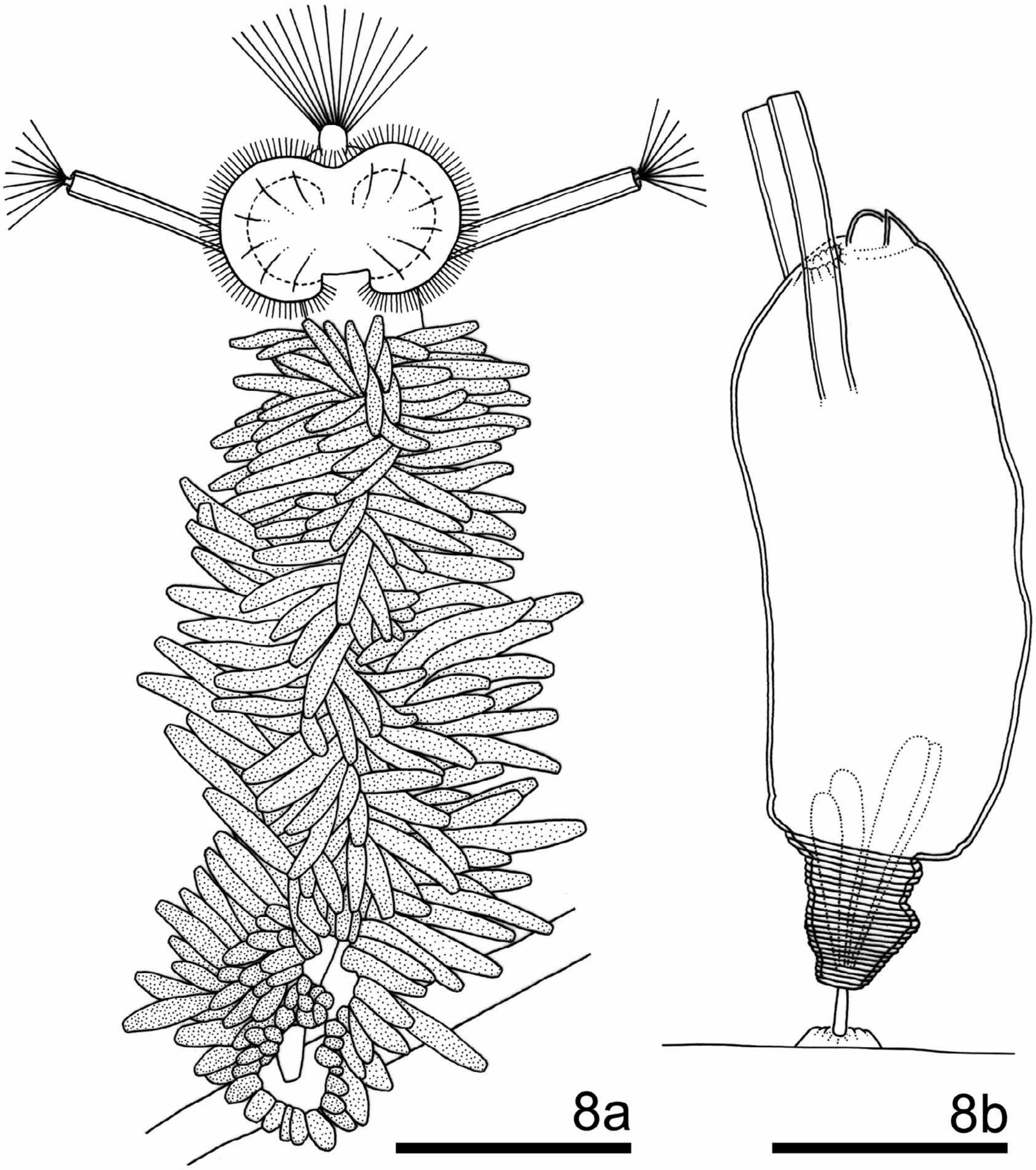


FIGURE 8. *Ptygura noodti* (Koste, 1972) **n. comb.** 8a: adult female; 8b: contracted specimen, apical region showing the dorsal projections. Scale bars: 8a = 100 µm; 8b = 50 µm.

