

New records of sessile rotifers (Phylum Rotifera: Flosculariacea, Collothecacea) from Southeast Asia

Hendrik Segers¹, Phuripong Meksuwan² & La-orsri Sanoamuang³

¹ Royal Belgian Institute of Natural Sciences, Brussels, Belgium. E-mail: Hendrik.Segers@naturalsciences.be

² Plankton Research Unit, Prince of Songkla University, Hat Yai, Thailand. E-mail: puripongbio@hotmail.com

³ Applied Taxonomic Research Center, Khon Kaen University, Khon Kaen, Thailand. E-mail: La_orsri@kku.ac.th

Corresponding author: Hendrik.Segers@naturalsciences.be

ABSTRACT. Recognizing the dearth of information on the biodiversity and biogeography of Southeast Asian micrometazoa, particularly sessile rotifers, we examined two samples of submerged aquatic macrophytes (*Hydrilla verticillata* (L.f.) Royle and *Utricularia* sp.) from different sites in Cambodia. We were able to distinguish a total of 23 taxa, three of which may represent undescribed species. Two more taxa could not unequivocally be ascribed to a known species. We further comment on the distribution of *Octotrocha speciosa* Thorpe, which may be much less widespread than previously thought.

In addition to the three possibly new species, nine are newly recorded for the Oriental region; of these, two are recorded for the second time ever. All represent new records for the fauna of Cambodia. Our results illustrate the need for more detailed and thorough taxonomic and faunistic studies on this group of poorly known organisms.

KEY WORDS: freshwater, diversity, biogeography, Cambodia, epiphyton

INTRODUCTION

Sessile rotifers, which belong to only two families (Collothecidae and Flosculariidae) of Class Gnesiotrocha, Monogononta, are a particularly interesting and attractive group of organisms. They are interesting because they exhibit a wide range of evolutionary adaptations, from solitary to fully colonial with task division between different individuals, and from fixosessile to permanently pelagic, conditions that, apparently evolved in parallel multiple times (WALLACE, 1980; 1987). They are attractive because of their relatively large size and static behavior, which makes them relatively easy objects to study when alive, and their beauty, which gave one of the taxa concerned its name, *Floscularia* or flower animals, referring to its lobed corona resembling flower petals. These features have led early microscopists, starting with VAN LEEUWENHOEK (1703, cited by HUDSON & GOSSE, 1886; and these authors themselves), to study and brilliantly illustrate many such animals. Recently, however, they are receiving much less attention. In particular, hardly anything is known about the Southeast Asian fauna of sessile rotifers, apart from the comprehensive taxonomic and faunistic report by KOSTE (1975), and the same is true for most tropical regions.

Of all Southeast Asian countries, Cambodia has one of the least well-documented rotifer faunas (SEGERS, 2001). The sole relevant paper is by BERZINS (1973), who describes *Anchitestudinella mekongensis* and *Filinia camasecla cambodgensis*, and the same author mentions some Cambodian material in taxonomic revisions of the *Keratella valga* group (BERZINS, 1955) and *Anuraeopsis* (BERZINS, 1962). Finally, MIZUNO & MORI (1970) include a few Cambodian records of rotifers in the results of their survey, and we welcome the recent contribution by MEAS

& SANOAMUANG (2010). None of these authors, however, mentions any sessile rotifers.

Considering this lack of information, we took the opportunity to study a limited number of samples of sessile rotifers when the occasion arose to visit Cambodia during early 2010. We believe that the results of this examination, as preliminary as they may be, are sufficiently significant to be formally presented here, especially as they draw attention to an almost completely overlooked taxon in which much remains to be discovered.

