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MICRO-FAUNAL DIVERSITY OF CLADOCERANS (CRUSTACEA : BRANCHIOPODA : CLADOCERA) IN RICE FIELD ECOSYSTEMS OF MEGHALAYA

SUMITA SHARMA

North-Eastern Regional Station, Zoological Survey of India, Fruit Gardens, Risa Colony, Shillong-793003, Meghalaya

INTRODUCTION

The rice-fields integrate salient features of aquatic and semi-aquatic environs and exhibit a rich mosaic of ecotones. These ecosystems are known to be colonized by a rich variety of aquatic organisms (Fernando *et al.*, 1979; Fernando, 1993) during the period of paddy cultivation in general and micro-invertebrate communities in particular. The later, in turn, show interesting heterogeneity of Cladocera, an important component of micro-crustaceans. Though taxonomic studies on the Indian freshwater Cladocera were initiated by Baird (1860), previous publications from this country deal with their α-taxonomy based on collections from scattered localities from different states of India (Sharma and Michael, 1987; Michael and Sharma, 1988; Sharma, 1991). The information on ecosystem diversity of these entomostracous Crustaceans is, however, practically lacking. This generalization also holds true to the cladoceran fauna of Meghalaya (Sharma and Sharma, 1999).

The present pioneering contribution on faunal diversity of cladocerans in the rice-field ecosystems of Meghalaya, therefore, assumes special biodiversity interest. Various rare and interesting species documented in this study are briefly diagnosed and illustrated. Remarks are made on nature and composition of the examined taxocoenosis and on distribution of interesting elements.

MATERIALS AND METHODS

The present observations are based on extensive plankton samples collected, during 2004-2005 from the rice-fields located in different districts of Meghalaya (Fig. 1, a-b) and the samples collected (during 1988-1990) for the "State Fauna of Meghalaya : Zooplankton survey". The collections deposited in Freshwater Biology Laboratory, Department of Zoology, North-Eastern Hill University, Shillong as well as those in the holdings of the Eastern Regional Station, Zoological Survey of India, Shillong are examined for this systematic survey.

Qualitative plankton samples were collected from the rice-fields, during the different phases of paddy-cultivation (May/June-October), by towing a nylobolt plankton net (No. 25) and were preserved in 5% formalin. Various species and their disarticulated appendages were mounted in Polyvinyl alcohol-lectophenol mixture. The head pores and their arrangements were studied following Megard (1965). The cladoceran species were identified following the works of Smirnov (1971, 1976, 1992, 1996), Smirnov and Timms (1983), Michael and Sharma (1988), Korovchinsky (1992), Sharma and Sharma (1999), Orlova-Bienkowskaja (2001) and Korinek (2002). The drawings were made with a Leitz-Dialux phase contrast stereoscopic microscope using a drawing-tube attachment and the measurements were indicated in millimeters (mm).

LIST OF THE EXAMINED TAXA

Superclass CRUSTACEA
Class BRANCHIOPODA
Superorder CLADOCERA *s. str.*
Order CTENOPODA
Family SIDIDAE

1. ***Diaphanosoma excisum*** Sars, 1885

2. ***D. sarsi*** Richard, 1895
3. ***D. senegal*** Gauthier, 1951**
4. ***Sida crystallina*** (O.F. Müller, 1776)

Order ANOMOPODA

Family DAPHNIIDAE

5. ***Ceriodaphnia cornuta*** Sars, 1885
6. ***C. reticulata*** (Jurine, 1820)**
7. ***Scapholeberis kingi*** Sars, 1903
8. ***Simocephalus acutirostratus*** (King, 1853)
9. ***S. serrulatus*** (Koch, 1841)
10. ***S. vetulus*** (O.F. Müller, 1776)

Family BOSMINIDAE

11. ***Bosmina longirostris*** (O.F. Müller, 1776)

Family MOINIDAE

12. ***Moina micrura*** Kurz, 1874
13. ***Moinodaphnia macleayi*** (King, 1853)**

Family MACROTHRICIDAE

14. ***Guernella raphaelis*** Richard, 1892**
15. ***Macrothrix spinosa*** King, 1853*
16. ***M. triserialis*** Brady, 1886

Family ILYOCRYPTIDAE

17. ***Ilyocryptus spinifer*** Herrick, 1882

Family CHYDORIDAE

Subfamily CHYDORINAE

18. ***Alonella excisa*** (Fischer, 1854)
19. ***Chydorus sphaericus*** (O.F. Müller, 1776)
20. ***C. parvus*** Daday, 1898**
21. ***C. pubescens*** Sars, 1901*
22. ***Dunhevedia crassa*** King, 1853
23. ***D. serrata*** Daday, 1898*
24. ***Ephemeroporus barroisi*** Richard, 1894

