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RESEARCH ARTICLE

Faunal diversity of Cladocera (Crustacea: Branchiopoda) with notes on biogeographically important species in the floodplain wetlands of the Subansiri River basin, India

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Abstract – The plankton samples collected from the Subansiri floodplain wetlands revealed a rich Cladocera assemblage of 55 species belonging to 30 genera and 7 families. The species richness represents 42% and 75% of the total amount of fresh water species reported from India and Assam, respectively. Chydoridae was the most speciose family, with 31 species, while Ilyocryptidae was represented by a single species. Sididae, Daphniidae, Bosminidae, Moinidae and Macrothricidae were represented by four, five, three, two and four species, respectively. The faunal composition is represented by cosmopolitan, tropical and oriental elements. The documentation of *Diaphanosoma dubium*, *Latonopsis australis*, *Simocephalus mixtus*, *Chydorus sphaericus*, *Chydorus parvus*, *Chydorus ovalis*, *Alonella clathratula*, *Pleuroxus* cf. *denticulatus*, *Picripleuroxus quasidenticulatus*, *Celsinotum macronyx*, *Coronatella anodonta* and *Kurzia (Rostrukurzia) brevilabris* has biogeographic importance. We provide brief geographical distributional remarks about these 12 species from the collected samples. This was a preliminary study, as the fauna from the Indian subcontinent is poorly documented, and requires a taxonomic revision as a whole. The faunistic diversity of cladocerans comprises a clear representation of a tropical cladoceran assemblage.

Keywords: Cladocera / Chydoridae / distribution / systematic / wetland

1 Introduction

Cladocera are a poorly known group of microcrustaceans, and their taxonomic enumeration remained poor during the twentieth century (Korovchinsky, 1997). The pioneer studies of Frey (1959, 1982a,b) and Smirnov (1971, 1976, 1992, 1996) along with continuous efforts of several other researchers around the world revealed about 700 valid species (Kotov, 2011). Taxonomic accounts are an essential base for a critical approach concerning the ecology and biogeography of these microcrustaceans and a rational assessment of their global diversity (Dodson and Frey, 2001). Thus, efforts in systematics, building of taxonomical capacity and the appraisal of the global richness of Cladocera have already increased in the Neotropics, South-East and East Asia (Elmoor-Loureiro, 2000; Maiphae *et al*., 2008; Kotov and Sinev, 2011).

Although the cladoceran fauna of Australia, America (especially South America) and Europe can be considered well studied, further endeavours are necessary in Asia, for which the validity of many currently described species is still being debated (Forró *et al*., 2008; Maiphae *et al*., 2008; Kotov *et al*., 2013). In South-East (SE) Asia, Cladocera from Thailand can be considered well studied (Sanoamuang, 1998; Maiphae *et al*., 2008; Kotov, 2011; Sinev and Kotov, 2012; Van Damme and Maiphae, 2013; Van Damme and Sinev, 2013). Despite this, from the 298 formal species recorded from SE Asia, only 67 species were found to be valid and 68 have been registered as synonyms, while the remaining163 are thought to represent "species complexes" (Korovchinsky, 2013). South-East Asia can be considered the most well-studied region from the Oriental zone, at least when concerning the subfamily Aloninae of the Chydoridae (Sinev, 2016; Sinev *et al*., 2017). Survey on Indian cladoceran species is still very scarce compared to other Asian countries, and the actual records of Indian species numbers remain obscure (Chatterjee *et al*., 2013; Padhye and Dumont, 2015). Fernando and Kanduru (1984) reported 130 species, Michael and Sharma (1988)

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reported 93 species, Raghunathan and Kumar (2003) reported 187 species and, more recently, Chatterjee *et al.* (2013) reported 133 species. Inadequate taxonomic analyses and the incongruences of the extant report on different taxa warrant the urgent need of confirmation of the diversity status of cladoceran species from India (Sharma and Sharma, 2008; Chatterjee *et al.*, 2013; Padhye and Dumont, 2015).

The cladoceran fauna from floodplain lakes of American and European countries such as the Upper Paraná (Serafim-Júnior *et al.*, 2003; Lansac-Tôha *et al.*, 2009), Danube (Kiss, 2004; Illyova and Nemethova, 2005; Kiss and Scholl, 2009) and Acthafalya river basins (Davidson *et al.*, 2000) were well documented. However, the study from Indian floodplain lakes are limited only to the reports of Khan (1987), Sharma and Sharma (2010) and Sharma (2008). The cladoceran fauna from floodplain wetlands of the Brahmaputra river basin of Assam (Sharma and Sharma, 2007, 2008, 2010, 2012; Sharma *et al.*, 2015) are considered well documented, with 74 species being reported to date (Sharma and Sharma, 2014). In this regard, the zooplankton fauna, and more specifically the cladoceran fauna of the floodplain wetlands of the Subansiri River basin of Northeast India, still remain mostly unknown. The present investigation, therefore, intended to (i) document the fauna of Cladocera from the floodplain wetlands of the Subansiri River basin, (ii) evaluate their richness and species composition, and also (iii) perform a systematic revision of the species encountered in the region.

2 Materials and methods

2.1 Study area

The Subansiri River floodplain encompasses different categories of floodplain wetlands in its 4350 km^2 catchment area in the plains of Assam. The study was conducted in three different types of wetland environments: Hatimora, a deep water rice field (27°.07′ N 94°.08′ E), Morikhaboli, a floodplain lake (27°.06′ N 94°.08′ E), and Halmora, an oxbow lake (27°.05′ N 94°.06′ E). All these study areas are located between 27°.02′ and 27°.15′ North latitude and 93°.99′ and 94°.15′ East longitude (Fig. 1). The deep water rice field is a seasonal wetland, whereas the oxbow lake and the floodplain lake are perennial environments seasonally flooded by the Subansiri River. Floodplain lakes are locally known as *beel*, being characterized as wide, shallow and connected to rivers through channels during the monsoon season. Oxbow lakes (OL) are locally known as *dubi*, which are abandoned river courses generally occupied by small water bodies, which are connected to rivers during the wet season. Deep water rice fields (DWR), locally known as *bao pathar*, are traditional *bao* rice farming zones where the water remains for 4–6 months with water depth ranging from 0.50 to 2.0 m or more. These wetlands are rich in macrophyte species such as *Leersia* spp., *Tapas* spp., *Eichhornia* spp., *Hydrilla* spp., *Hygroryza* spp., *Ipomea* spp., *Lemna* spp., *Pistia* spp., *Nymphaea* spp., *Nymphoides* spp., *Potamageton* spp., *Azolla* spp., *Utricularia* spp. and *Sagittaria* spp.

2.2 Sampling, sorting, quantification and identification

A total of 120 plankton samples were collected from four selected sites in each wetland type from May 2013 to April 2015 (Fig. 1). Plankton samplings were performed by filtering 100 L of the subsurface water of the littoral and limnetic regions with a nylon cloth plankton net (60 μm mesh size). The filtrated water collected in a vial attached to the bottom core of the plankton net was then transferred to labelled plankton vials and immediately preserved in 5% formalin.