MATERIALS AND METHODS

During a short visit to Cambodia from January 30th to February 1st, 2010, we collected samples of submerged macrophytes in two different localities. The first sample consists of a fragment of *Hydrilla verticillata* (L.f.) Royle, collected on January 31st, from the historical pond Sra Srang, in the Ankhor temple complex region near Siem Reap (N 13° 25' 51.7", E 103° 54' 44.4", water temperature 29°C, DO 2.9mg.L⁻¹, pH 8.1, Cond. 6.0µS.cm⁻¹); the second is a strand of *Utricularia* sp., collected February 1st, from the swampy edge of a reservoir near Trapang, along the road from Seam Reap to the Phusing border crossing with Thailand (N 14° 14' 05.5", E 104° 05' 0.30", water temperature 30°C, DO 1.2mg.L⁻¹, pH 7.6, Cond. 16.0µS.cm⁻¹). Plants were kept in sufficiently large containers to avoid crowding during transport and examination in the days following collection. The samples were examined at the Applied Taxonomic Research Center of Khon Kaen University. Small plant fragments were first examined using an Olympus SZ-PT dissecting microscope, and fragments onto which epi-

phytic rotifers had attached were transferred to an Olympus BX51 compound microscope equipped with an image capturing device for detailed examination of their external and trophi morphology. Apart from a limited number of permanent preparations of trophi, no material was deposited due to the difficulty, and, at times, impossibility of obtaining specimens that, in preserved condition, are useful for subsequent morphological study. Identification of the material was done using the works by EDMONDSON (1949) and KOSTE (1978), and papers as indicated below; nomenclature and taxonomy follow SEGERS (2007).

RESULTS

The material reported here consists of the epiphytic rotifers living on two species of submerged macrophyte, *Hydrilla verticillata* (L.f.) Royle, and *Utricularia* sp. (Table 1: “H” and “U”, respectively). The number of species observed in the *Hydrilla* and *Utricularia* samples is similar (13 and 14 species, respectively), but only five species are shared. On the *Hydrilla*, rotifers were almost exclusively present on the underside of leaves, and, in many cases (e.g., *Floscularia armata* Segers, 1997) and *Limnias ceratophylli* Schrank, 1803) present as pseudocolonies of up to 5 (*F. armata*) or 20 (*L. ceratophylli*) individuals. On *Utricularia*, rotifers appeared on all parts of the plants, but the most abundant species were concentrated on the *Utricularia* traps, with *Ptygura beauchampi* (Edmondson, 1940) and *P. melicerta* Ehrenberg, 1832 var. *socialis* Weber, 1888 in mixed groups on the trap doors, and individual *Floscularia bifida* Segers, 1997 and *P. crystallina* (Ehrenberg, 1834) on the traps proper.

A total of 23 taxa were observed (Table 1). Of these nine are new records for the Oriental region, while two are being recorded for the second time ever. All are new records for the Cambodian fauna, a result of this fauna being notoriously understudied, as mentioned above.

DISCUSSION

Of the 23 taxa of epiphytic rotifer observed, five could not be positively identified. Three of these may represent undescribed species, and two more belong to a probable species complex (*B. cf. crucigera*) or could not be reliably identified. We refrain from formally describing and naming these species here, as we feel more observations are needed. However, we do present some remarks on their taxonomy and biogeography as follows:

Beauchampia cf. crucigera (Dutrochet, 1812) – (Figs 1-2) The Cambodian specimens have the autapomorphic and diagnostic feature of prolonged and stiff dorsal antenna of genus *Beauchampia*, however, the length of this dorsal antenna is relatively short when compared to literature records. Only DONNER (1954) records a specimen with a similarly short antenna, but that case concerns a young specimen, as can be judged from the very short tube it inhabits (less than trunk length). The Cambodian specimens are definitely adults, as they inhabit a well-developed tube containing an egg. The case calls for a review of the taxonomy of this purportedly monospecific, cosmopolitan and eurytopic taxon (KOSTE, 1978).

