The Indian species of the genus *Brachionus* (Eurotatoria: Monogononta: Brachionidae)

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Abstract

The different species and infraspecific categories of the genus *Brachionus,* so far reported or described from India, are reviewed. Their distribution and taxonomic validity are discussed. Remarks are made on the ecology and epizoic nature of various species.

Introduction

Brachionus is the most ancient genus amongst monogonont rotifers (De Beauchamp 1965). It is the oldest valid generic name in the Rotatoria (Ahlstrom 1940).

The different species of this genus, like many planktonic Rotifera, may exhibit great morphological variability between habitats. Variations are reflected in size, shape and ornamentation of the lorica, in the relative size and shape of the occipital spines and in the presence or absence of posterior spines. Because of such variations, it may be difficult to decide upon the specific limits and to delimit the multitude of infraspecific categories.

Various Indian workers have applied infraspecific categories (forms, varieties etc.) without recourse to the original descriptions or without ascertaining their proper validity. This has lead to a number of taxonomic discrepancies in the various reports on the Indian taxa of *Brachionus.* The validity of these records is discussed in the present account. Remarks are also made on the distribution, ecology and epizoic nature of various species.

Regarding taxonomic concepts, the opinions expressed by Pejler (1977a) are followed.

Distribution

Brachionus is entirely missing in arctic areas but increases in importance as one approaches the Equator (Pejler 1977b). The abundance of *Brachionus* species in tropical rotifer faunas has been pointed out by Green (1972), Chengalath *et al.* (1974), Pejler (1977b) and Fernando (1980a, b). This generalisation also holds true for Indian Rotatoria (Sharma & Michael 1980).

Twenty species of *Brachionus* have so far been reported from this country, which is the highest number from South-East Asia. The total number of species recorded from the different States/Union Territories of India are indicated in Table 1. The maximum number of species are known from West Bengal and Panjab. The various species are common in Eastern India but rare in the Hill States of North-Eastern India (Sharma, unpublished) and at high altitudes in the North-Western region, particularly in Ladak (Edmondson & Hutchinson 1934), from where only two species have been reported.

B. angularis, B. calyciflorus, B. quadridentatus and *B. caudatus* appear to be widely distributed in India, *B. donneri, B. dimidiatus,* (?)*B. durgae* and *B. leydigi* show a restricted occurrence. Some other species exhibit no definite pattern but it may be premature to comment on those until more collec-

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Table 1.

States/Union Territories	No. of *Brachionus* spp. reported	Source
Andhra Pradesh	10	Naidu 1967; Dhanapathi 1974; Mohan & Rao 1976a, 1976b; Rao & Mohan 1977
Andaman & Nicrobar Islands	4	Sharma, unpublished
Arunachal Pradesh	–	–
Assam	12	Patil 1978; Sharma 1980b
Bihar	9	Nasar, 1973; Laal & Nasar 1978
Chandigarh (U.T.)	5	Vasisht & Gupta 1967
Delhi (U.T.)	7	George 1966
Goa (U.T.)	–	–
Gujarat	8	Wulfert 1966
Harayana	9	Sharma 1976; Sharma, unpublished
Himachal Pradesh	3	Sharma, unpublished
Jamu & Kashmir	7	Edmondson & Hutchinson 1934; Das & Akhtar 1971; Jyoti & Sehgal 1979, 1980
Karnataka	–	–
Kerala	7	Nayar & Nair 1969; Nair & Nayar 1971
Nagpur (Madhya Pradesh)	8	Arora 1963, 1966a, 1966b, 1966c
Maharastra	6	Sharma, in press
Meghalaya	4	Patil 1978; Sharma, unpublished
Manipur	1	Patil 1978
Mizoram	–	–
Nagaland	–	–
Orissa	10	Sharma 1977, 1980a
Panjab	14	Vasisht & Battish 1971; Sharma 1976, 1981
Rajasthan	10	Nayar 1968
Tamil Nadu (former Madras State)	8	Hauer 1937; Ahlstrom 1940; Brehm 1951; Michael 1973
Tripura	–	–
Uttar Pradesh	–	–
West Bengal	14	Anderson 1889; Sewell 1935; Tiwari & Sharma 1977; Sharma 1979a, 1979b

tions from the different parts of India have been examined. Indian taxa of *Brachionus* do not present any good example of endemism. (?)*B. durgae* Dhanapathi 1974 is known only from its original locality. *B. donneri*, described from Madras (Brehm 1951), has also been reported from Cambodia (Bērziņš 1973), Sri Lanka (Chengalath *et al.* 1973) and Gatun Lake, Panama (Koste & Jose de Paggi 1982).