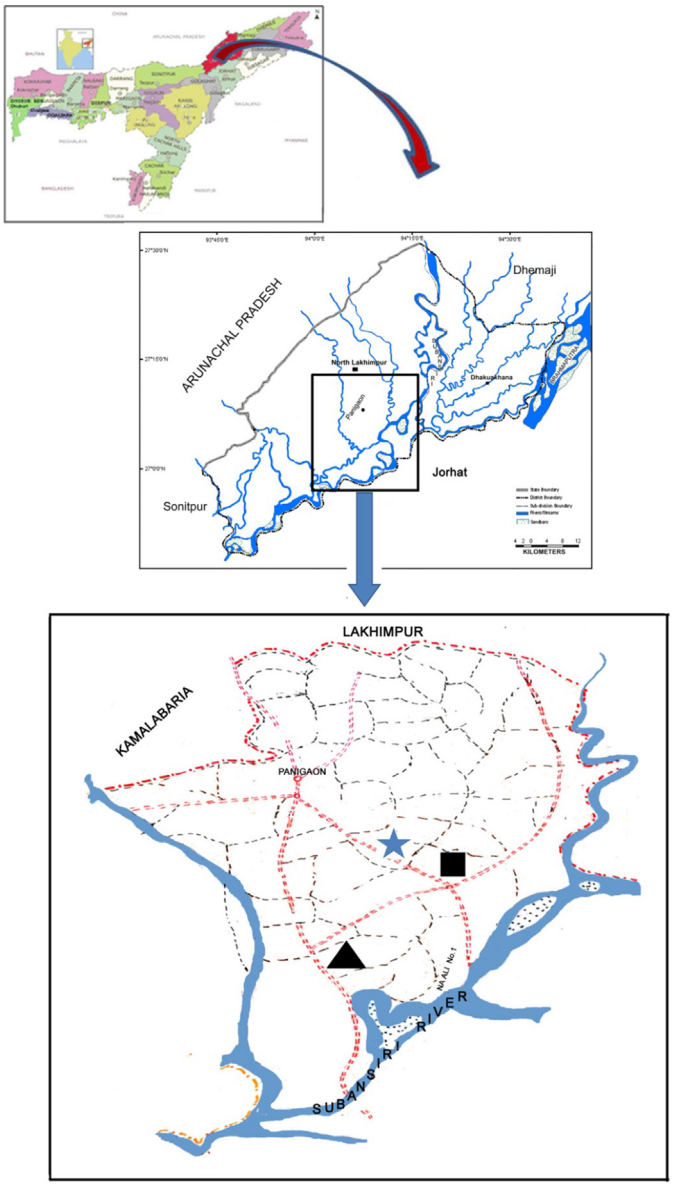

Fig. 1. Map showing the study areas in the Subansiri floodplain (★ Hatimora DWR, ■ Morikhaboli beel and ▲ Halmora dubi).

Afterwards, plankton samples were screened under a stereoscopic binocular light microscope (Nikon eclipse E200) for quantification and separation of different specimens of Cladocera. The isolated cladocerans were individually mounted in glycerin for qualitative studies. The specimens were examined under a Leica DM 5000 camera attached to a microscope fitted with an image analyzer, and then identified following Smirnov (1971, 1996), Michael and Sharma (1988), Subhash Babu and Nayar (2004); Kotov *et al.* (2012, 2013) and Pascual *et al.* (2014). We used specialized papers to aid in the

identification of species of *Macrothrix* (Dumont *et al*., 2002; Kotov, 2008), *Kurzia* (Hudec, 2000; Padhye and Van Damme, 2015), *Celsinotum* (Rajapaksa and Fernando, 1985), *Chydorus* (Rajapaksa and Fernando, 1986a; Smirnov, 1996; Van Damme and Dumont, 2007), *Alona* (Sinev, 1999; Van Damme *et al*., 2010), *Karualona* (Dumont and Silva-Briano, 2000; Van Damme *et al*., 2013), *Coronatella* (Van Damme and Dumont, 2008; Sousa *et al*., 2015a), *Notoalona* (Rajapaksa and Fernando, 1987), *Anthalona* (Van Damme *et al*., 2011; Sinev and Kotov, 2012; Sousa *et al*., 2015b), *Dadaya* (Rajapaksa and Fernando, 1982a), *Diaphanosoma* (Korovchinsky, 1998, 2002), *Pleuroxus* (Hudec and Illyova, 1998; Chiambang and Dumont, 2004; Sinev and Sanoamuang, 2013), *Simocephalus* (Young *et al*., 2012), *Bosmina* (Taylor *et al*., 2002; Kotov *et al*., 2009), *Bosminopsis* (Rey and Vasquez, 1986; Kotov, 1999), and *Ephemeroporus* (Frey, 1982b; Smirnov, 1996). The specimens were deposited in the Laboratory of Fisheries and Aquatic Ecology of the Rajiv Gandhi University, Itanagar, India.

2.3 Data analysis

Species composition: The species composition was evaluated through occurrence constancy analysis for each type of floodplain wetland, obtained by dividing the number of sampling units in which a given species occurred by the total number of sampling units studied. Results were then multiplied by 100. According to the obtained values of occurrence constancy, the species were classified as constant (>50%), accessory (25–50%) and accidental (>25%) (Dajoz, 1983). To compare the species composition between different floodplain wetland types, the Bray–Curtis similarity index was calculated using the PAST software, version 3.07.

Species richness and species abundance curve: The species richness (Margalef's index) was estimated by using the PAST software, version 3.07.

Margalef's richness index (Brower and Zar, 1977)

$R = S - 1/\ln N$

where S = number of species, N = total number of individuals in the sample.

The species abundance curve was prepared by plotting the abundances of species against their respective rank. The species rank was assigned on the basis of their relative abundance; with the most abundant species being assigned the 1st rank, the second to the 2nd and so forth.

3 Results

3.1 Species composition

The 55 species (39 species in DWR, 53 species in both the floodplain lake and oxbow lake) represented seven families: Sididae, Daphniidae, Bosminidae, Moinidae, Macrothricidae, Ilyocryptidae and Chydoridae. These families are contained in two distinct orders: Ctenopoda and Anomopoda, both of which were documented in the entire study area (Tab. 1). Chydoridae was the most species-rich family, with 36 species, which represented about 64.5% of the species richness, while the Ilyocryptidae was represented by a single species. Sididae, Daphniidae, Bosminidae, Moinidae and Macrothricidae were represented by four, five, three, two and four species, respectively. *Simocephalus mixtus* (Sars, 1903) and *Pleuroxus* cf. *denticulatus* (Birge, 1879) are new records for the state of Assam. Eight species (*Daphnia lumholtzi*, *Ceriodaphnia cornuta*, *Bosmina longirostris*, *Bosminopsis deitersi*, *Macrothrix triserialis*, *Chydorus sphaericus*, *Chydorus ventricosus*, *Chydorus* cf. *ovalis*, *Ephemeroporus barroisi*, *Celsinotum macronyx* and *Coronatella rectangula*) were numerically dominant and collectively represented in more than 50% of the samples. *Simocephalus mixtus*, *Bosmina* cf. *tripurae*, *Macrothrix spinosa*, *Chydorus parvus*, *Chydorus eurynotus*, *Pseudochydorus globosus*, *Picripleuroxus* cf. *quasidenticulatus*, *Flavalona* cf. *costata*, *Alona guttata*, *Notoalona globulosa*, *Karualona karua*, *Coronatella anodonta* and *Kurzia longirostris* were represented in a range of 25–50% of the samples, and the rest of the listed species were rarely encountered.