TABLE 1
List of rotifer taxa recorded

<i>Beauchampia cf. crucigera</i> (Dutrochet, 1812):	H ^{1,6}
<i>Collotheca cf. ambigua</i> (Hudson, 1883):	U ⁶
<i>Collotheca campanulata</i> (Dobie, 1849):	H, U ^{2,6}
<i>Collotheca ornata</i> (Ehrenberg, 1832):	H, U ^{3,6}
<i>Collotheca tenuilobata</i> (Anderson, 1889):	H, U ^{4,6}
<i>Collotheca trilobata</i> (Collins, 1872):	U ⁶
<i>Floscularia armata</i> Segers, 1997:	H ⁶
<i>Floscularia bifida</i> Segers, 1997:	U
<i>Lacinularia elliptica</i> Shephard, 1897:	H ^{3,6}
<i>Lacinularia flosculosa</i> (Müller, 1773):	U ⁶
<i>Limnias ceratophylli</i> Schrank, 1803:	H, U ^{5,6}
<i>Ocotrocha speciosa</i> Thorpe, 1893:	H ⁶
<i>Pentatrocha gigantea</i> Segers & Shiel, 2008:	U
<i>Ptygura barbata</i> Edmondson, 1939:	H
<i>Ptygura beauchampi</i> (Edmondson, 1940):	U
<i>Ptygura crystallina</i> (Ehrenberg, 1834):	H, U
<i>Ptygura melicerta</i> Ehrenberg, 1832 var. <i>socialis</i> Weber, 1888:	U ⁶
<i>Ptygura</i> sp. near <i>linguata</i> Edmondson, 1939:	H
<i>Ptygura</i> sp. near <i>melicerta</i> Ehrenberg, 1832:	H
<i>Ptygura pedunculata</i> Edmondson, 1939:	H ⁶
<i>Ptygura pilula</i> (Cubitt, 1878):	H
<i>Sinantherina socialis</i> (Linnaeus, 1758):	U ^{5,6}
<i>Sinantherina</i> sp. near <i>triglandularis</i> Arora, 1963:	U

¹ recorded from Thailand by KOSTE (1975) and HECKMANN (1979),

² by SANOAMUANG et al. (1995),

³ by HECKMANN (1979),

⁴ by SANOAMUANG & SAVATENALINTON (2001),

⁵ by KOSTE (1975);

⁶ recorded from China (ZHUGE et al., 1998)

H: on *Hydrilla verticillata* (L.f.) Royle, U: on *Utricularia* sp.

Collotheca cf. ambigua (Hudson, 1883) – We observed one specimen that matched the diagnosis of *C. ambigua*. A ring-shaped stiffening on the basis of the foot, diagnostic for the related *C. ferox* Pénard, 1914 was not observed but this may follow from the difficulty of examining living specimens attached to a substratum.

Floscularia bifida Segers, 1997 – The Cambodian material matches the diagnosis of the species in all aspects (e.g., trophi morphology, long attachment stalk), albeit that the shape of the species-specific pair of bifid dorsal hooks differs slightly from previously described material. This feature is, however, quite variable in the related *F. armata*, which was also observed during this survey and, more recently, from Thuy Tien Lake, Hue city, Vietnam (7 March 2010). The present records are the second and third ever of the species, after its description from South America (Brazil: SEGERS, 1997).

Ocotrocha speciosa Thorpe, 1893 – (Figs 3-7). Several specimens of this remarkable species were found attached to *Hydrilla*. When comparing the material with published records of the species, we noted that its trophi morphology matches the original description by THORPE (1893), but is at variance with all subsequent illustrated records, including EDMONDSON (1959), KOSTE (1974; 1978; 1989), SARMA & ELIAS-GUTIEREZ (1998), and SEGERS & SHIEL (2008). In particular, the differentiation of