Taxonomic remarks

The identity of seven species, *B. donneri, B. diversicornis, B. plicatilis, B. pterodinoides, B. leydigi, B. rubens* and *B. patulus*, is more or less clearly delineated (Figs. 1–9). However, other taxa are commented upon below:

Brachionus angularis Gosse: A cosmopolitan species, apparently widely distributed in India. Various earlier reports (Figs. 10–13) refer to the typical form. Arora (1963) identified Nagpur material as 'v. *bidens*' but it (Fig. 14) appears identical with typical *angularis* found elsewhere in this country.

Some specimens (Figs. 15–18) collected from Rajasthan (Nayar 1968) represent small forms. Ahlstrom (1940) reported a small form (Fig. 19), somewhat similar to f. *aestivus* Skorikov, from Sholavaram Lake (South India). Sudzuki (1964) states it to be only a young form while Koste (1978) designates it as 'v. *chelonis* Ahlstrom.'

Brachionus bidentata Anderson: This pantropical species was described from West Bengal (Anderson 1889) and has since been reported from a number of other States. Edmondson & Hutchinson (1934) listed *B. furculatus* Thorpe from Kashmir; this is a synonym of *B. bidentata.*

The material from West Bengal (Fig. 20) represents the typical form. Some other specimens from West Bengal (Fig. 21) and those from Orissa (Fig. 22) and Panjab (Fig. 23) refer to f. *crassispineus* (Hauer 1963). The forms (Fig. 24) reported by Vasisht & Battish (1971) are identical with f. *testudinarius* (Jakubski 1912).

In addition, Wulfert (1966) described f. *adorna* (Fig. 25) from Baroda. This form was also reported from West Bengal (Sharma 1979a) and Panjab (Sharma 1981).

Brachionus budapestinensis Daday (Fig. 26): A cosmopolitan species, reported from India only from Panjab (Vasisht & Battish 1971; Sharma 1981), West Bengal (Sharma 1979a) and Assam (Sharma 1980b).