The species composition was similar between the studied wetlands. The results indicated a faunal similarity of almost 80% between the Oxbow lake and the Floodplain lake. The similarity between the DWR, the OL and the FP was of 50% and 55%, respectively (Bray–Curtis similarity analysis values were of 0.56 between the DWR and the FP, of 0.50 between the DWR and the OL, and of 0.79 between the OL and the FP).

3.2 Species richness index and abundance curve

The Margalef index indicated a spatial variation of the species richness among the studied ecosystems. The lowest value was observed in the DWR wetland, while the FP and OL presented similar values (Fig. 2). Regarding the abundance ranks, the DWR wetland exhibited dominant species with lower values compared to the FP and OL (Fig. 3). Another important difference between the wetland types was related to the set of dominant species. The non-planktonic species were the most abundant in the DWR, while typically planktonic species were the most abundant in the floodplain lake and the Oxbow lake (Fig. 3).

4 Discussion

River floodplains are heterogeneous landscapes (Ward *et al*., 1999) and hypothesized to be rich habitats harbouring high zooplankton diversity (Sharma and Sharma, 2008). We encountered a total of 55 species belonging to 30 genera under 7 families, revealing the speciose nature of cladoceran assemblages in the wetlands of the Subansiri floodplain. The species richness represents roughly ~42% of the cladoceran species known from India as reported in a recent checklist by Chatterjee *et al*. (2013) and ~75% of the species richness known from the Brahmaputra basin, Assam, following reports of Sharma and Sharma (2014). The generic diversity of 31 genera was lower than the total of 47 genera known from India. The cladoceran composition was characterized by high generic diversity and the records of 31 genera closely corresponded to the previous report of 32 genera (Sharma *et al*., 2015) from the same state.

Chydoridae was the most species-rich family (31 species, 64.58%) while Daphniidae, Bosminidae and Macrothricidae were subdominant groups. The observations agree with the notion that Chydoridae are a particularly diverse group of cladocerans, being typical of the tropical and subtropical

Table 1. Checklist of species of Cladocera and their relative occurrences in the Subansiri floodplain wetlands (DWR: deep water rice field; FP: floodplain lake; OL: oxbow lake).

Taxa	OL	FP	DWR	Relative occurrences
Family: Sididae Baird, 1850				
Diaphanosoma dubium (Manuilova, 1964)	+	+	+	R
Diaphanosoma excisum Sars, 1885	+	+	+	R
Diaphanosoma spp.	+	+	+	R
Latonopsis australis Sars, 1885 s.lat.	+	–	+	R
Family: Daphniidae Straus, 1820				
Daphnia lumholtzi Sars, 1885	+	+	+	A
Ceriodaphnia cornuta Sars, 1885	+	+	+	A
Ceriodaphnia spp.	+	+	+	MA
Simocephalus serrulatus (Koch, 1841)	+	+	–	R
Simocephalus mixtus Sars, 1903	+	+	+	MA
Family: Bosminidae Baird, 1845 *emend.* Sars, 1865				
Bosmina longirostris (Müller, 1776)	+	+	+	A
Bosmina cf. *tripurae* Kořinek *et al*., 1999	+	+	+	MA
Bosminopsis deitersi Richard, 1895 s.lat.	+	+	+	A
Family: Moinidae Goulden, 1968				
Moina micrura Kurz, 1874	+	+	+	R
Moinodaphnia macleayi (King, 1853)	+	+	+	R
Family: Macrothricidae Norman and Brady, 1867 *emend.* Dumont and Silva-Briano, 1998				
Macrothrix spinosa King, 1853	+	+	+	MA
Macrothrix rosea (Jurine, 1820)	+	+	+	R
Macrothrix triserialis (Brady, 1886)	+	+	+	A
Guernella raphaelis Richard, 1892	–	+	+	R
Family: Ilyocryptidae Smirnov, 1976 *emend.* Smirnov, 1992				
Ilyocryptus spinifer Herrick, 1882	+	+	+	R
Family: Chydoridae Dybowski and Grochowski, 1894 *emend.* Frey, 1967				
Subfamily: Chydorinae Dybowski and Grochowski, 1894 emend. Frey, 1967				
Chydorus sphaericus (Müller, 1776)	+	+	+	A
Chydorus ventricosus Daday, 1898	+	+	+	A
Chydorus parvus (Daday, 1898)	+	+	–	MA
Chydorus cf. *ovalis* Kurz, 1874	+	+	+	MA
Chydorus reticulatus Daday, 1898	+	+	+	R
Chydorus angustirostris Frey, 1987 s.lat	+	+	–	R
Chydorus eurynotus Sars, 1901. s.lat	+	+	–	MA
Pseudochydorus globosus (Baird, 1843) s.lat	+	+	–	MA
Ephemeroporus barroisi (Richard, 1894)	+	+	+	A
Dadaya macrops (Daday, 1898)	+	+	+	R
Disparalona caudata Smirnov, 1996	–	+	+	R
Alonella clathratula Sars, 1896	+	+	–	R
Alonella cf. *excisa* (Fischer, 1854)	+	+	+	R
Pleuroxus cf. *denticulatus* Birge, 1879	+	+	+	R
Pleuroxus cf. *trigonellus* (Müller, 1776)	+	+	–	R
Picripleuroxus cf. *quasidenticulatus* (Smirnov, 1996)	+	+	–	MA
Subfamily: Aloninae Dybowski and Grochowski, 1894 *emend*. Frey, 1967				
Flavalona cf. *costata* (Sars, 1862)	+	+	+	MA
Alona affinis (Leydig, 1860) s.lat.	–	+	+	R
Alona guttata Sars, 1862	+	+	+	MA
Flavalona cheni Sinev, 1999	+	+	+	R
Alona spp. 1	+	+	–	MA
Alona spp. 2	+	+	–	R
Alona spp. 3	+	+	–	R
Notoalona globulosa (Daday, 1898)	+	+	+	MA
Karualona karua (King, 1853)	+	+	+	MA
Karualona spp.	+	+	–	R

Table 1. (continued).