the unci teeth of the *O. speciosa* we identified here is much less pronounced than reported in these sources. In addition, the corona of the present material again matches the description by THORPE (1893), but differs from that of the material seen by the senior author (SEGERS & SHIEL, 2008) in having more numerous and more developed corona loops. We at present believe that the species reported by the recent authors cited above, as well as that identified as *O. speciosa* by Myers (see JERSABEK et al., 2003) belong to a different species. This would explain how EDMONDSON (1959) and KOSTE (1989) came to question the accuracy of THORPE'S (1893) original description. *Octotrocha speciosa*, as recognized here, is known to us from China (THORPE, 1893), and was seen in abundance, but always solitary, in a lake in Southern Thailand (Thale Noi Lake, Phatthalung province, Southern Thailand: P. MEKSUWAN, unpublished) and Vietnam (Thuy Tien Lake, near Hue City, Central Vietnam, January 2009 and March 2010: H. SEGERS, unpublished), and also Cambodia. These observations may imply that the species is restricted to China and Southeast Asia, rather than being widespread (KOSTE, 1978).

Pentatrocha gigantea Segers & Shiel, 2008 – (Fig. 8). We observed several specimens of this unmistakable but only recently described species. The present record expands the known range of the species beyond its type locality in Australia (SEGERS & SHIEL, 2008) and into the Oriental region.

Ptygura sp. near *linguata* Edmondson, 1939 – (Figs 9-12). At first glance, the species belongs to the *P. brachiata* (HUDSON & GOSSE, 1886) group, by its elongate lateral antennae and by the presence of a pair of sharp dorsal hooks. The presence of a tongue-shaped process in its buccal region places it closest to *P. linguata* Edmondson, 1939. However, the different corona, buccal process carrying a group of long, immobile cilia, variable peduncle and of the dorsal antenna being situated on a rather prominent, rounded rise anterior and between the dorsal hooks, distinguishes it from that species. It could also be mistaken for *P. brachiata*, on account of the relatively strong rods supporting the corona. The latter species has a short peduncle, and lacks a process in the buccal region (see Table 2) (note: EDMONDSON'S (1944) "*P. longicornis* var. *bispicata*" is not implied here as there exists no formal description of the taxon). We at present consider the material to belong to a possibly undescribed species of the *P. brachiata* group, closest to *P. linguata*.

Ptygura sp. near *melicerta* Ehrenberg, 1832 – A single specimen of this species had installed itself in the mucous tube of an *Octotrocha speciosa*. The animal clearly belongs to the *P. melicerta* complex, by its relatively small corona (only ca. 1.5 times the width of the trunk) and presence of diagnostic dorsal spines. However, the latter are unlike any of the known members of the complex (see KOSTE, 1978): in the present animal, there is a pair of quite minute spines, which have a low basis and are pointed dorsally rather than ventrally as in *P. melicerta*. In addition, it has a particularly long foot (ca. 4-5 times the trunk length). Again, we are unable to iden-

tify this animal as any described species. The taxonomy of the *P. melicerta* complex is particularly confused, especially, the status of the taxa that are presently considered as of infrasubspecific rank, and is in need of revision (see SEGERS & SHIEL, 2008). Considering this, it is noteworthy that the variety *socialis*, which was also observed in one of the present samples, had, to date not been recorded from the Oriental region.

Sinantherina sp. near *triglandularis* Arora, 1963 – (Figs 13-14). We found a single specimen of a *Sinantherina* that eluded identification. It most closely matches the general shape of *S. triglandularis* by the foot being relatively short, giving the impression as if the ovifer is situated basally, but we were unable to assess the presence of the three pairs of gastric glands that are purportedly diagnostic for the species (ARORA, 1963). In addition, the corona of the Cambodian specimen is much larger than reported for *S. triglandularis*. The basal position of the ovifer is further shared with *S. spinosa* (Thorpe, 1893), but that species has prominent ventral spines, which are absent in our material. We tentatively identify the species as an undescribed one, close to *S. triglandularis*.

TABLE 2

Comparison of *P. brachiata*, *P. linguata* and *P. cf. linguata*.