Arora (1963) designated Nagpur specimens,

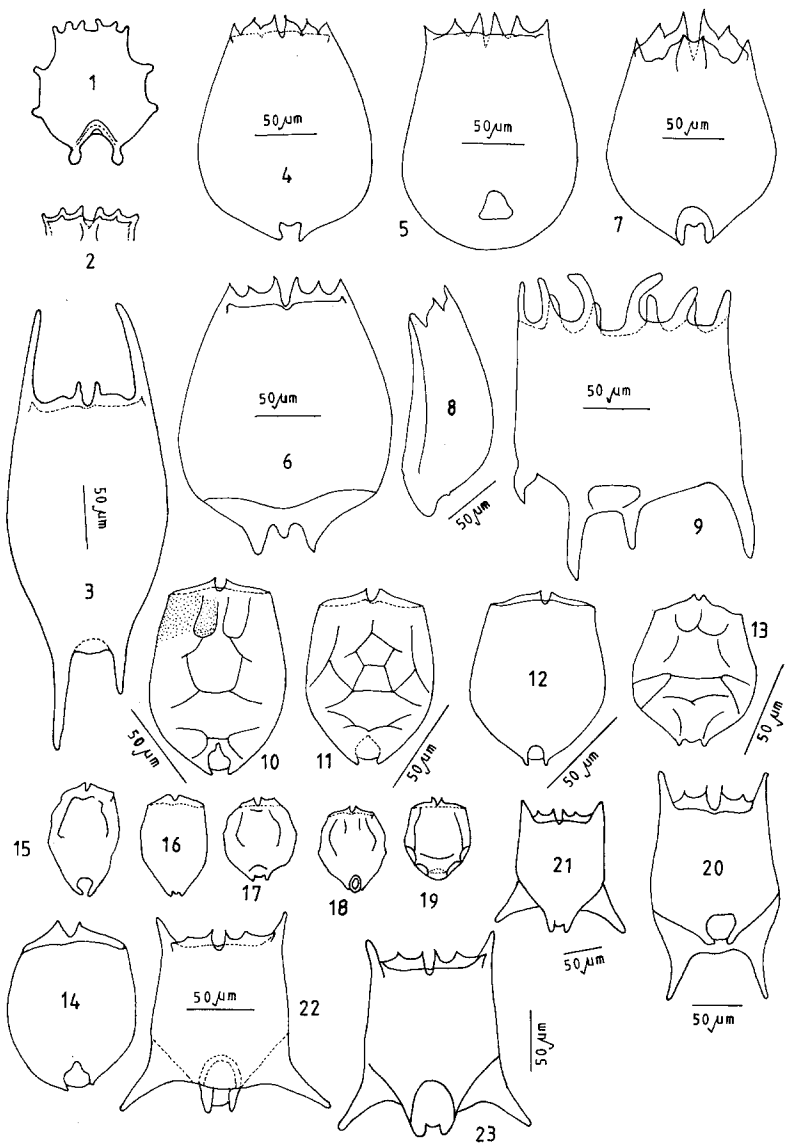
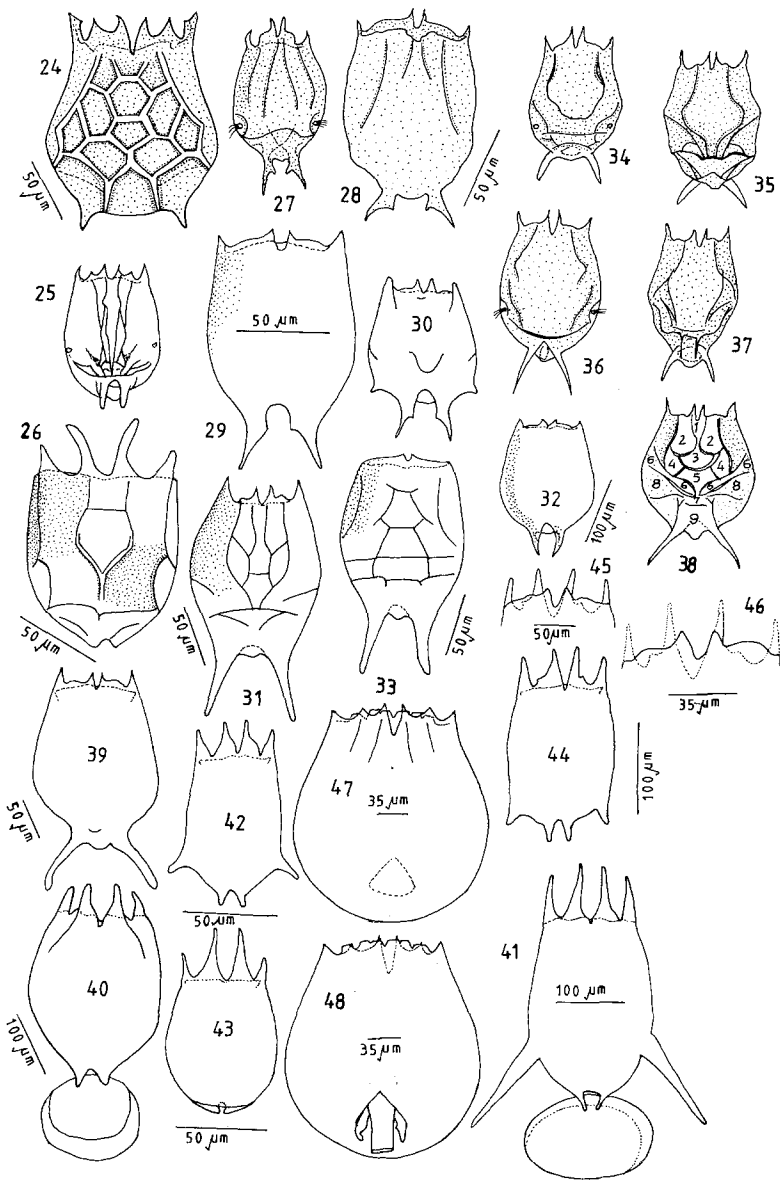
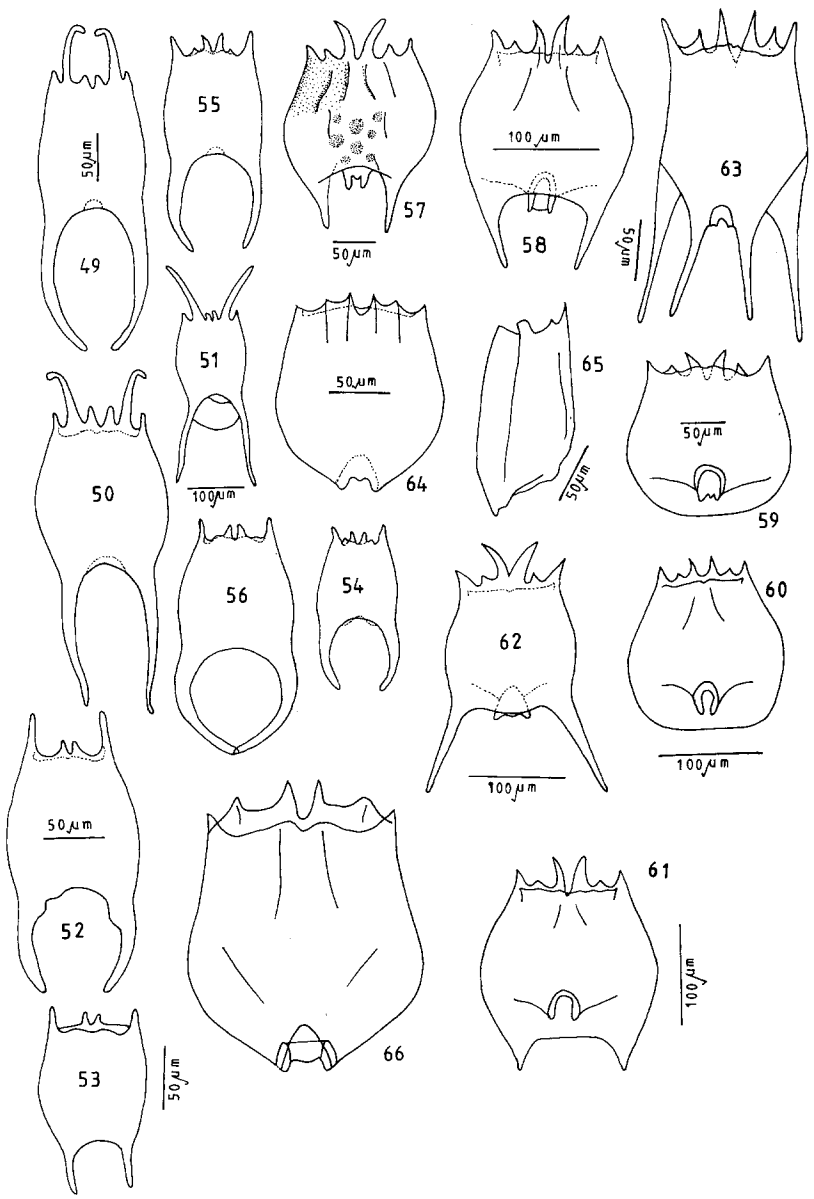