Taxa	OL	FP	DWR	Relative occurrences
Celsinotum macronyx (Daday, 1898)	+	+	–	A
Coronatella anodonta (Daday, 1905)	+	+	+	MA
Coronatella rectangula (Sars, 1862)	+	+	+	A
Coronatella cf. *acuticostata* (Stingelin, 1904)	+	–	+	R
Anthalona harti Van Damme, Sinev and Dumont 2011	+	+	–	R
Euryalona orientalis (Daday, 1898)	+	+	+	MA
Camptocercus uncinatus Smirnov, 1971	+	+	+	R
Graptoleberis testudinaria (Fischer, 1854) s.lat	+	+	–	R
Kurzia (Rostrokurzia) longirostris (Daday, 1898)	+	+	+	MA
Kurzia (Rostrokurzia) brevilabris (Rajapaksa and Fernando, 1986)	+	+	–	R

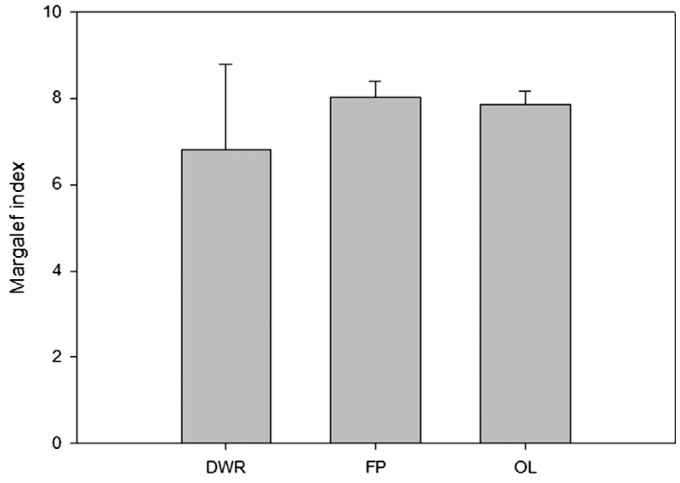

Fig. 2. Species richness (Margalef's index) of the floodplain wetlands of Subansiri (DWR: deep water rice field; FP: floodplain lake; OL: oxbow lake).

cladoceran fauna (Michael and Sharma, 1988) while Bosminidae and Daphniidae are subdominant groups in these climatic regions (Lansac-Tôha *et al*., 2009; Ghidini *et al*., 2009; Shah and Pandit, 2013). The representativeness of Chydoridae in number of species is a common pattern in many regions of the world and the results observed herein are often reported for other locations in East Asia (Sinev and Korovchinsky, 2013; Kotov *et al*., 2013). Regarding water bodies in the Indian subcontinent, Chydoridae also seems to have high richness (Sharma and Sharma, 2008; Shah and Pandit, 2013; Sharma *et al*., 2015). This can be partly explained by the specializations of Chydoridae to exploit many microenvironments and anti-predation refuges provided by the vegetation (Jones *et al*., 2000; Forró *et al*., 2008). Besides, diverse assemblages of cladoceran in floodplain wetlands might be related to factors such as climatic conditions, depth of water bodies and the perenniality of wetlands (Sa-ardrit and Beamish, 2005; Sousa *et al*., 2013).

The faunal similarity was higher between the OL and FP, which was of approximately 80%. Both environments are shallow and are greatly influenced by rivers through channels during the rainy season. In many cases, changes in the community structure of aquatic invertebrates in floodplains are driven by hydrological dynamics (Dias *et al*., 2016, 2017). Faunal homogenization can be a plausible result when species from lotic and lentic systems are combined in the same habitat (Bozelli *et al*., 2015). Thus, it is possible that the hydrological dynamics, with lotic systems being seasonally connected with lentic environments, may result in faunal similarities between OL and FP. Regarding the DWR, species composition was quite different from OL and FP due to the prevalence of slow flowing water and macrophytes (similarity approximated to 50%). The Margalef index results also indicate spatial variations of cladoceran communities (Fig. 2). Both wetlands presented a high number of rare species (Tab. 1), such as species with low abundances (Fig. 3). The number of rare species characterizes the numerical structure of communities (Warwick *et al*., 1987; Aoki, 1995) and explains the pattern of planktonic assemblages (Hwang *et al*., 2009).

The spring and summer seasons were found to be the most favourable periods for the population growth of cladocerans. Higher densities during summer–spring months was associated with an abundance of small-sized cladocerans such as