	<i>P. brachiata</i> *	<i>P. linguata</i> **	<i>P. cf. linguata</i>
Attachment stalk	Present, short	Present, elongated	Present, variable in length (age-dependent?)
Dorsal hooks	Two, hooked	Two, large, with opposed points, containing a pair-shaped gland	Two, sharp, with sizeable projection in between hooks
Corona	Bilobed, with ventral concavity; dorsal gap wider than the ventral; supported by strong rods	Bilobed, dorsal gap narrow, ventral notch deep, wide	Bilobed, dorsal gap narrow, ventral notch much deeper; corona supported by rods
Tube	Gelatinous, incorporating diatom cells (cultured animals!)	Gelatinous, laminated horizontally; dense inner sheath	Gelatinous, laminated horizontally; walls relatively thick
Additional diagnostic features	Lateral antennae with swollen bases	Lateral antennae extremely long; buccal area with cylindrical tongue-like process covered with short cilia; pair of small conical projections in neck region	Buccal area with short, cylindrical process covered with elongate ciliae

* Based on the original description by HUDSON & GOSSE (1886); KOSTE'S (1970, 1978) report does not correspond with HUDSON & GOSSE'S (1886) in several aspects and is therefore not retained as representative for this species.

** After EDMONDSON (1939)

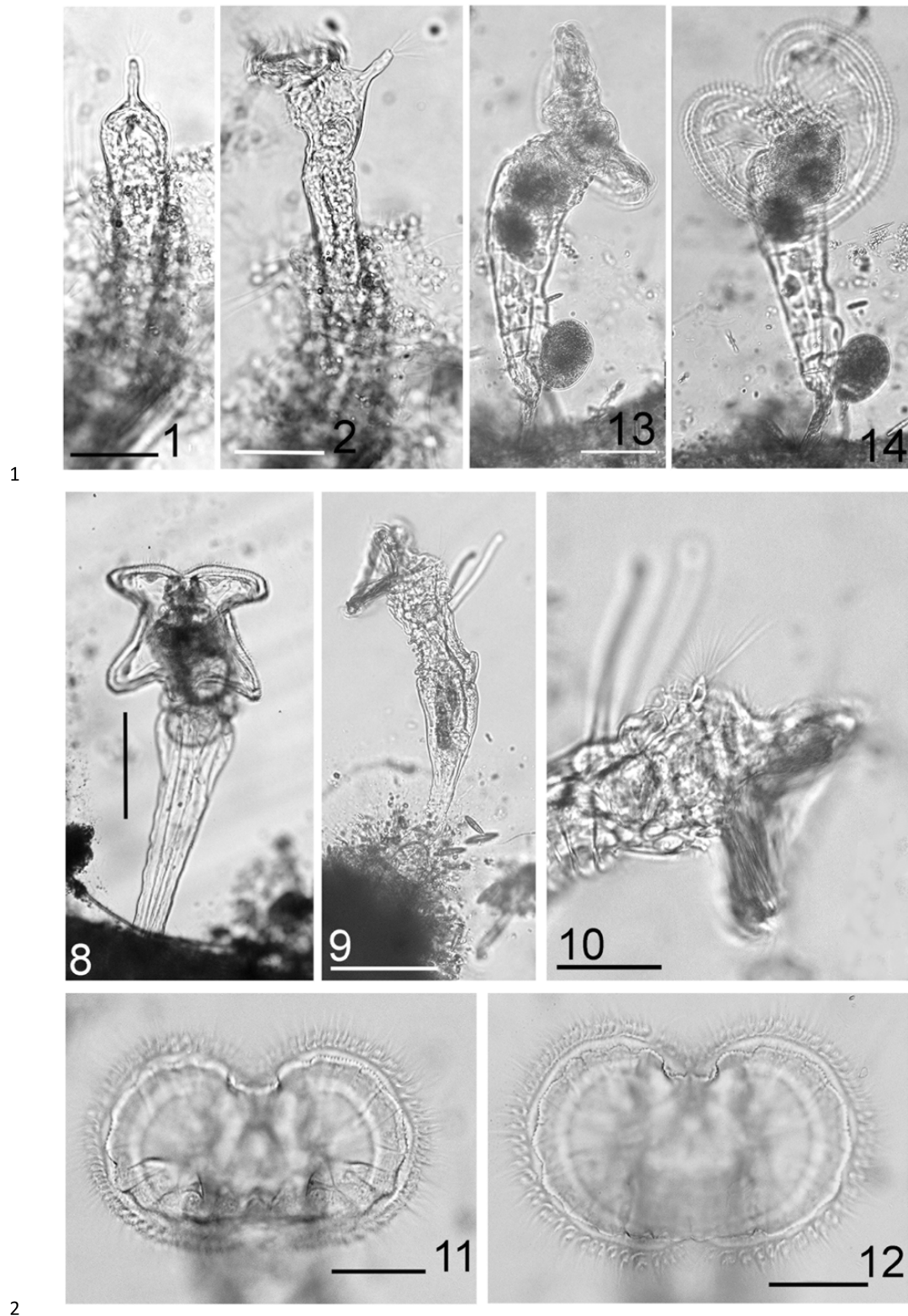
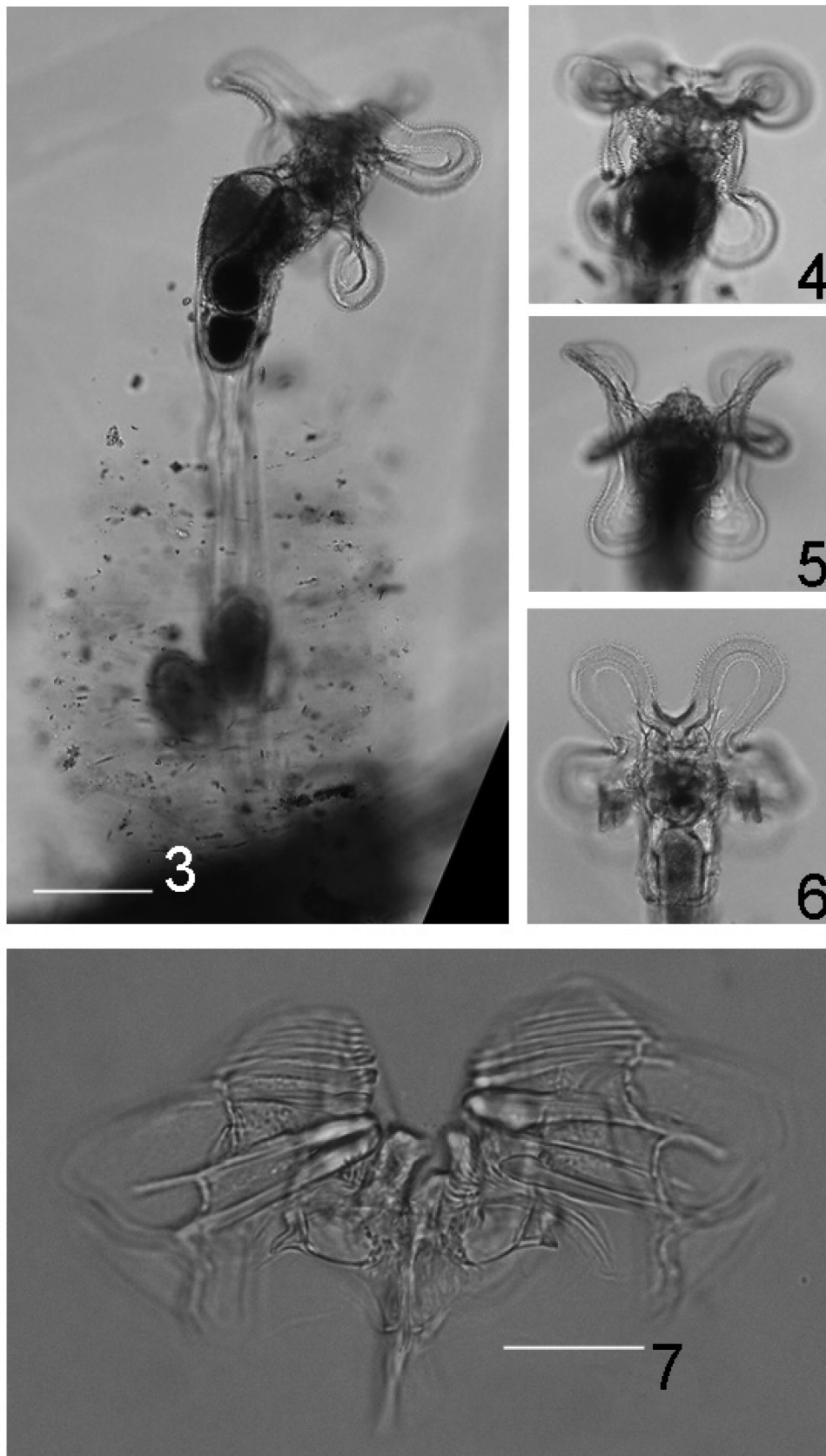