Fig. 1–23. B. donneri Brehm: *Fig. 1,* ventral view & *Fig. 2,* occipital margin (after Brehm 1951); *B. diversicornis* (Daday): *Fig. 3,* dorsal view, from Orissa (Sharma 1980a); *B. plicatilis* (O. F. Müller): *Fig. 4,* dorsal view, from West Bengal (Sharma 1979a); *B. pterodinoides* (Rousselet): *Fig. 5,* ventral view, from West Bengal (Sharma 1979a); *B. leydigi* Cohn: *Fig. 6,* ventral view, from Panjab (Sharma 1981); *B. rubens* Ehrenberg: *Fig. 7,* ventral view & *Fig. 8,* lateral view, from West Bengal (Sharma 1979a); *B. patulus* (O. F. Müller): *Fig. 9,* ventral view, from West Bengal (Sharma 1979a); *B. angularis* (Gosse): *Fig. 10,* dorsal view, from West Bengal (Sharma 1979a); *Fig. 11,* dorsal view, from Orissa (Sharma 1980a); *Figs. 12 & 13,* dorsal and ventral views, from Panjab (Sharma 1981); *Fig. 14,* ventral view, from Nagpur (Arora 1963); *Figs. 15–18,* small forms, from Rajasthan (Nayar 1968); *Fig. 19,* dorsal view, from Sholavaram Lake, South India (Ahlstrom 1940); *B. bidentata* Anderson: *Fig. 20,* ventral view, from West Bengal (Sharma 1979a); *B. bidentata* f. *crassispineus* (Hauer): *Fig. 21,* ventral view, from West Bengal (Sharma 1979a); *Fig. 22,* dorsal view, from Orissa (Sharma 1980a); *Fig. 23,* ventral view, from Panjab (Sharma 1981).



