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Faunal diversity of Cladocera (Crustacea: Branchiopoda) in wetlands of Majuli (the largest river island), Assam, northeast India

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Abstract. Our collections from the wetlands of Majuli, the largest river island of the world and a unique fluvial landform of the Brahmaputra river basin of northeast India, reveal 55 Cladocera species belonging to 36 genera. These represent ~46.0% and ~79.0% of the freshwater species and genera of the taxon known from India, respectively. The Indo-Chinese *Alona kotovi* is new record from India and the Indo-Chinese *Chydorus angustirostris* is new to northeast India. The Australasian *Disperalona caudata*, the Indo-Chinese *Alona cheni*, and the Oriental *Celsinotum macronyx* and *Kurzia* (*Rostrokurzia*) *brevilabris* are other biogeographically notable elements while several species are of regional interest. The speciose and diverse Cladocera reflect habitat diversity and environmental heterogeneity of the sampled ecosystems. The fauna records rich diversity of the littoral-periphytonic taxa in general and the Chydoridae in particular. Majuli Cladocera is characterized by lack of *Leydigiopsis, Daphnia* spp. and *Acroperus harpae*; fewer *Diaphanosoma* spp., and uncommon occurrence of the Bosminidae and Moinidae as compared with our samples elsewhere from the floodplains of the Brahmaputra basin.

Keywords. Biodiversity, Brahmaputra basin, fluvial floodplain, distribution, Cladocera biogeography.

INTRODUCTION

Majuli, the largest river island of the world (Wikipedia) situated in the upper reaches of the river Brahmaputra in Upper Assam, is an interesting landform of fluvial geomorphology and of unique geographical occurrence resulting from the dynamics of this vast river system. This hotspot for flora and fauna and one of the globally important cultural heritage sites is under serious threat of its extinction due to alarming erosion of its landmass. Various wetlands ranging from small *dobas* or *dubies* to large floodplain lakes (*beels*) form an important part of its landscape and socio-economy due to their significant fishery production potential.

This first report on diversity of Cladocera, an integral link in aquatic food-webs, of floodplains of the Majuli River Island merits special biogeography value. It assumes biodiversity interest in light of our hypothesis (Sharma and Sharma 2008, 2012) on the floodplain wetlands of the Brahmaputra river basin as one of the globally rich habitats for aquatic biodiversity due to their habitat diversity and environmental heterogeneity.

Here, we present an inventory of cladoceran species examined from the floodplains of Majuli with comments on the nature and composition of the fauna, occurrence of interesting elements and distribution of different species.

MATERIALS AND METHODS

This study is based on plankton samples collected, during 2010–2012, from 20+ floodplain lakes (*beels*) and 30+ small wetlands (*dobas* or *dubies*) of Majuli River Island (Long.: 93^0–95^0 E, Lat.: 25^0–27^0 N), upper Assam (Fig.1). The beels (area: 10–120 ha; average depth: 0.90–3.0 m) sampled are summarized in Table 1.

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Table 1. Geograpghical data of the beels sampled.

Bhereki Beel*	26°57'09.1''(N)	94°12'23.0''(E)	Altitude 67 m ASL
Chela Beel*	27° 04'58.2''(N)	94° 17'51.9''(E)	Altitude 89 m ASL
Ghotonga Beel*	27°01'52.7''(N)	94°15'28.7''(E)	Altitude 73 m ASL
Holmari Beel*	26°59'17.3''(N)	94°12'30.6''(E)	Altitude 75 m ASL
Khorkhoria Beel*	26° 56'47.4''(N)	94°12'28.8''(E)	Altitude 74 m ASL
Chakuli Beel*	26°56'40.3''(N)	94°09'01.9''(E)	Altitude 69 m ASL
Baatomaari Beel	26°59'25.9''(N)	94°13'08.0''(E)	Altitude 71 m ASL
Tuni Beel:	26° 58'35.3''(N)	94°15'57.8''(E)	Altitude 67 m ASL
Noldunga Beel	26°58'09.4''(N)	94°03'03.4''(E)	Altitude 74 m ASL
Kakorikata Beel	26°57'19.1''(N)	94°08'35.7''(E)	Altitude 74 m ASL
Bor Beel	27°05'13.2''(N)	94°22'41.8''(E)	Altitude 75 m ASL
Doriya Beel	26°57'27.7''(N)	94°10'02.4''(E)	Altitude 70 m ASL
Dighaliya Beel	26°56'15.5''(N)	94°03'45.7''(E)	Altitude 68 m ASL
Lingri Beel	26°57'02.7''(N)	94°05'05.3''(E)	Altitude 69 m ASL
Jur Beel:	26°59'45.3''(N)	94°14'34.4''(E)	Altitude 71 m ASL
Puronibaari Beel	26°59'23.7''(N)	94°11'16.8''(E)	Altitude 96 m ASL
Chereki Beel	26°58'25.4''(N)	94°10'38.7''(E)	Altitude 67 m ASL
Gukhai Beel	26°57'07.0''(N)	94°09'04.2''(E)	Altitude 70 m ASL
Baalichapori Beel	26°55'42.0''(N)	94°02'44.7''(E)	Altitude 75 m ASL
Mohorichuk Beel	26°55'40.4''(N)	94°01'47.7''(E)	Altitude 89 m ASL
Dubori Beel	26°57'01.9''(N)	94°16'13.8''(E)	Altitude 70 m ASL
Karatipar Beel:	26°56'39.4''(N)	94°04'13.5''(E)	Altitude 74 m ASL