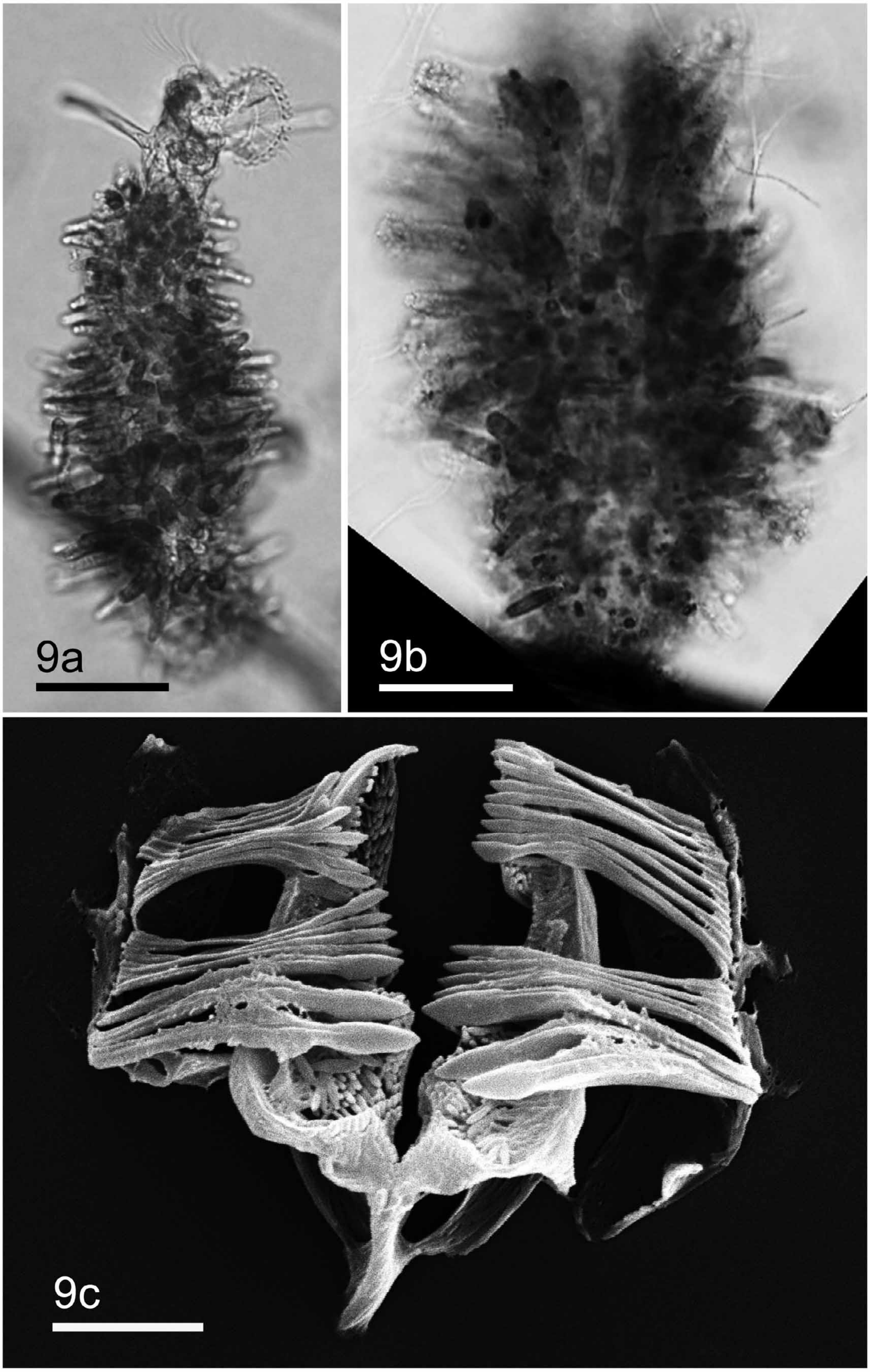


FIGURE 9. *Ptygura noodti* (Koste, 1972) **n. comb.**: 9a–9b: tube structure in different specimens; 9c: Trophi SEM photograph, frontal view. Scale bars: 9a–9b = 100 µm; 9c = 5 µm.