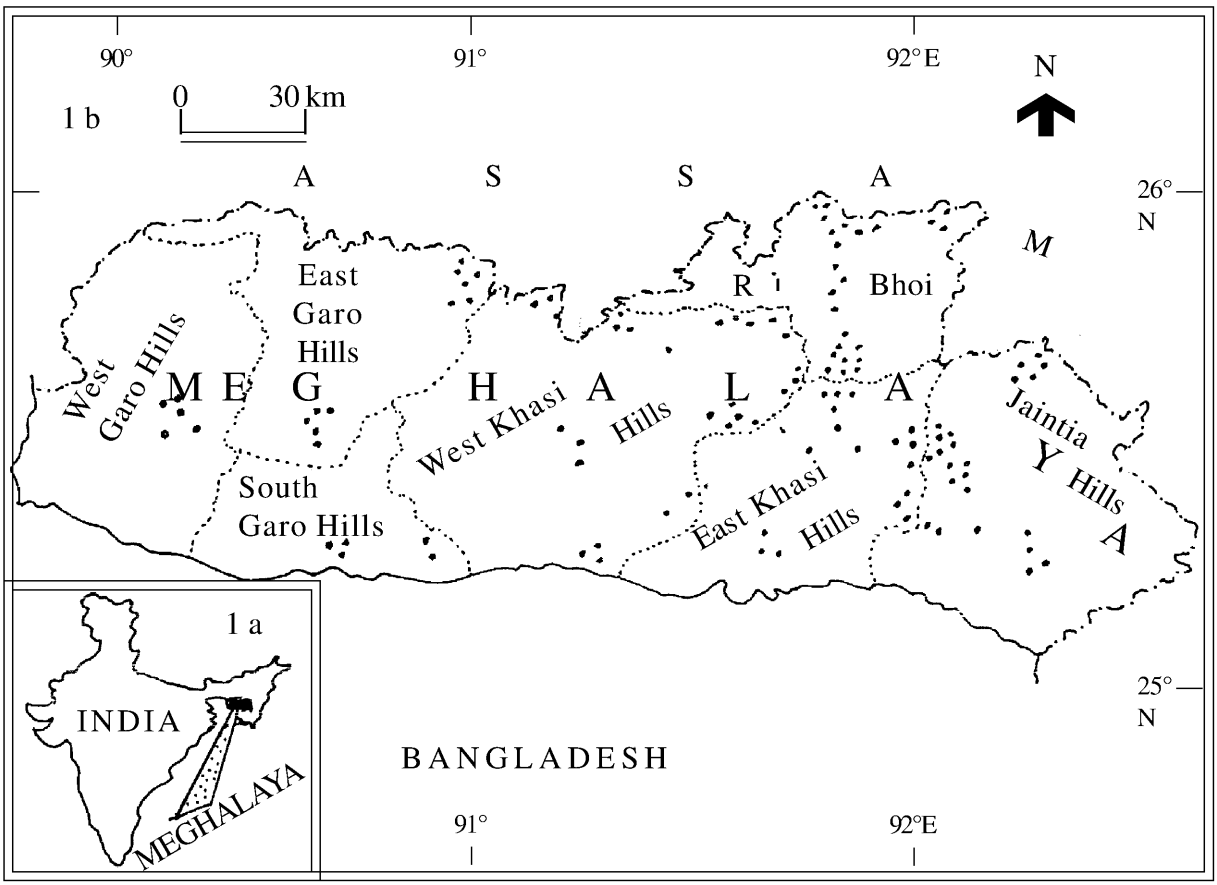


Fig. 1, a-b : 1a. Map of India indicating the state of Meghalaya; 1b. Map of Meghalaya showing the sampling sites.

* New records from Meghalaya

** New Records from N.E. India

Subfamily ALONINAE

25. ***Acroperus harpae*** (Baird, 1894)
26. ***Alona costata*** Sars, 1862
27. ***A. pulchella*** King, 1853*
28. ***Alona rectangula*** Sars, 1862
29. ***A. quadrangularis*** (O.F. Müller, 1776)
30. ***A verrucosa pseudoverrucosa*** (Smirnov, 1971)**
31. ***Euryalona orientalis*** (Daday, 1898)
32. ***Karualona karua*** (King, 1853)
33. ***Kurzia longirostris*** (Daday, 1898)
34. ***Notalona globulosa*** (Daday, 1905)
35. ***Oxyurella singalensis*** (Daday, 1898)

NOTES ON INTERESTING TAXA

The following systematic notes deal with various new records and, rare and interesting species observed in the present study :

Diaphanosoma senegal Gauthier, 1951

(Figs. 2-4)

1951. *Diaphanosoma senegal* Gautheir, *Alger,* p. 43-45, pl. IX, A-J.

Distribution : N.E. India : new record. India : Gujarat and Maharashtra. Elsewhere : Africa and Bangladesh.

Ceriodaphnia reticulata (Jurine, 1820)

(Figs. 5-7)

1820. *Monoculus reticulatus* Jurine, *Histoire des monocles, qui se trouvent aux environs de Geneve,* p. 139, pl. 14, figs. 3, 4.
1901. *Ceriodaphnia reticulata* (Jurine) : Sars, *Arch. Math. Naturvidensk. Christiania,* **23**, p. 21.