* Sampled monthly between August 2010–July 2011 while other *dobas* or *dubies* (area: 0.5 ha–1.20 ha; average depth: 0.70–1.5m) are sampled randomly during winter (December/January), pre-monsoon (March–May), monsoon (June–August) and post-monsoon (September–October) between August 2010–July 2012.

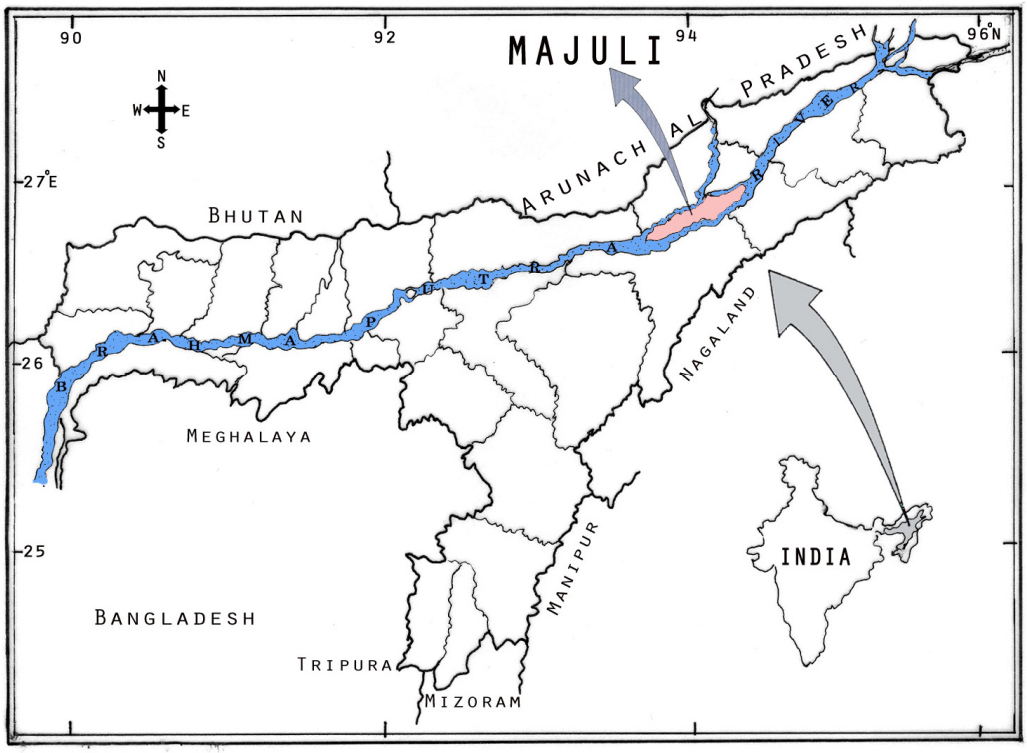

Figure 1. District map of Assam state indicating location of Majuli River Island (insert Map of India indicating Assam state of northeast India)

The sampled beels possessed different aquatic macrophytes' compositions consisting of such species as *Eichhornia crassipes, Hyrdrilla verticellata, Utricularia flexuosa, Trapa natans, Lemna major, L. minor, Pistia striates, Salvinia* sp.*, Nymphaea* spp.*, Nymphoides* spp.*, Potamageton* spp.*, Azolla pinnata, Euryale ferox,* and *Sagittaria* sp.