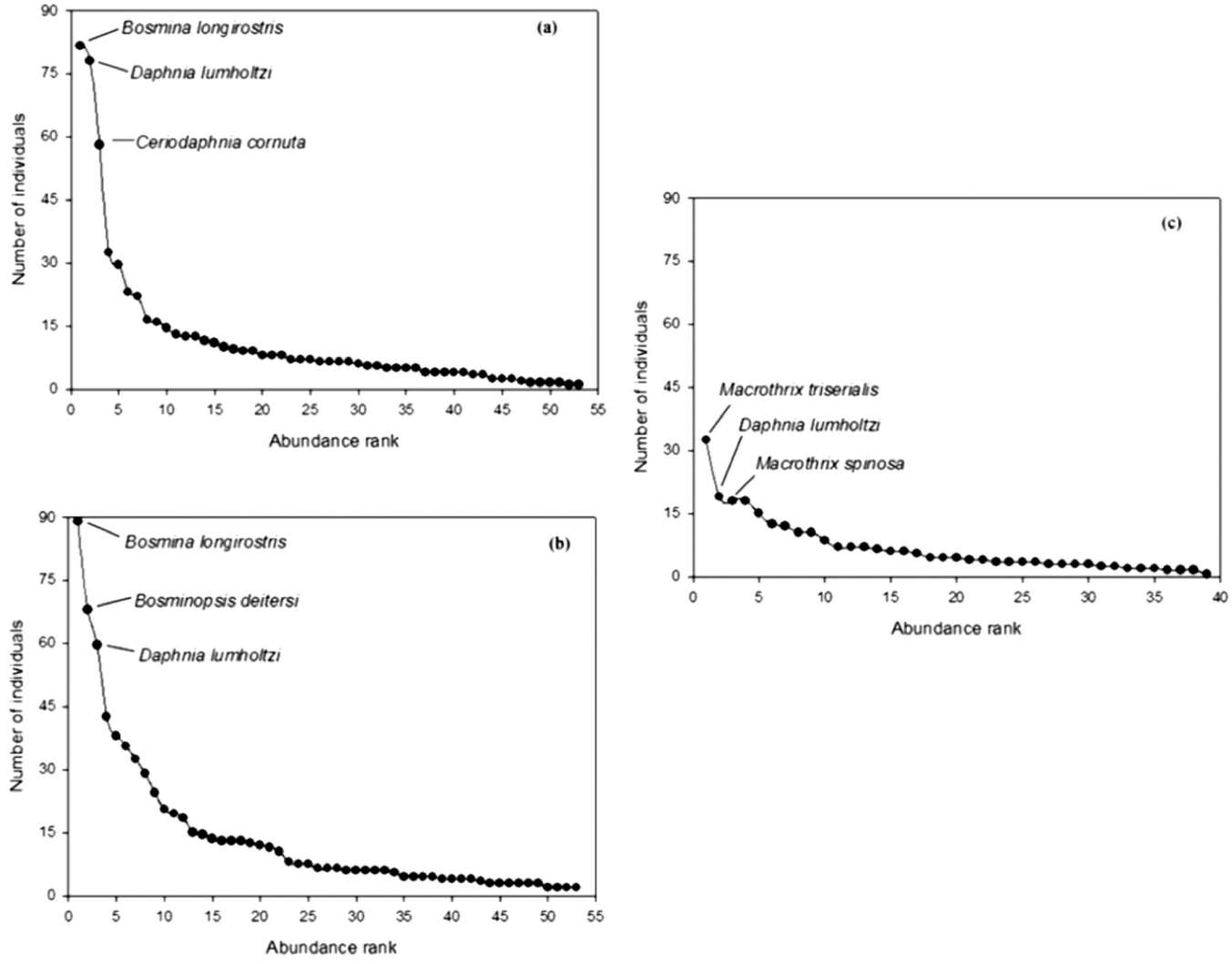

Fig. 3. Species abundance curves. (a) Floodplain lake. (b) Oxbow lake. (c) Deep water rice field.

Chydorus, *Alona*, *Dadaya*, *Ephemeroporus*, *Coronatella*, *Kurzia* and so on. Higher temperatures favour the development of small species and suppress the development of large species (Gillooly *et al*., 2002; Feniova *et al*., 2013). The summer peak might be related to multiple factors, including favourable temperature, high nutrient conditions, food availability and hatching of resting eggs (Dejen *et al*., 2004; Okogwu, 2010). The observed species richness was in conformity with the observation of Sharma *et al*. (2015) in the floodplain lakes of the Majuli River island. The species composition and density of cladoceran in floodplain ecosystems were probably regulated by temperature, food availability and their intrinsic interactions.

The cladoceran fauna of the Subansiri River floodplain wetlands were represented by biogeographically important taxa such as *Diaphanosoma dubium. Latonopsis australis*, *Simocephalus mixtus*, *Chydorus sphaericus*, *C. parvus*, *Chydorus* cf. *ovalis*, *Alonella clathratula*, *Pleuroxus* cf. *denticulatus*, *Picripleuroxus* cf. *quasidenticulatus*, *C. macronyx*, *Coronatella anodonta* and *Kurzia (Rostrukurzia) brevilabris.* Of these, *S. mixtus* and *P.* cf. *denticulatus* comprises new records for the Assam state.

Regarding the Sididae species, *D. dubium* (Manuilova, 1964) (Fig. 4, a–d) is an Asian tropical–subtropical species originally described from Russia. It was treated as *Diaphanasoma leuchtenbergianum* (Chiang and Du, 1979) until its description from India (Kanduru, 1981), Bangladesh (Hossain, 1982) and further records from India (Fernando and Kanduru, 1984). It was reported from East, South-East and South Asia (Korovchinsky, 1998). It is distributed in Assam, Central India and Delhi within India. *L. australis* Sars, 1888 (Fig. 4, e–g) was described from Australia; however, 12 setae were illustrated on dorsal ramus, which leads to describing it as *Latonopsis occidentalis* by Birge (1892) from Wincinson and as *Latonopsis breviremis* by Daday (1905). This is apparently a group of cryptic species (Korovchinsky, 2004). It is a common and widely distributed tropicopolitan species in South-East Asia (Kotov *et al*., 2013). It is reported from Andaman & Nicobar Islands, Goa, Karnataka, Maharashtra, Rajasthan, Tamil Nadu, Tripura, Assam and West Bengal within India.

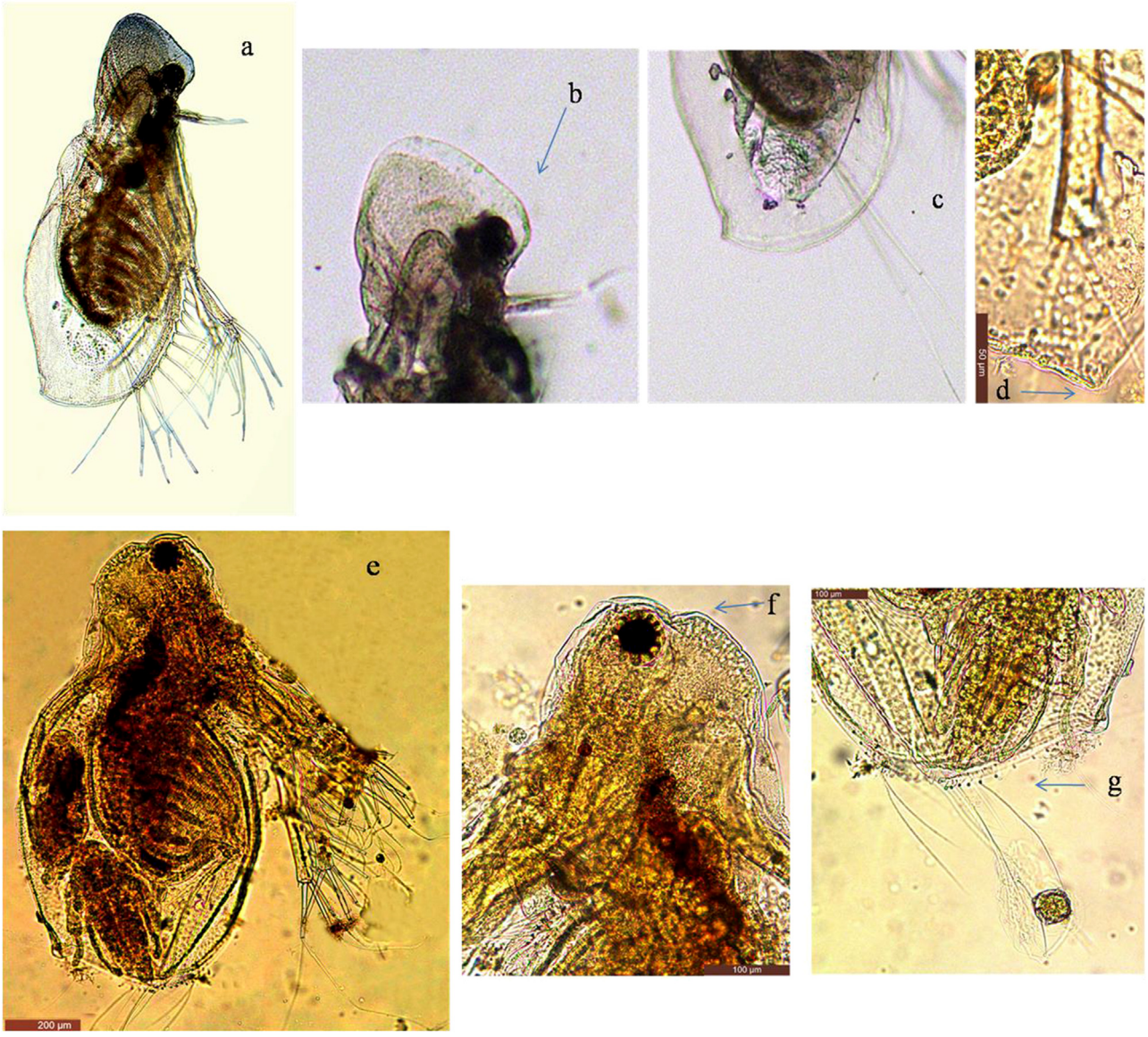

Fig. 4. Cladocerans (Sididae) from the Subansiri floodplain wetlands. (a–d) *Diaphanosoma dubium*: (a) lateral view; (b) head; (c) postabdomen with postabdominal setae; (d) posterodorsal corner; (e–g) *Latonopsis australis*: (e) lateral view; (f) head; (g) posterior protuberance with setae. Scale bars = 50–200 µm.