Fig. 1-2. – *Beauchampia cf. crucigera*. 1: ventral view, corona retracted; 2: lateral view, corona extended. Scale bars: 20µm.

Fig. 8. – *Pentatrocha gigantea*, habitus. Scale bar: 250µm.

Fig. 9-12. – *Ptygura sp. near linguata*. 9: habitus, lateral view; 10: head and corona, lateral view (note the ciliated projection in the mouth region); 11, 12: corona, frontal view. Scale bars: 50µm (Fig. 9), 20µm (Figs 10-12).

Fig. 13-14. – *Sinantherina sp. near triglandularis*, habitus. 13: lateral view, 14 dorsal view. Scale bars: 100µm.



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Fig. 3.7 – *Octotrocha speciosa*. 3: habitus, lateral view; 4-6: corona, different views; 7: trophi, frontal view (Thai specimens) Scale bars: 3: 250µm, 7: 20µm.

CONCLUSIONS

As mentioned before, all of the species recorded here are new to the records of Cambodian fauna, and several represent taxonomic novelties. The significance of this is questionable, as this fauna is notoriously understudied. A more meaningful comparison could be made with the much better known Thai fauna, but even so only seven of the species we report here have been recorded from that country (see Table 1). A comparison with the relatively well-known Chinese fauna (ZHUGE et al., 1998) reveals that 11, or nearly half of the taxa in our samples, have not been recorded from China. This once again illustrates the lack of information and comparative data on the diversity and biogeography of the rotifers, and in particular of the sessile ones, of Southeast Asia.