The collections were made from the littoral and semi-limnetic / limnetic regions of different ecosystems by towing plankton net (# 50 µm) and were preserved in 5% formalin. All the samples (~250) were screened with a Wild-stereoscopic binocular microscope, various cladocerans and their disarticulated appendages were mounted in Polyvinyl alcohol-lactophenol mixture, and observed with a Leica (DM 1000) stereoscopic phase contrast microscope fitted with an image analyzer. Cladocera species were identified following the works of Smirnov (1971, 1976, 1992, 1996)**,** Michael & Sharma (1988), Korovchinsky (1992), Sharma & Sharma (1999, 2008), Orlova-Bienkowskaja (2001) and Korinek (2002). The reference collections are deposited in the holdings of Freshwater Biology Laboratory, Department of Zoology, North-Eastern Hill University, Shillong.

RESULTS

We examined 55 species belonging to 36 genera and seven families in our collections from Majuli River Island and their detailed systematic list is presented below:

Systematic list of the examined Cladocera

Super-class: **Crustacea**
Class: Branchiopoda
Super-order: Cladocera (*sensu strictu*)
Order: Ctenopoda
Family: Sididae

1. *Diaphanosoma excisum* Sars, 1885
2. *D. sarsi* Richard, 1895
3. *D. senegal* Gauthier, 1951
4. *Pseudosida szalayi* (Daday, 1898)
5. *Sarsilatona serricaudata* (Sars, 1901)
6. *Sida crystallina* (O. F. Muller, 1776)

Order: Anomopoda
Family: Daphniidae

7. *Ceriodaphnia cornuta* Sars, 1885
8. *Scapholeberis kingi* Sars, 1901
9. *Simocephalus (Echinocaudus) acutirostratus* (King, 1853)
10. *S.* (*Echinocaudus*) *exspinosus* (De Geer, 1778)
11. *S.* (*Coronocephalus*) *serrulatus* (Koch, 1841)
12. *S.* (*Simocephalus*) *mixtus* Sars, 1903

Family: Bosminidae

13. *Bosmina longirostris* (O. F. Muller, 1776) s. lato
14. *Bosminopsis deitersi* Richard, 1895

Family: Moinidae

15. *Moina micrura* Kurz, 1874
16. *Moinodaphnia macleayi* (King, 1853)

Family: Macrothricidae

17. *Macrothrix laticornis* (Fischer, 1857)
18. *M. spinosa* King, 1853
19. *M. triserialis* (Brady, 1886)
20. *Guernella raphaelis* Richard, 1892
21. *Grimaldina brazzai* Richard, 1892

Family: Ilyocryptidae

22. *Ilyocryptus spinifer* Herrick, 1882

Family: Chydoridae
Subfamily: Chydorinae

23. *Alonella* (*Alonella*) *clathratula* Sars, 1886
24. *A.* (*Alonella*) *excisa* (Fischer, 1854)
25. *Chydorus angustirostris* Frey, 1987
26. *C. reticulatus* Daday, 1898
27. *C. sphaericus* (O. F. Muller, 1776) s.lat
28. *C. ventricosus* Daday, 1898
29. *Dadaya macrops* (Daday, 1898)
30. *Disperalona caudata* Smirnov, 1996
31. *Dunhevedia crassa* King, 1853
32. *D. serrata* Daday, 1898
33. *Ephemeroporus barroisi* (Richard, 1894)
34. *Picripleuroxus laevis* Sars, 1862
35. *P. similis* Vavra, 1900
36. *Pseudochydorus globosus* (Baird, 1843)

Subfamily: Aloninae

37. *Alona affinis* (Leydig, 1860) s.lat
38. *A. cheni* Sinev, 1999
39. *A. guttata tuberculata* Kurz, 1875
40. *A. kotovi* Sinev, 2012
41. *Anthalona harti* Van Damme et al. 2011
42. *Celsinotum macronyx* (Daday, 1898)
43. *Coronatella monacantha* (Sars, 1901) s.lat.
44. *C. rectangula* (Sars, 1862) s.lat
45. *Camptocercus uncinatus* Smirnov, 1973
46. *Euryalona orientalis* (Daday, 1898)
47. *Graptoleberis testudinaria* (Fischer, 1854)
48. *Karualona karua* (King, 1853)
49. *Kurzia* (*Kurzia*) *latissima* Kurz, 1874
50. *K.* (*Rostrokurzia*) *brevilabris* Rajapaksa & Fernando,1986
51. *K.* (*Rostrokurzia*) *longirostris* (Daday, 1898)
52. *Leberis diphanus* (King, 1853)
53. *Leydigia acanthocercoides* (Fischer, 1854)
54. *Notoalona globulosa* (Daday, 1898)
55. *Oxyurella singalensis* (Daday, 1898)