The Daphniidae *S. mixtus* Sars, 1903 (Fig. 5, a–e) was originally described from Mongolia by Sars (1903). It is a cosmopolitan species distributed in Asia, Eastern Europe, Northern Africa and North America (Orlova-Bienkowskaja, 2001). The *S. mixtus* is a new record for the state of Assam in addition to the reports of distribution from Manipur and Meghalaya within India.

In Chydoridae, *Chydorus sphaericus* (Müller, 1776) (Fig. 6, a–e) was originally described from Denmark. The *C. sphaericus* complex remains morphologically unrevised. The *C. sphaericus* complex is considered cosmopolitan (Elmoor-Loureiro, 1997; Sharma and Kotov, 2015), but its true diversity and biogeographical patterns remain unknown because of the taxonomical difficulties (Belyaeva and Taylor, 2009). This complex comprises a species assemblage with little morphological (Belyaeva, 2003) but significant molecular divergences (Belyaeva and Taylor, 2009; Kotov *et al.*, 2016). This pattern of cryptic diversity can be expected in Chydorid species groups (Frey, 1987; Van Damme *et al.*, 2010). It is distributed in Andhra Pradesh, Assam, Bihar, Jammu & Kashmir, Jharkhand, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Manipur, Meghalaya, Mizoram, Rajasthan, Tamil Nadu, Tripura, Uttarakhand and West Bengal within India. *C. parvus* (Daday, 1898) (Fig. 6, f–i) was originally described from Sri Lanka. It is widespread in the Oriental zone (Idris, 1983; Maiphae *et al.*, 2005) and one of the most common *Chydorus* species in India (Chatterjee *et al.*, 2013). It is common in the Ethiopian and Indo-Malayan regions (Smirnov, 1996). It is distributed in Andaman & Nicobar Islands, Andhra Pradesh, Jharkhand, Kerala, Meghalaya,

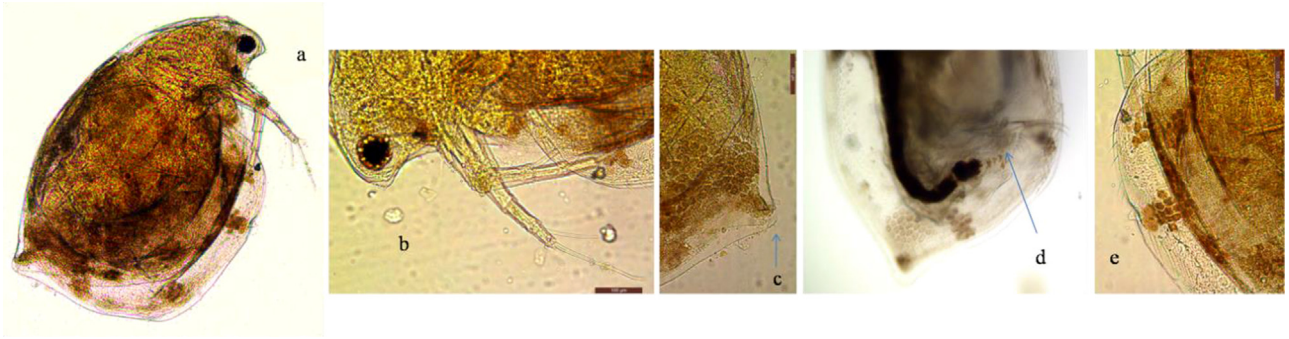

Fig. 5. Cladoceran (Daphniidae) from the Subansiri floodplain wetlands. (a–e) *Simocephalus mixtus:* (a) lateral view; (b) head with antennules and antennae; (c) posterior protuberance; (d) postabdomen; (e) ventral margin. Scale bars = 50–200 μm.

Punjab, Tamil Nadu, West Bengal and Assam within India. *Chydorus* cf. *ovalis* Kurz, 1874 (Fig. 6, j–l) was described from the Czech Republic and distributed throughout the Palaearctic region (Smirnov, 1976). It is distributed in Rajasthan, Jammu & Kashmir and Assam within India.

A. clathratula Sars, 1896 (Fig. 6, m–p) was originally described from Australia and was formerly treated as a subspecies of *Alonella excisa* by Smirnov (1971). Smirnov (1996) subsequently revived its specific status based on an elongated body and postabdomen, as well as a different distributional range. It occurs in Australia, the Neotropical and Ethiopian regions, and Java (Smirnov, 1996; Van Damme and Dumont, 2010). It is quite common in the Oriental zone (Sanoamuang, 1998; Maiphae *et al*., 2005; Tanaka and Ohtaka, 2010) while showing a cosmopolitan distribution. *A. clathratula* was apparently overlooked in studies in India, until its reports from Bihar (Sharma and Sharma, 2001), Assam (Sharma and Sharma, 2008, 2010) and Meghalaya (Sharma, 2010). It is distributed in Assam, Bihar, Kerala, Manipur and Meghalaya within India.

Pleuroxus cf. *denticulatus* Birge 1879, (Fig. 6, q–t) was described from North America by Birge (1879) and redescribed by Hudec and Illyova (1998) from Slovakia. It was reported from Italy (Margaritora, 1983), the Iberian Peninsula (Alonso, 1996), France (Amoros, 1984), Belgium (Dumont, 1989), England (Scourfield, 1907), India (Michael and Sharma, 1988), Central Africa (Kořinek, 1984) and Australia (Smirnov and Timms, 1983). It is Holarctic in distribution and other records should be reconsidered (Smirnov, 1996). It is a new record for the Assam state in addition to its distribution in Andaman & Nicobar Islands, Delhi, Goa, Jammu & Kashmir, Karnataka, Maharashtra, Uttarakhand and West Bengal.

Picripleuroxus cf. *quasidenticulatus* (Smirnov, 1996), (Fig. 7, a–d) was originally described from Australia by Smirnov (1996). It was redescribed by Sinev and Sanoamuang (2013) from specimens of Thailand, Vietnam and Russia. It was reported from Iraq and Argentina (Smirnov, 1996), Thailand (Maiphae *et al*., 2008) and Vietnam (Sinev and Korovchinsky, 2013). It was reported from India by Sharma *et al*. (2015) and we have confirmed its distribution in the Indian subregion within the Oriental region. It is reported only from Assam within India.