Distribution : N.E. India : new record. India : Rajasthan, Bihar, Gujarat. Elsewhere : Holarctic, Neotropical and Ethiopian regions.

Simocephalus acutirostratus (King, 1853)

(Figs. 8-10)

1852. *Daphnia elizabethae* var. *acutirostrata* King, *Pap. Proc. R. Soc. Tasmania,* **2**, p. 234, pl. VI.
1896. *Simocephalus acutirostratus* (King) : Sars, *Arch. Math. Naturvidensk. Christiania,* **18**, p. 12.
1990. *Simocephalus vidae* Rane : Sharma and Sharma, *Rev. Hydrobiol. trop.* **23**, p. 106, Figs. 6 & 7.
1990. *Simocephalus vidae gajareae* Rane : Sharma and Sharma, *Rev. Hydrobiol. trop.* **23**, p. 110, Figs. 32 & 33.

Distribution : N.E. India : Assam, Meghalaya and Tripura. India : Madhya Pradesh, Maharashtra, Tamil Nadu, Karnataka. Elsewhere : Australia, S.E. Asia and Sri Lanka.

Simocephalus serrulatus (Koch, 1841)

(Figs. 11-13)

1841. *Daphnia serrulata* Koch, *Deutschlands Crustacean, Myriapoden und Arachnidan. Regensburg,* p. 35.
1900. *Simocephalus serulatus* (Koch) : Lilljeborg, *Nova Acta Reg. Soc. Sci. Uppsala, ser. III,* **19**, p. 179, pl. 26, figs. 9-16.
1990. *Simocephalus surekhae* Rane : Sharma and Sharma, *Rev. Hydrobiol. trop.* **23**, p. 110, Figs. 23-25.

Distribution : N.E. India : Meghalaya, Assam and Tripura, India : Madhya Pradesh, Bihar and Tamil Nadu. Elsewhere : Europe, Asia, Africa, North America, South America and Australia.

Moinodaphnia macleayi (King, 1853)

(Figs. 14 & 15)

1853. *Moina macleayi* King, *Pap. Proc. R. Soc. Tasmania,* **2**, p. 251-252, pl. 2.
1901. *Moinodaphnia macleayi,* Sars, *Arch. Math. Naturvidensk. Christiania,* **18**, p. 16-19.

Distribution : N.E. India : new record. India : West Bengal, Bihar, Kerala. Elsewhere : tropical and sub-tropical regions of America, Africa and Southeast Asia.

Macrothrix spinosa King, 1853

(Figs. 16-18)

1853. *Macrothrix spinosa* King, *Pap. Proc. R. Soc. Tasmania,* **2**, p. 256, pl. VI F.

Distribution : N.E. India : Assam, Tripura and Manipur. India : Rajasthan, Tamil Nadu, Andaman & Nicobar islands. Elsewhere : Cosmopolitan.

Guernella raphaelis Richard, 1892

(Figs. 19-21)

1892. *Guernella raphaelis* Richard, *Mem. Soc. Zool. France,* 5, p. 2-6, Figs. 1-3.

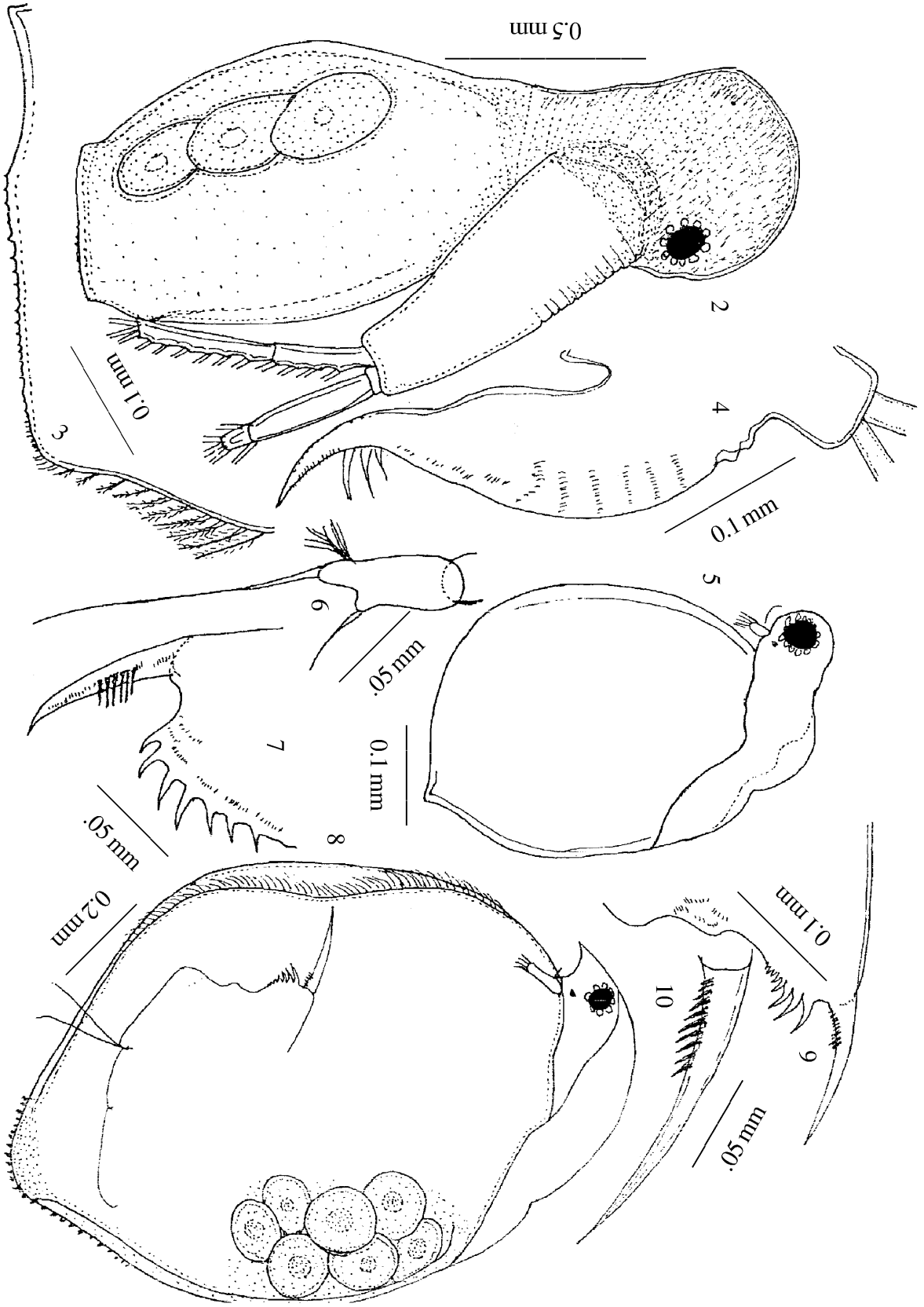
Distribution : N.E. India : new record. India : West Bengal, Bihar and Rajasthan. Elsewhere : Pantropical.