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REFERENCES

- ARORA HC (1963). Studies on Indian Rotifera IV. On some species of sessile Rotifera from India. *Archiv für Hydrobiologie*, 59:502-507.
- BERZINS B (1955). Taxonomie und Verbreitung von *Keratella valga* und verwandten Formen. *Arkiv Zoologie*, 8(7):549-559.
- BERZINS B (1962). Revision der Gattung *Anuraeopsis* Lauterborn (Rot.). *Kungliga fysiografiska Sällskapet i Lund Föreläsningar*, 32:33-47.
- BERZINS B (1973). Some rotifers from Cambodia. *Hydrobiologia*, 41:453-459.
- DONNER J (1954). Zur Rotatorienfauna Südmährens. *Österreichische Zoologische Zeitschrift*, 5(1/2):30-117.
- EDMONDSON WT (1939). New species of Rotatoria, with notes on heterogonic growth. *Transactions of the American Microscopical Society*, 58:459-472.
- EDMONDSON WT (1944). Ecological studies of sessile Rotatoria. Part I. Factors affecting distribution. *Ecology Monographs*, 14:31-66.
- EDMONDSON WT (1949). A formula Key to the Rotatorian genus *Ptygura*. *Transactions of the American Microscopical Society*, 68:127-135.
- EDMONDSON WT (1959). Rotifera. In: WARD & WHIPPLE (eds), *Freshwater Biology*, 2nd ed. Wiley, N.Y.: 420-494.
- HECKMAN CW (1979). Rice field ecology in Northeastern Thailand. The effects of wet and dry seasons on a cultivated aquatic system. In: ILLIES J (ed.), *Rice field ecology*. Junk publishers, The Hague, The Netherlands. *Monographiae biologiae* 34: 113-120.
- HUDSON CT & GOSSE PH (1886). *The Rotifera; or Wheel-animalcules*. London, Longmans, Green & Co.
- JERSABEK CD, SEGERS H & DINGMANN BJ (2003). The Frank J. Myers Rotifera Collection. The whole collection in digital images. The Academy of Natural Sciences of Philadelphia, Special Publication 20.
- KOSTE W (1970). Über die sessilen Rotatorien einer Moorblänke in Nordwestdeutschland. *Archiv für Hydrobiologie*, 68:96-125.
- KOSTE W (1974). Zur Kenntnis der Rotatorienfauna der "schwimmenden Wiese" einer Uferlagune in der Varzea Amazoniens, Brasilien. *Amazoniana*, 5:25-60.
- KOSTE W (1975). Über den Rotatorienbestand einer Mikrobiözönose in einem tropischen aquatischen Saumbiotop, der Eichhornia-crassipes-Zone im Litoral des Bung-Borapet, einem Stausee in Zentralthailand. *Gewässer und Abwässer*, 57/58:43-58.
- KOSTE W (1978). *Rotatoria. Die Rädertiere Mitteleuropas*. Borntraeger, Berlin, Stuttgart.
- KOSTE W (1989). Die sessile Art *Octotrocha speciosa*. *Mikrokosmos*, 78:115-121.
- MEAS S & SANOAMUANG S (2010). New records of rotifer fauna in the Cambodian Mekong River Basin. *Cambodian Journal of Natural History*, 1:48-62.
- MIZUNO T & MORI S (1970). Preliminary hydrobiological survey of some Southeast Asian inland waters. *Biological Journal of the Linnean Society*, 2:77-117.
- SANOAMUANG L & SAVATENALINTON S (2001). The rotifer fauna of Lake Kud-Thing, a shallow lake in Nong Khai Province, northeast Thailand. *Hydrobiologia*, 446/447:297-304.
- SANOAMUANG L, SEGERS H & DUMONT HJ (1995). Additions to the rotifer fauna of South-East Asia: new and rare species from North-East Thailand. *Hydrobiologia*, 313/314:35-45.
- SARMA SSS & ELIAS-GUTIERREZ M (1998). Rotifer diversity in a central Mexican pond. *Hydrobiologia*, 387/388:47-54.
- SEGERS H (1997). Contribution to a revision of *Floscularia* Cuvier, 1798 (Rotifera: Monogononta): notes on some Neotropical taxa. *Hydrobiologia*, 354:165-175.
- SEGERS H (2001). Zoogeography of the Southeast Asian Rotifera. *Hydrobiologia*, 446/447:233-246.
- SEGERS H (2007). Annotated checklist of the rotifers (Phylum Rotifera), with notes on nomenclature, taxonomy and distribution. *Zootaxa*, 1564:1-104.
- SEGERS H & SHIEL RJ (2008). Diversity of cryptic Metazoa in Australian freshwater: a new genus and two new species of sessile rotifer (Rotifera, Monogononta, Gnesiotrocha, Flosculariidae). *Zootaxa*, 1750:19-31.
- THORPE VG (1893). The Rotifera of China. *Journal of the Royal Microscopical Society*, 145-152.
- WALLACE RL (1980). Ecology of sessile rotifers. *Hydrobiologia*, 73:181-193.
- WALLACE RL (1987). Coloniality in the phylum Rotifera. *Hydrobiologia*, 147:141-155.
- ZHUGE Y, HUANG X & KOSTE W (1998). Rotifera recorded from China, 1893-1997, with remarks on their composition and distribution. *International Review of Hydrobiology*, 83:217-232.

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