C. macronyx (Daday, 1898) (Fig. 7, e–i) was originally described from Sri Lanka by Daday (1898) as *Alona macronyx*. Brehm (1933) included it as *Alonella macronyx* in the species list of the Indo-Malaysian region. Smirnov (1974) assigned it to the genus *Indialona*, further Sinev and Kotov (2012) allocated it to the genus *Celsinotum.* The first Indian report of *A. macronyx* was referred to as *Indialona jabalpurensis*, a new species described by Rane (1983) from Madhya Pradesh, which was designated as a synonym of *A. macronyx* by Sharma and Sharma (1990) and reported as *C. macronyx*, a new record from Assam by Sharma and Sharma (2012). It is an oriental species widely found in India, Sri Lanka, Indo-China, Indonesia, Philippines, Vietnam and South China. It is distributed in Assam, Madhya Pradesh, Maharashtra and Meghalaya within India.

Coronatella anodonta (Daday, 1905) (Fig. 7, j–m) was described by Daday (1905) from Paraguay as *Alona anodonta*. Rajapaksa and Fernando (1982b) recorded a tuberculated form of *A. anodonta* as *Alona.* cf. *anodonta* from Sri Lanka. Van Damme *et al*. (2010) proposed to allocate *A. anodonta* to the genus *Coronatella*. Sharma and Sharma (2011) reported it as *Coronatella anodonta* from Meghalaya, India. Chatterjee *et al*. (2013) emphasize the need of a revision of this species, given that it is easily confused with *Coronatella rectangula*. It was reported from Assam, Meghalaya and Tamil Nadu within India.

Kurzia (*Rostrokurzia*) *brevilabris* (Rajapaksa and Fernando, 1986) (Fig. 7, n–q) is an oriental endemic, which was originally described from Thailand (Rajapaksa and Fernando, 1986b), while Hudec (2000) placed it to the subgenus *Rostrokurzia*. It was recently reported from Northeast India by Sharma and Sharma (2012) and the record of this species in the Subansiri floodplain wetlands confirms its distribution within the South Asian region. It was also reported from Sri Lanka, Philippines Iraq and Argentina (Smirnov, 1996), Thailand (Maiphae *et al*., 2008) and Vietnam (Korovchinsky, 2013). It is distributed in Assam and Uttarakhand within India.

The occurrences of these species could reveal links of the cladoceran fauna of India to those of South-East Asia and other regions of the world. Furthermore, the documentation of these species from the Subansiri floodplain wetland has confirmed their distribution in Indian River floodplain wetlands. Documentation of the Australasian *Disparalona caudata*, the Indo-Chinese *Flavalona cheni*, and the Oriental *C. reticulata* in the Subansiri floodplain wetlands has confirmed the occurrence of these important taxa in India. Among the species documented, *D. dubium* was reported as an Asian tropical–subtropical species, while *C. macronyx*, *Chydorus*

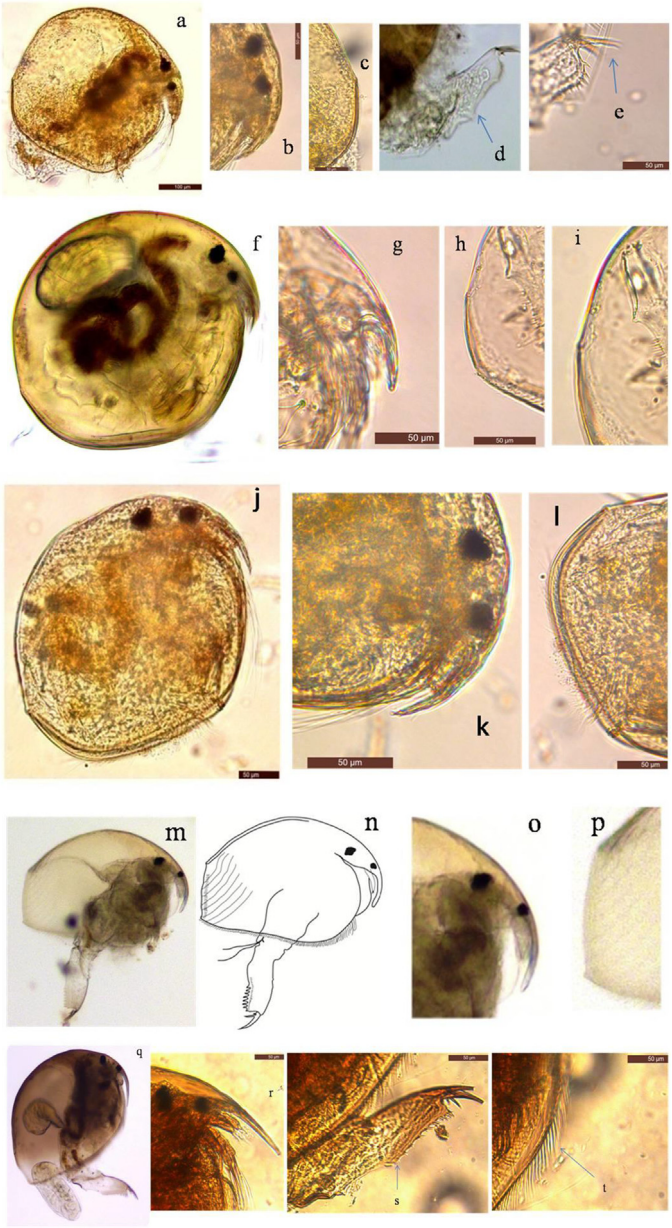

Fig. 6. Cladocerans (Chydoridae) from the Subansiri floodplain wetlands. (a–e) *Chydorus sphaericus*: (a) lateral view; (b) rostrum and antennules; (c) posterior margin; (d) postabdomen; (e) claw; (f–i) *C. parvus*: (f) lateral view; (g) rostrum and labrum; (h) posteroventral margin; (i) posterodorsal margin; (j–l) *Chydorus ovalis*: (j) lateral view; (k) rostrum and antennules; (l) posterior margin; (m–p) *A. clathratula*: (m) lateral view; (n) line drawing; (o) rostrum and antennules; (p) posterior margin; (q–t) *Pleuroxus* cf. *denticulatus:* (q) lateral view; (r) rostrum, antennules and labrum; (s) postabdomen; (t) ventral margin. Scale bars = 50–200 µm.

angustirostris and *Kurzia (Rostrukurzia) brevilabris* were reported as oriental species (Maiphae *et al*., 2008).