Chydorus parvus Daday, 1898

(Figs. 22-25)

1898. *Chydorus parvus* Daday, *Termes, Füzetek,* Anhangesheft **21**, p. 25-26, fig. 7.

Distribution : N.E. India : new record. India : Kerala, Tamil Nadu, Andhra Pradesh. Elsewhere : The Ethiopian and Indo-Malayan regions.



Diaphanosoma senegal Gauthier : Fig. 2, parthenogenetic female, Fig. 3, armament on posterior valve margin, Fig. 4, postabdomen; *Geriodaphnia reticulata* (Jurine) : Fig. 5, parthenogenetic female, Fig. 6, antennule, Fig. 7, postabdomen (part); *Simocephalus acutirostratus* (King) : Fig. 8, parthenogenetic female, Fig. 9, postabdomen, Fig. 10, claw (enlarged).

Chydorus pubescens Sars, 1901

(Figs. 26 & 27)

1901. *Chydorus pubescens* Sars, *Arch. Math. Naturvidensk. Christiania,* **23**, p. 71-73, Pl. XI, figs. 4 a-c.

Distribution : N.E. India : Assam and Tripura. India : Bihar and West Bengal. Elsewhere : Cosmotropical.

Dunhevedia serrata Daday, 1898

(Figs. 28-30)

1898. *Dunhevedia serrata* Daday, *Termes, Füzetek,* Anhangesheft **21**, p. 32-33, fig. 13.

Distribution : N.E. India : Assam, Tripura. India : West Bengal, Gujarat, Rajasthan, Tamil Nadu, Andhra Pradesh. Elsewhere : Africa, Sri Lanka, India, Indonesia, Thailand, Philippines, New Guinea.

Alona pulchella King, 1853

(Figs. 31 & 32)

1853. *Alona pulchella* King, *Pap. Proc. R. Soc. Tasmania,* **2**, p. 260, pl. VIII B.

Distribution : N.E. India : Tripura. India : West Bengal, Gujarat, Rajasthan and Tamil Nadu. Elsewhere : Cosmotropical.

Alona verrucosa pseudoverrucosa (Smirnov, 1971)

(Figs. 33-36)

1971. *Biapertura pseudoverrucosa pseudoverrucosa* Smirnov, *The World Chydorid Fauna.* USSR Acad. Sci. Zool. Inst. Nova ser. **101**, p. 480, Fig. 606.

1985. *Biapertura verrucosa pseudoverrucosa* (Smirnov) : Sharma and Sharma, *J. Meghalaya Sci. Soc.,* **7 & 8**, p. 18, Figs. 41-43.

Distribution : N.E. India : new record. India : West Bengal. Elsewhere : Paraguay and Nigeria.