REMARKS AND DISCUSSION

Fifty-five Cladocera species observed in our collections from Majuli reveal speciose nature of their assemblage. The richness represents ~46.0% of the faunal diversity of Indian freshwater Cladocera (BKS unpublished) though Chatterjee *et al.* (2013) listed 130 freshwater species including certain records yet warranting confirmation. Further, these form ~77.0% of species of these micro-crustaceans examined from Assam (BKS unpublished). Though based on sampling from limited geographical area of this island, our report merits biodiversity value in view of a conservative estimate of occurrence of up to 60 – 65 cladoceran species from tropical and subtropical parts of India (Fernando & Kanduru 1984, Sharma & Michael 1987). This report broadly corresponds with 58 and 56 species recorded from fairly well studied cladoceran faunas of Meghalaya (Sharma & Sharma 1999, Sharma 2008) and West Bengal (Venkataraman 1999) respectively; the richness is higher than 49 species listed from Tripura (Venkataraman & Das 2000) while incomplete species inventories from other states of India facilitate no such comparisons. We also register rich higher-taxa diversity (36 genera and seven families); the former form about ~79.0% of the freshwater genera of the group known from India (BKS unpublished) and the latter include all families represented from northeast India. The species-rich and diverse Cladocera reflect habitat diversity and environmental heterogeneity of the wetlands of this interesting River Island. Besides, our study supports the hypothesis of Sharma & Sharma (2008, 2013) on the floodplains of the Brahmaputra basin to be Cladocera rich habitats.

The species richness compares well with 56 species examined from various floodplain lakes (*beels*) of Assam (Sharma & Sharma 2008) and with 58 species observed from Deepor Beel, a Ramsar site and a biodiversity hot-spot (Sharma & Sharma 2013). On the other hand, the number of species examined from Majuli is distinctly higher than the record of 14 species from 37 floodplain lakes (Sarma 2000) of Assam; 9 species from 65 wetlands of 24-Parganas district (Nandi *et al.* 1993) as well as 36 species from 20 wetlands of Southeastern West Bengal (Khan 2003); 39 species from 30 wetlands of the Keoladeo National Park, Rajasthan (Venkataraman 1992) and 29 species from 25 water bodies of Melaghat Tiger reserve, Maharashtra (Rane 2005).

This study also presents a distinct contrast to the reports of five species from a wetland (Yousuf *et al.* 1986) and eleven species from two floodplain lakes (Khan 1987) of Kashmir; one (Baruah *et al.* 1993), four (Sinha *et al.* 1994) and 12 species (Sanjer & Sharma 1995) from a floodplain lake of Bihar; and only three species from Mori Beel (Goswami & Goswami 2001) of Assam. We caution against over-emphasis on comparisons with poor richness of several Indian studies because of inadequate sampling or incomplete species inventories due to lack of adequate taxonomic expertise.

Alona kotovi Sinev, 2012 (Figs. 2–3), described from South Vietnam, is an interesting addition to the Indian Cladocera. It forms a notable example of connection between South American and Australasian faunas of Chydoridae (Sinev 2012) and differs from the other species of *Alona* s. str. (the *quadrangularis*-group) by the morph-

ology of its postabdomen, labrum and thoracic limbs. Our report of *A. kotovi* from northeast India extends its distribution from Vietnam to the Indian subregion. We also propose re-examination of earlier Indian reports of *A. quadrangularis* as *A. kotovi* is likely to occur elsewhere in this country instead of *A. quadrangularis* s. str. particularly in light of pleas for validation of its non-Palaearctic populations (Sinev & Coronel 2006, Van Damme & Dumont 2008) and also its populations from North America, Australia and Tropical Asia, including Indochina (Sinev & Elmoor-Loureiro 2010).

Chydorus angustirostris is a new record from northeast India (Figs. 4–5). Originally described from Madhya Pradesh (Frey 1987) and also examined from Jammu & Kashmir, it is not reported since its description as this publication is overlooked in general cladocera studies from this country. On the other hand, the Indian populations of honeycombed *Chydorus* are invariably confused on general appearance and erroneously identified as *C. faviformis* – a North American species. Following Frey's excellent review of this species-group, identification of our specimens from Majuli as *C. angustirostris* extends the distribution of this endemic taxon to eastern Himalayas. In light of this report, we propose re-examination of all Indian reports of *C. faviformis*. With its recent report from South Vietnam (Sinev & Korovchinsky 2013), this erstwhile Indian endemic is now an Indo-Chinese element.