Redescription. Body fusiform. Foot clearly separated from trunk, foot peduncle short. Corona distinctly bilobed, ventral sinus distinct, dorsal gap wide, width about 1/5 of corona width. Buccal area with distinct rounded projection near the ventral margin, bearing a cluster of fairly long relatively stiff cilia, these are moved up and down nervously. A single dorsal projection protecting the dorsal antenna ("Nackenhäckchen" of Koste 1972, 1978) present; this projection is composed of two fairly equal, adjacent elements: a ventral, spherical one and a smaller, blunt-triangular dorsal one. Lateral antenna long and slender. Tube consist of elongate, rather ill-defined lumps of strongly elongated gelatinous material in which some detritus material is embedded; these are arranged horizontally, radiating outward from the central cavity inhabited by the animal. Trophi malleoramate, symmetrical. Three proximal unci teeth on both sides slightly reinforced; left – right 18–16 unci teeth in total.

Measurements. Female total height ca. 410 µm. Trunk length ca. 130–150 µm, width ca. 60 µm. Foot stalk length ca. 13 µm. Corona height ca. 75–90 µm, width ca. 100–150 µm. Length of buccal setae cluster ca. 55 µm. Length of lateral antenna ca. 75–100 µm. Tube length ca. 250–370 µm.

Biogeography and ecology

Of all the sessile and colonial rotifers registered, two, one of which is described here, appear to belong to unknown species, ten are new to the Oriental region, and twenty-seven are new to Thailand (compare with Boonsom 1984; Chittapun *et al*. 2007; Koste 1975; Sanoamuang 1998, 2007; Segers 2007; Segers *et al*. 2004). Apart of the new species, which are treated as local endemics until proof to the contrary, *Octotrocha speciosa* is a regional Southeast Asian – Chinese endemic, and *Pentatrocha gigantea* and *Floscularia wallacei* are Australian and Southeast Asian. A suite of species (*Floscularia armata*, *F. bifida*, *Ptygura noodti*, *P. elsteri*) are known from tropical South America and Southeast Asia. We interpret this as potentially representing a tropical fauna element, considering the dearth of information on the sessile and colonial rotifer fauna of tropical Africa. Some more taxa exhibit peculiar, disjunct distributions (e.g., *P. agassizi*) but this probably indicates lack of knowledge rather than being factual. On the other hand, most of the taxa on record are widespread. So, although our results illustrate that a lot remains to be discovered of these peculiar micrometazoans, the fauna record concurs with the moderate endemicity model of Foissner (2006) and Chao *et al*. (2006), rather than with the ubiquity model of Finlay (2002) and Fenchel & Finlay (2004), by combining both endemic elements as well as cosmopolitan ones (Segers 2008; Segers & De Smet 2008).

All of the aquatic plant species investigated potentially serve a substratum for sessile rotifers (Table 1, 2). *Ptygura beauchampi* Edmondson was found in high numbers, but was observed only on *Utricularia aurea* Lour., which confirms Wallace's (1978) observations of a specific preference of the rotifer with this plant genus as substratum. No other clear preferences between rotifers and plant species or growth forms could be discerned. We must caution that the occurrence of some small or cryptic species such as *Ptygura agassizi*, *P. ctenoida*, *P. elsteri*, *P. furcillata*, and *P. mucicola* may be underrepresented, as these relatively small species usually inhabit fractures or damaged areas of plants and are easily overlooked during investigation if they remain contracted.

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