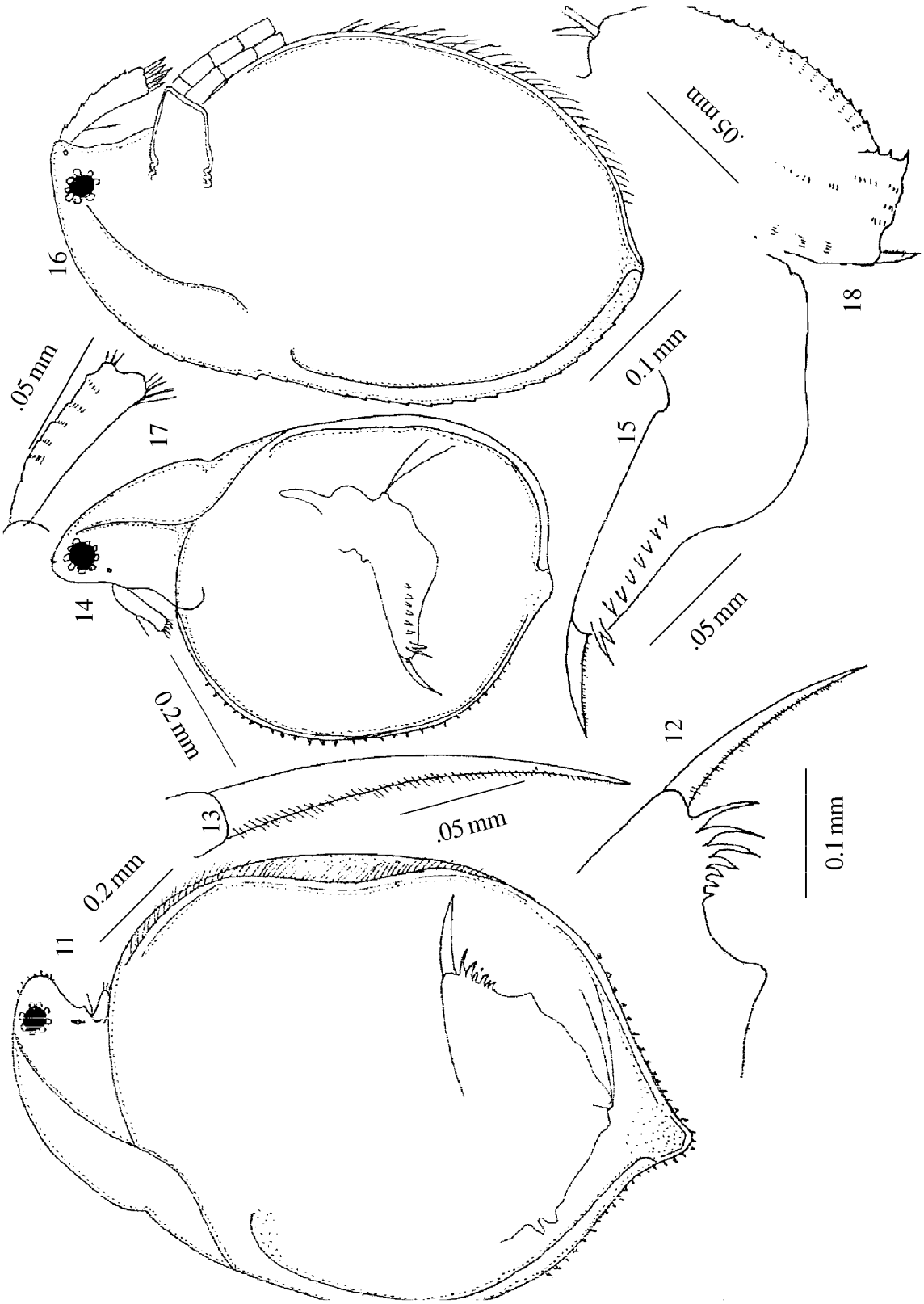
DISCUSSION

Zooplankton communities of the rice-fields of Meghalaya state reveal thirty-five of Cladocera, exhibit fairly rich faunal diversity of these micro-crustaceans and, hence, reflect greater environmental heterogeneity of the sampled environs. The last aspect is attributed to complex rice-field limnology (Fernando, 1995) caused due to various aspects namely water level fluctuations, tilling of soil, application of fertilizers, plantation and growth of paddy and growth of aquatic weeds. The stated conclusion on ecosystem diversity re-affirms the authors earlier observations based on the rotifer communities of the rice-fields of Meghalaya (Sharma, 2006).

The cladoceran richness recorded in the present study reflects the highest qualitative diversity of these branchiopod crustacens known till date from the rice-fields of the Indian subcontinent (Fernando, 1980, 1995). The richness, however, assumes special importance in light of a conservative estimate (Fernando and Kanduru, 1984; Sharma and Michael, 1987) of occurrence of upto 60-65 species of cladocerans from tropical and subtropical parts of India. Interestingly, the cladoceran communities reflect greater higher diversity (26 genera) as compared with 36 genera so far known from India (Sharma, 1991). The generic richness in the sampled rice fields is well comparable to the reports of 29 genera each in the cladoceran faunas of the states of Meghalaya (Sharma and Sharma, 1999) and Tripura (Venkataraman and Das, 2000). Besides, all the seven families of freshwater Cladocera known to occur in the Indian inland aquatic biotopes are represented in the examined collections. These, in turn, represent two phylogenetic stems of Cladocera (Smirnov and Timms, 1983) namely the Ctenopoda and the Anomopoda; the former includes only the family Sididae while members of six families of the latter (Macrothricidae-Ilyocryptidae-Chydoridae-Bosminidae-Moinidae-Daphniidae) are reported in this account.