The Australasian *Disperalona caudata* (Figs. 6–7); the Indo-Chinese *Alona cheni* (Figs. 8–9); the Oriental *Celsinotum macronyx* (Figs. 10–11) and *Kurzia* (*Rostrokurzia*) *brevilabris* (Figs. 12–13) are biogeographically interesting elements. Of these, *D. caudata* is an important link between the Cladocera faunas of northeast India, South East Asia and Australia while the rest endorse affinity of northeast Cladocera with SE Asia. Their presence holds parallel to the reports of several such elements of Rotifera from northeast India (Sharma 2005, Sharma & Sharma 2005, 2013) and thus endorses our earlier remarks (Sharma & Sharma 2008) on the affinities of zooplankton communities of this region of India in general.

The Indo-Chinese *Alona cheni,* a member of *A. costata*-complex was described by Sinev (1999) based on the material examined from Aiwa Reservoir, Ahmedabad (Gujarat). Its occurrence in northeast India is recently confirmed from Deepor Beel (Sharma & Sharma 2013). According to (Sinev 1999), *A. costata* in (sub) tropical Asia seem to actually belong to *A. cheni*, likely a tropical congener failing to occur in temperate regions, while *A. costata* s. str. inhabits all Europe and much of North Asia, reaching East Siberia and central Mongolia in the east, as well as the Caucasus and northern Kazakhstan in the southeast. We endorse Sinev's remarks and thus propose re-examination of all earlier Indian records of *A. costata*.

The Oriental *Alona macronyx* was recorded from northeast India from Meghalaya (Sharma, 2008) and is a recent addition to Assam Cladocera (Sharma & Sharma, 2012). Its first Indian report, however, referred to *Indialona jabalpurensis,* a new species described by Rane (1983) from Madhya Pradesh, which was designated as a synonym (Sharma and Sharma 1990) of *A. macronyx*. We assign our specimens of the taxon to *Celsinotum* following Sinev & Kotov (2012); it is widely distributed in the Oriental zone, inhabiting India and Sri Lanka, Indochina, Indonesia, Philippines, Vietnam and South China. *Kurzia brevilabris*, another Oriental endemic, was described from Sri Lanka (Rajapaksa & Fernando 1986) who also examined its specimens from south India while Hudec (2000) allocated it to the subgenus *Rostrokurzia*. The second Indian report of this interesting chydorid from Deepor Beel (Sharma & Sharma 2012) recently extended is distribution to northeast India.

We follow Van Damme *et al*. (2011) for their revision of status of *Alona verrucosa*-group and identify our specimens from Majuli as *Anthalona harti*. This species is recently reported from India from Deepor Beel (Sharma & Sharma 2013) while all earlier reports of *A. verrucosa*-group from this country need re-examination in view of restricted global distribution of *A. verrucosa s. str.* Our report of *Kurzia latissima* from Majuli

deserves mention; initially considered as a Palaearctic element, it is known from India from by its disjunct populations from Assam, Manipur, Madhya Pradesh, Maharashtra and West Bengal. *Alona monacantha* specimens from Majuli are presently asigned to genus *Coronatella* following Van Damme *et al.* (2010). This species is known from Neotropical, Afrotropical and Oriental zones (Sinev 2004).

We prefer to identify tuberculate morphotypes of *Alona guttata* from Majuli as A *guttata tuberculata* in view of consistent characteristic tubercles in all our populations as well its different distribution than cosmopolitan nominate taxon (Sharma & Sharma 2008). *A. guttata tuberculata* is documented from India from Meghalaya state (Sharma 2008); this report further extends its distribution within northeast India. In addition, *Sarsilatona serricaudata, Simocephalus* (*Echinocaudus*) *acutirostratus, Guernella raphaelis, Grimaldina brazzai, Alonella clathratula, Picripleuroxus laevis, Graptoleberis testudinaria, Leberis diphanus* and *Notoalona globulosa* are examples of regional distribution interest observed in our Majuli collections.