Many of the species such as *Daphnia lumholtzi*, *Latonopsis australis*, *Bosminopsis deitersi*, *Ceriodaphnia cornuta*, *M. spinosa*, *Chydorus sphaericus*, *Ilyocryptus spinifer*, *Kurzia longirostris*, *A. clathratula*, *Flavalona* cf. *costata*, *Coronatella* cf. *acuticostata*, *Pleuroxus* cf. *denticulatus*, *Euryalona orientalis*, *Simocephalus serrulatus* and *Picripleuroxus* cf. *quasidenticulatus* have been reported to show broad geographical distributions (Egborge *et al*., 1994; Davidson *et al*., 2000, Chiambeng and Dumont, 2004). Species such as *Coronatella anodonta*, *Simocephalus serrulatus*, *Camptocercus uncinatus*, *C. ventricosus*, *Notoalona globulosa*, *Graptoleberis testudinaria*, *Coronatella* cf. *acuticostata*, *A. clathratula*, *Alona guttata* and *Notoalona globulosa* were also found in the study area. They exhibit discontinuous distribution throughout India (Sharma and Sharma, 2014). Meanwhile, *Latonopsis australis*, *Bosmina longirostris*, *Moinodaphnia macleayi*, *Macrothrix triserialis*,

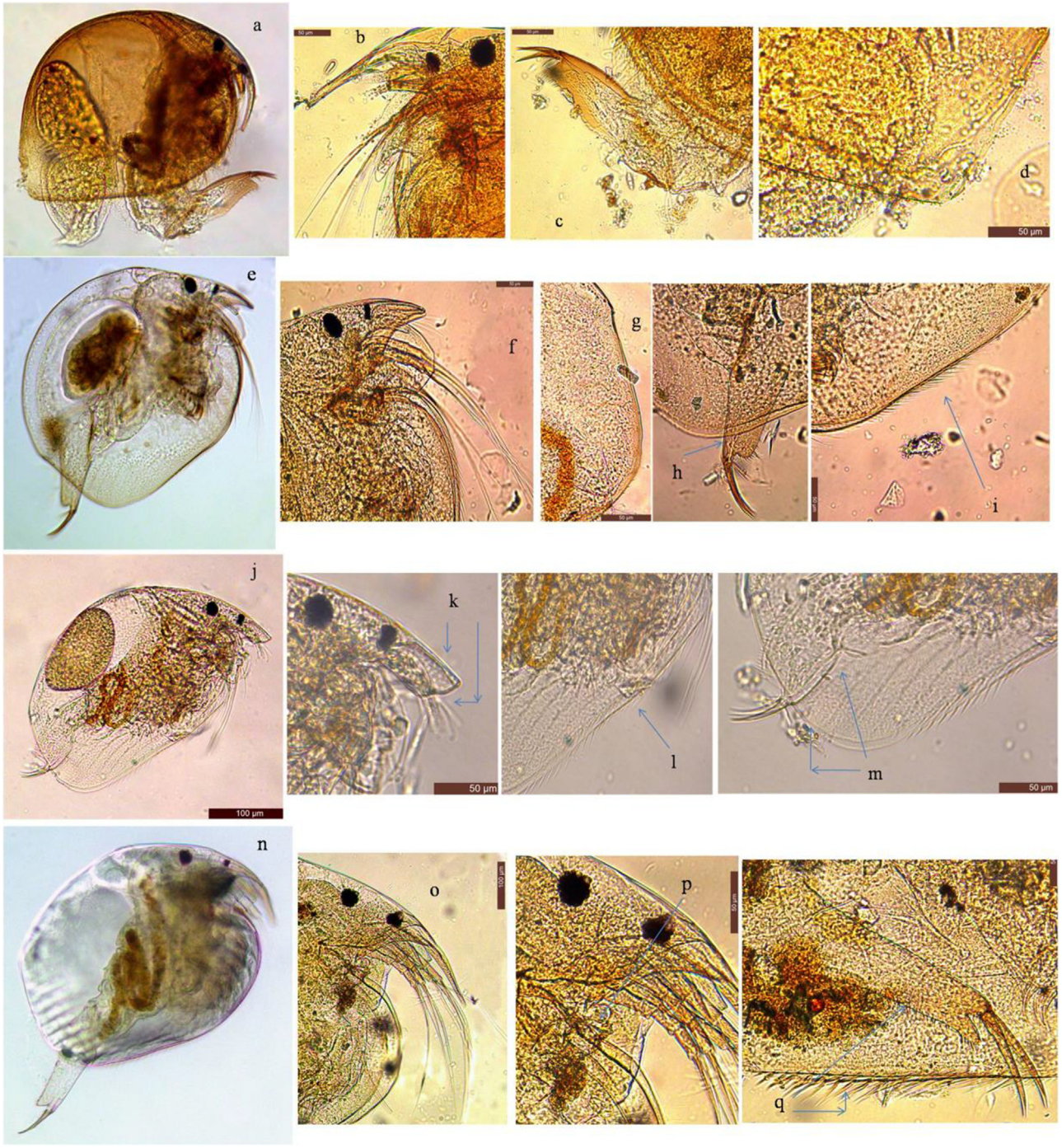

Fig. 7. Cladocerans (Chydoridae) from the Subansiri floodplain wetlands. (a–d) *Picripleuroxus* cf. *quasidenticulatus*: (a) lateral view; (b) rostrum, antennules and antennae; (c) postabdomen; (d) posterior corner; (e–i) *C. macronyx:* (e) lateral view; (f) rostrum, antennules, antennae and labrum; (g) posterior margin; (h) postabdomen; (i) ventral margin; (j–m) *Coronatella anodonta:* (j) lateral view; (k) rostrum and antennules; (l) ventral margin; (m) postabdomen and posterior margin; (n–q) *Kurzia* (*Rostrokurzia*) *brevilabris:* (n) lateral view; (o) rostrum, antennules and antennae; (p) labral keel and labrum; (q) postabdomen and ventral margin. Scale bars = 50–200 µm.

M. spinosa, *Guernella raphaelis*, *Kurzia (Rostrokurzia) longirostris*, *Dadaya macrops*, *C. eurynotus*, *C. ventricosus*, *C. parvus* and *Flavalona cheni* belong to the group of circumtropical species (Padhye and Dumont, 2015), also documented from similar habitats elsewhere. The cladoceran fauna of the Subansiri floodplain wetlands revealed tropical characteristics with cosmopolitan, cosmotropical and oriental elements. The rich faunal composition might be attributed to the diversification of habitats and ecological niches provided by macrophytes (Dejen *et al.*, 2004).

5 Conclusion

The cladoceran fauna of the Subansiri River floodplain wetland is comprised of cosmopolitan, cosmotropical and oriental elements. Faunal composition reveals the characteristics of tropical Cladocera with the occurrence of biogeographically interesting elements. The occurrences of several biogeographically important species highlight the importance of the biodiversity of Subansiri River floodplain wetlands. The records of globally interesting species contribute to the information on cladoceran biogeography. Even though baseline information gathered in the present study contributes with valuable information to the diversity and distribution of cladoceran in the Indian floodplain wetlands, we still do not possess enough information to draw conclusions concerning patterns in species richness. Further extensive sampling and continuous systematic efforts with recent morphological techniques and standards will definitely increase the total number of species reported for the region. Despite the presence of taxonomic uncertainties regarding certain species (Chatterjee *et al*., 2013), the distribution of the 55 species in the wetlands clearly supports the validity of other reports of certain species of Cladocera in India.

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