Six species namely *Diaphanosoma senegal, Ceriodaphnia reticulata, Moinodaphnia macleayi, Guernella raphaelis, Chydorus pavus* and *Alona verrucosa pseudoverrucosa* are new records from Northeast India. In addition, four species i.e., *Macrothrix spinosa, Chydorus pubescens, Alona pulchella* and *Dunhevedia serrata* are new records from Meghalaya. The present study, therefore, raises the cladoceran richness (41 species) known earlier from this state (Sharma and Sharma, 1999) to 51 species. Overall diversity from Meghalaya now ranks the third highest from India and figures next to that of Jammu & Kashmir (59 species) > West Bengal (52 species). The Chydoridae (18 species) > Daphniidae (6 species) form a dominant fraction of the documented species. Such a feature confirms with the general composition of the Indian Cladocera (Sharma, 1991) and also with the faunas of various regions/states of this country.

The present study indicates several examples of local and regional distributional interest from India.



Simocephalus. serrulatus (Koch) : Fig. 11, parthenogenetic female, Fig. 12, postabdomen, Fig. 13, claw (enlarged); *Moinodaphnia macleayi* (King) : Fig. 14, parthenogenetic female, Fig. 15, postabdomen; *Macrothrix spinosa* King : Fig. 16, parthenogenetic female, Fig. 17, antennule, Fig. 18, postabdomen.

Guernella raphaelis exhibits disjunct distribution in this country (Sharma and Sharma, 2001), with reports from West Bengal, Bihar and Rajasthan. *Diaphanosoma senegal* is recorded from Gujarat and Maharashtra; *Ceriodaphnia reticulata* is examined from Rajasthan, Bihar and Gujarat; *Chydorus pavus* is reported from Kerala, Tamil Nadu and Andhra Pradesh; *Moinodaphnia macleayi* is examined from West Bengal, Bihar, Kerala while *Alona verrucosa pseudoverrucosa* is recorded only from West Bengal (Sharma and Sharma, 1985). The distribution ranges of the stated taxa are presently extended to Northeast India.

Among other species, *Macrothrix spinosa* is observed from Tripura, Manipur, Rajasthan, Tamil Nadu and Andaman & Nicobar islands; *C. pubescens* is known from Bihar, West Bengal, Assam and Tripura; *Alona pulchella* is recorded from Tripura, West Bengal, Gujarat, Rajasthan and Tamil Nadu and *Dunhevedia serrata* is observed from Tripura, West Bengal, Gujarat, Rajasthan, Tamil Nadu and Andhra Pradesh. In addition, *Simocephalus acutirostratus* appears to occur in Central India and southwards (Sharma, 1991) while *S. serrulatus* is so far known from S. India and Meghalaya.

The cladoceran communities of the rice-fields of Meghalaya are characterized by qualitative predominance of Cosmopolitan species and occurrence of several Cosmotropical species; these features impart a general "tropical character" to the examined fauna. The stated generalization is in broader conformity with the general composition of several tropical cladoceran communities (Fernando, 1980; Fernando and Kanduru, 1984; Dussart *et al.* 1984; Sharma and Michael, 1987; Sharma, 1991; Sharma and Sharma, 2001). The examined collections depict qualitative dominance of littoral or periphytic forms (29 species) and fewer euplanktonic species namely *Diaphanosoma sarsi, D. excisum, Ceriodaphnia cornuta, C. reticulata, Bosmina longirostris* and *Moinodaphnia macleayi*. The later even show much restricted occurrence in this study. The general paucity of planktonic Cladocera may be attributed to lack of open-water conditions and the shallow nature of the ephemeral rice-fields ecosystems.