Lack of the Neotropical genus *Leydigiopsis* in Majuli Cladocera is noteworthy in particular as *L. curvirostris*, its sole Indian species, is exclusively observed from floodplains of the Brahmaputra river basin, northeast India (Sharma & Sharma 2007, 2008, 2012). Other interesting departures from Cladocera of the floodplains elsewhere from Assam state include lack of *Daphnia* spp. and *Acroperus harpae*, occurrence of relatively fewer species of *Diaphanosoma,* and uncommon nature of *Grimaldina brazzai, Graptoleberis testudinaria* and members of the families Bosminidae and Moinidae. The first feature is of special interest in light of earlier remarks (Sharma 1991) on much restricted distribution of the Daphniidae in northeast India while Sharma & Sharma (2013) reported on the presence of *D. lumholtzi* and *D. pulex* in Deepor beel – a Ramasar site and an important floodplain lake of this region. This coupled with general paucity of limnetic taxa may be attributed to lack of definite limnetic regions as well as presence of various aquatic macrophytes in the sampled wetlands. The last feature explains occurrence of weed-associated biota in general and member of the family Chydoridae in particular which, in turn, comprise an important fraction (60.0%) of Cladocera richness documented from Majuli.

The common occurrence of the members of Macrothricidae and Sidiidae is also attributed to the prevalence of the littoral-periphytonic conditions. The importance of these three families concurs with the report from inland swamps of Southern Thailand (Van Damme *et al.* 2013). Besides, this study registers common occurrence of *Macrothrix* spp., *Simocephalus mixtus* and *Guernella raphaelis*.

To sum up, the species-rich and diverse nature of Majuli Cladocera indicating environmental heterogeneity of the wetlands of this river islands of the Brahmaputra basin merits biodiversity value. The occurrence of several globally interesting elements adds to our knowledge on Cladocera biogeography. Certain notable differences of their composition than other floodplain communities elsewhere from Assam state as well occurrence of a number of species of regional interest are other interesting aspects of the fauna. In general, this study adds valuable information to the diversity and distribution of Cladocera in the Indian floodplains.

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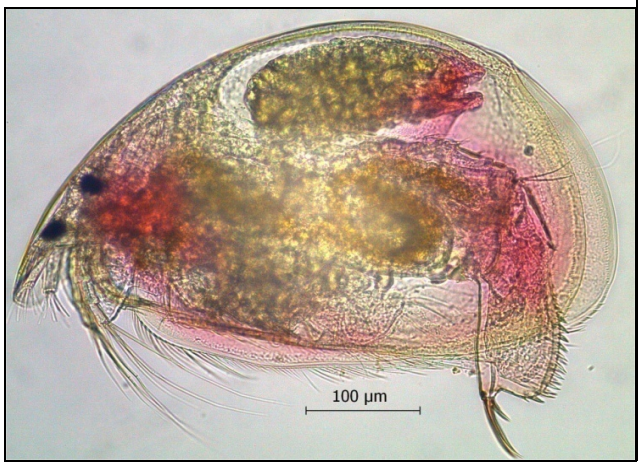

Figure 2. *Alona kotovi* Sinev: parthenogenetic female.

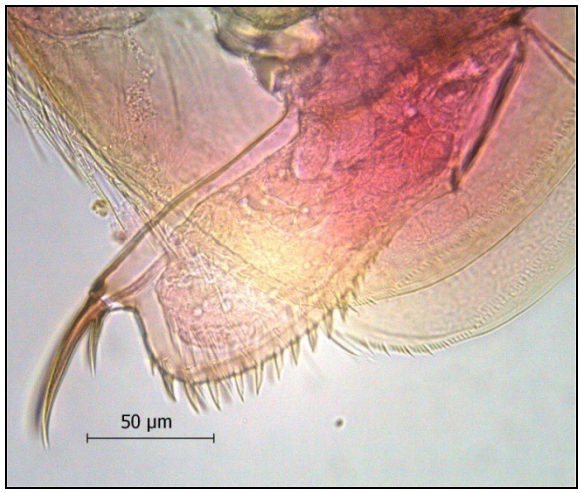

Figure 3. *A. kotovi* Sinev, postabdomen.

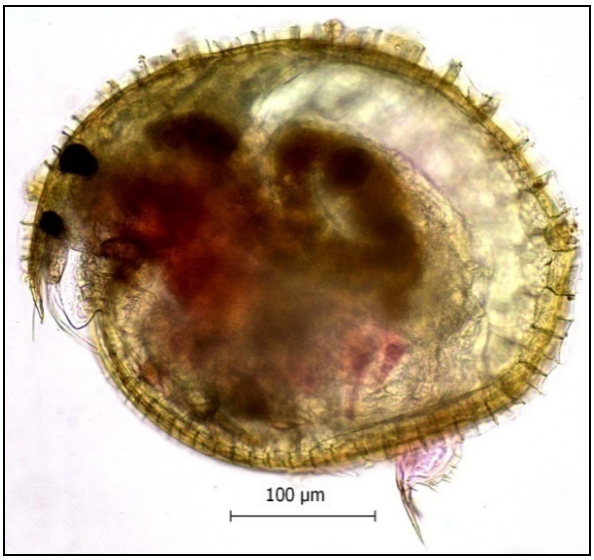

Figure 4. *Chydorus angustirostris* Frey, parthenogenetic female.

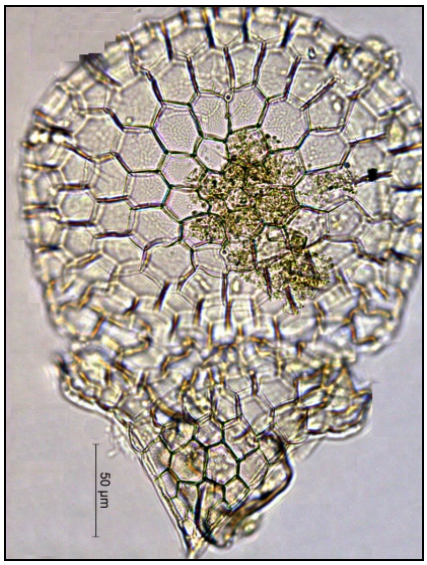

Figure 5. *Ch. angustirostris* Frey, postabdomen.

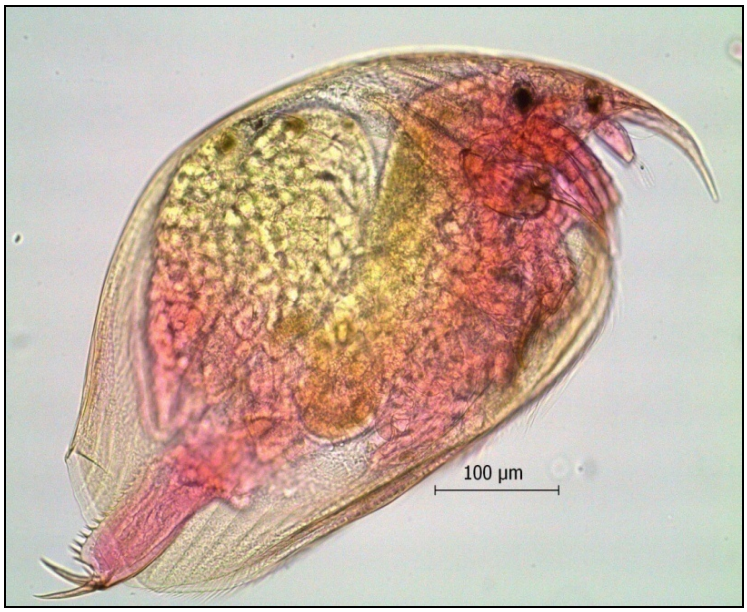

Figure 6. *Disperalona caudata* Smirnov, parthenogenetic female.