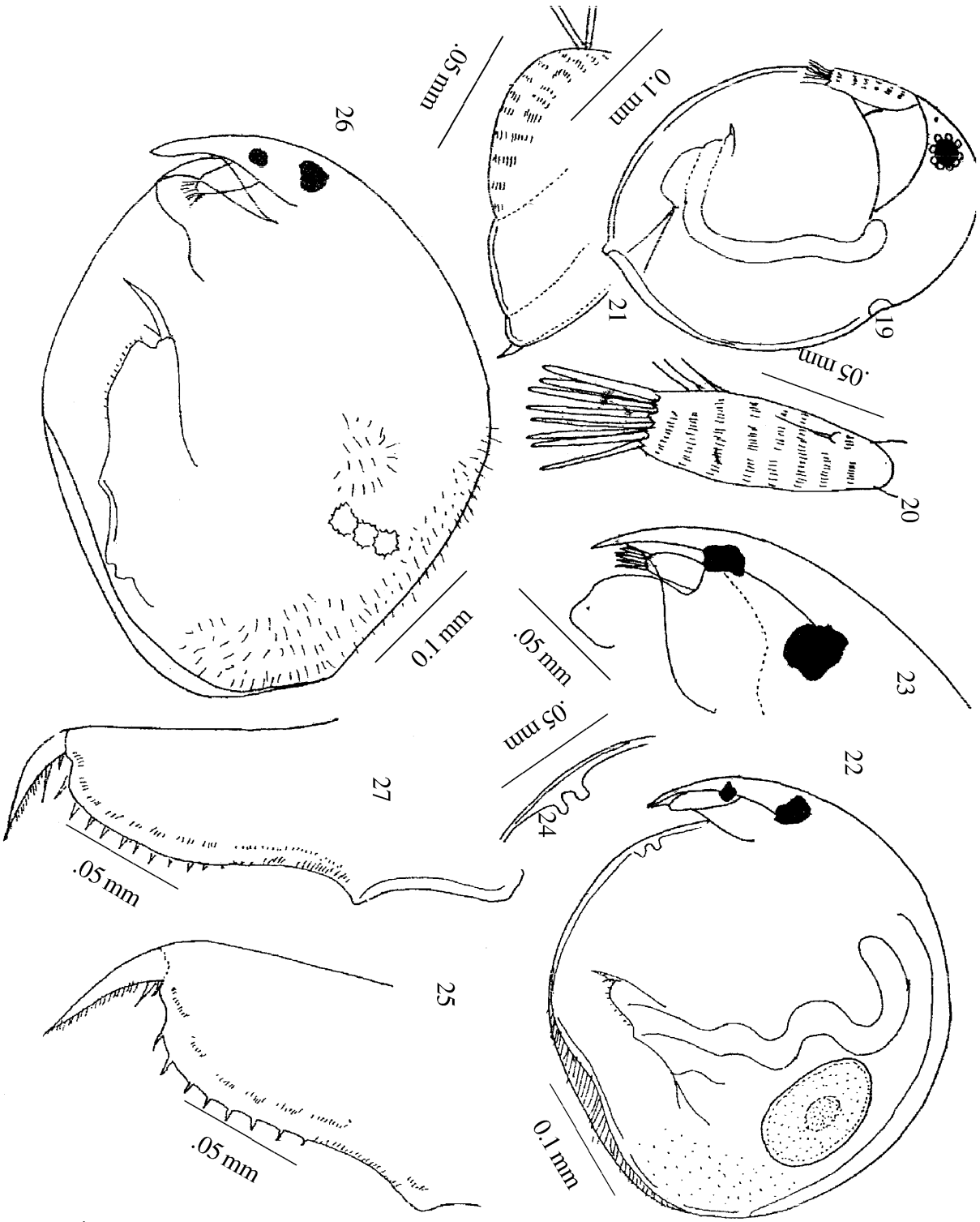
The majority of the species are identified by their parthenogenetic females while the males of only four species *Ephemeroporus barroisi, Alona costata, Notalona karua* and *Acroperus harpae* are examined in the present study. *Diaphanosoma excisum, Ceriodaphnia cornuta, Macrothrix triserialis, Chydorus sphaericus, Ephemeroporus barroist, Alona costata, Karualona karua, Notalona globulosa* show relatively common occurrence. On the other hand, *Diaphanosoma senegal, Ceriodaphnia reticulata, Moina micrura, Bosmina longirostris, Moinodaphnia macleayi, Guernella raphaelis, Chydorus parvus, Chydorus pubescens* and *Alona verrucosa pseudoverrucosa* are rare elements.

To sum up, this pioneering contribution on the micro-crustaceans from the rice-field ecosystems of Meghalaya highlights fairly rich and diversified nature of cladoceran communities, significantly enhances overall richness from this state to 51 species, exhibits general tropical characters, paucity of planktonic taxa, and records several species of local and regional distributional importance.