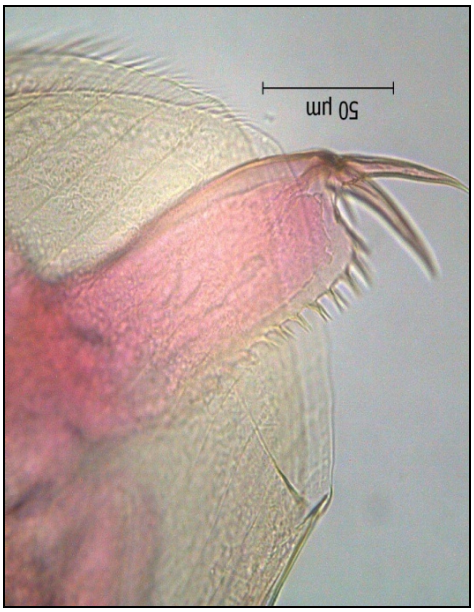

Figure 7. *D. caudata* Smirnov, postabdomen

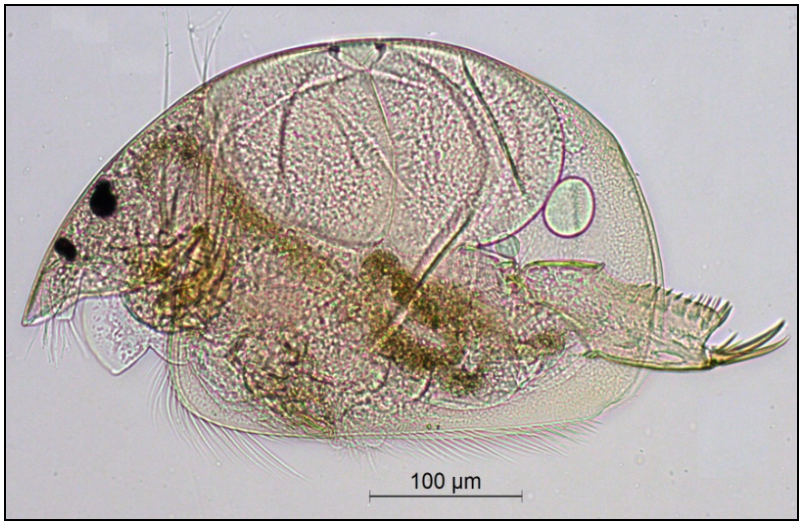

Figure 8. *Alona cheni* Sinev, parthenogenetic female.

Figure 9. *A. cheni* Sinev, postabdomen.

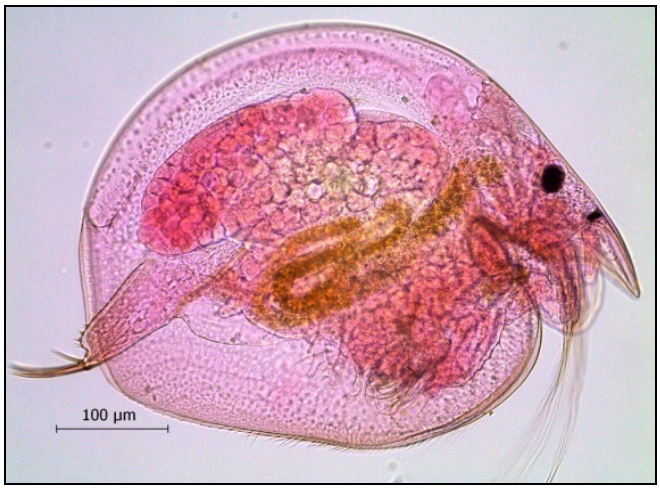

Figure 10. *Celsinotum macronyx* (Daday) parthenogenetic female.

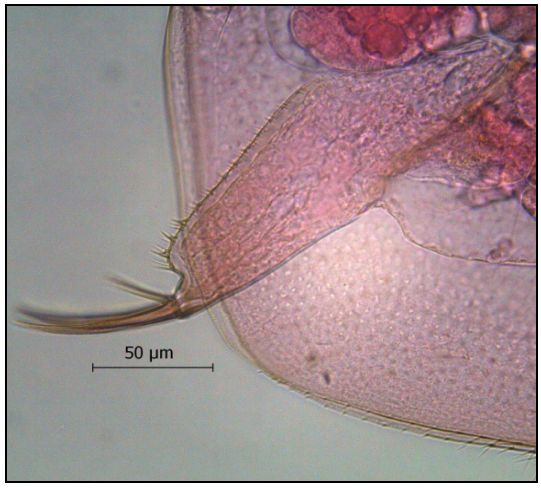

Figure 11. C. *macronyx* (Daday) postabdomen.

Figure 12. *Kurzia brevilabris* Rajapaksa & Fernando, parthenogenetic female.

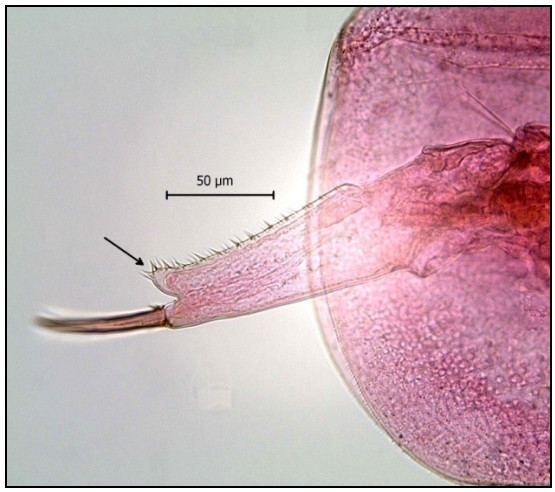

Figure 13. *K. brevilabris* Rajapaksa & Fernando, postabdomen.