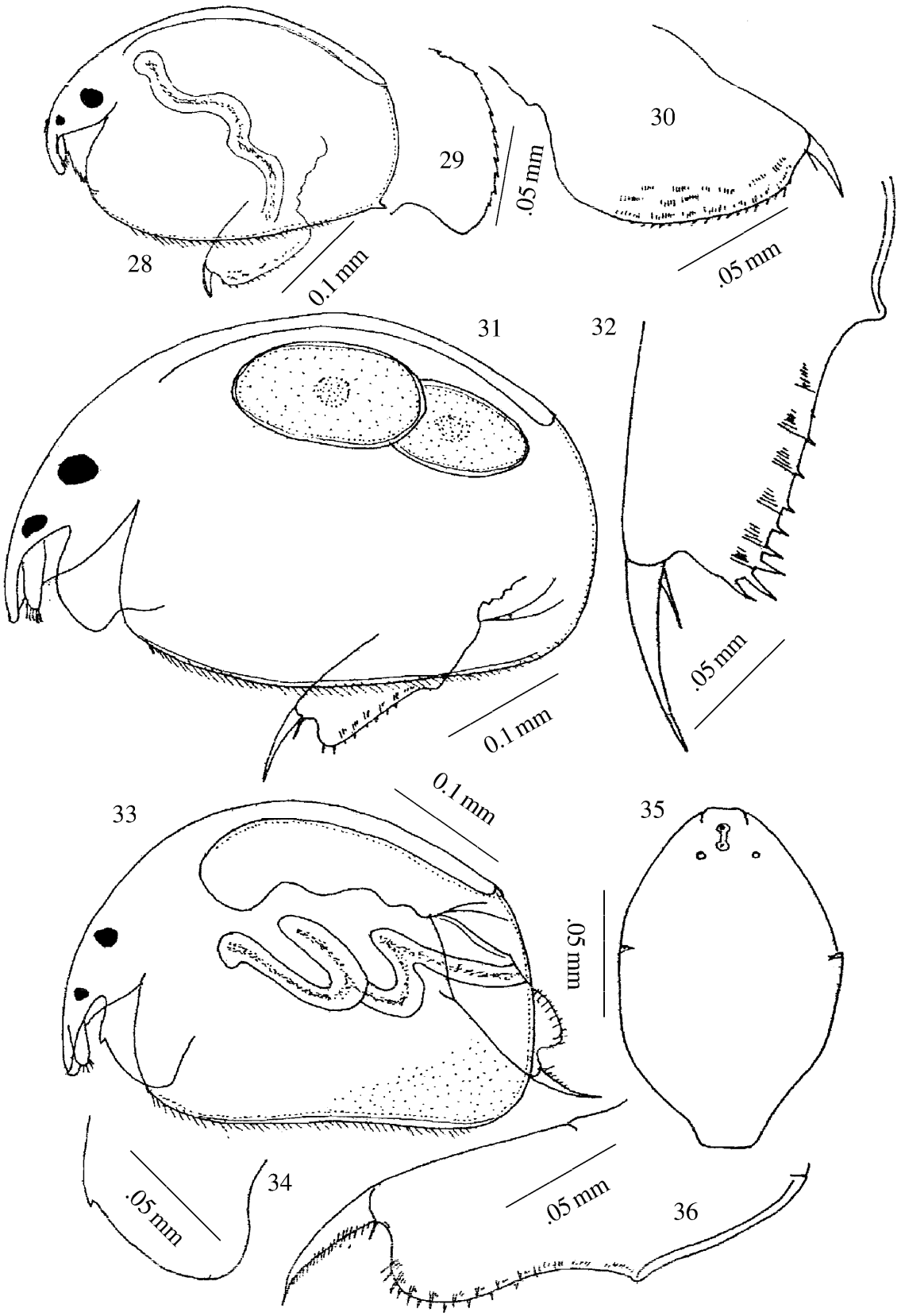
SUMMARY

Thirty-five species of Cladocera belonging to 26 genera and seven families are recorded from the rice-fields of Meghalaya. This report exhibits fairly rich cladoceran faunal diversity and reflects greater environmental heterogeneity of the sampled environs. The present study raises the cladoceran richness known from this state to 51 species. *Diaphanosoma senegal, Ceriodaphnia reticulata, Moinodaphnia macleayi, Guernella raphaelis, Chydorus parvus* and *Biapertura verrucosa pseudoverrucosa* are new records from Northeast India. In addition, *Macrothrix spinosa, Chydorus pubescens, Alona pulchella* and *Dunhevedia serrata* are new records from Meghalaya.

The examined taxocoenosis depicts general tropical character, shows qualitative importance of Cosmopolitan and littoral or periphytic elements, and registers predominance of the Chydoridae. This study includes several examples of regional and local distribution interest. The males of only four species *Ephemeroporus barroisi, Alona costata, Karualona karua* and *Acroperus harpae* are examined. *Diaphanosoma excisum, Ceriodaphnia cornuta, Macrothrix triserialis, Chydorus sphaericus, Ephemeroporus barroisi, Alona costata, Alona*



Guernella raphaelis Richard : Fig. 19, parthenogenetic female, Fig. 20, antennule, Fig. 21, postabdomen; *Chydorus parvus* Daday : Fig. 22, parthenogenetic female, Fig. 23, head (enlarged), Fig. 24, shell lock-like structure, Fig. 25 postabdomen; *C. pubescens* Sars : Fig. 26, parthenogenetic female, Fig. 27, postabdomen.



Dunhevedia serrata Daday : Fig. 28, parthenogenetic female, Fig. 29, Labral plate, Fig. 30, postabdomen; *Alona pulchella* King : Fig. 31, parthenogenetic female, Fig. 32, postabdomen; *Alona verrucosa pseudoverrucosa* (Smirnov) : Fig. 33, parthenogenetic female, Fig. 34, Labral plate, Fig. 35, head-shield with head pores, Fig. 36, postabdomen.

globulosa and *Notalona karua* show relatively common occurrence. *Diaphanosoma senegal, Ceriodaphnia reticulata, Moina micrura, Bosmina longirostris, Moinodaphnia macleayi, Guernella raphaelis, Chydorus parvus, Chydorus pubescens* and *Alona verrucosa pseudoverrucosa* are rare elements.

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