Figs. 24–48. B. bidentata f. *testudinarius* (Jakubski): *Fig. 24,* dorsal view, from Panjab (Vasisht & Battish 1971); *B. bidentata* f. *adorna* Wulfert: *Fig. 25,* dorsal view, from Baroda (Wulfert 1966); *B. budapestinensis* Daday: *Fig. 26,* dorsal view, from West Bengal (Sharma 1979a); *B. caudatus* f. *aculeatus* (Hauer): *Fig. 27,* dorsal view, from Baroda (Wulfert 1966); *Fig. 28,* ventral view, from Panjab (Vasisht & Battish 1971); *Fig. 29,* dorsal view, from West Bengal (Sharma 1979a); *Fig. 30,* dorsal view, from Rajasthan (Nayar 1968); *B. caudatus* f. *personatus* (Ahlstrom): *Fig. 31,* dorsal view, from West Bengal (Sharma 1979a); *B. caudatus* f. *apsteini* (Fadeew): *Fig. 32,* dorsal view, from Panjab (Sharma 1981) (Vasisht & Battish 1971); *B. caudatus* f. vulgatus Ahlstrom: *Fig. 33,* dorsal view, from West Bengal (Sharma 1979a); *B. caudatus* f. *personatus* (Ahlstrom): *Figs. 34–38,* dorsal view *(B. caudatus),* from Baroda (Wulfert 1966); *Fig. 39,* dorsal view (f. *majusculus*), from Rajasthan (Nayar 1968); *B. calyciflorus* Pallas: *Fig. 40,* dorsal view, from Panjab (Vasisht & Battish 1971); *B. calyciflorus* f. *anuraeiformis* (Brehm): *Fig. 41,* dorsal view, from Panjab (Vasisht & Battish 1971); *B. calyciflorus* f. *amphiceros* (Ehrb.): *Fig. 42,* dorsal view, from West Bengal (Sharma 1979a); *B. calyciflorus* f. *dorcas* (Gosse): *Fig. 43,* ventral view, from West Bengal (Sharma 1979a); *B. calyciflorus* f. *borgerti* (Apstein): *Fig. 44,* dorsal view and *Fig. 45,* occipital margin (ventral view), from West Bengal (Sharma 1979a); *Fig. 46,* occipital margin ('v. *hymani*' Dhanapathi), from Andhra Pradesh (Dhanapathi 1974); ?*B. durgae* Dhanapathi: *Figs. 47 & 48,* dorsal and ventral views, from Andhra Pradesh (Dhanapathi 1974).



Figs. 49–66. B. falcatus Zacharias: *Fig. 49,* dorsal view, from Orissa (Sharma 1980a); *B. falcatus* f. *lyratus* (Lemmermann): *Fig. 50, (B. falcatus),* dorsal view, from Kerala (Nair & Nayar 1971); *Fig. 51,* dorsal view *(B. falcatus),* from Bihar (Nasar 1973); *B. forficula* Wierzejski: *Fig. 52,* dorsal view, from Panjab (Sharma 1981); *B. forficula* f. *minor* (Voronkov): *Fig. 53,* ventral view, from Panjab (Sharma 1981); ?*B. forficula* v. *keralaiensis* Nayar & Nair: *Fig. 54,* dorsal view, from Kerala (Nayar & Nair 1969); *B. forficula* Wierzejski: *Fig. 55,* dorsal view, from Kerala (Nair & Nayar 1971); *Fig. 56,* dorsal view, from Sri Lanka (Changalath *et al.* 1973); *B. quadridentatus* (Hermann): *Fig. 57,* dorsal view, from West Bengal (Sharma 1979a); *B. quadridentatus* f. *clunirbicularis* (Skorikov): *Fig. 59,* ventral view, from West Bengal (Sharma 1979a); *Fig. 60,* ventral view, from Panjab (Sharma 1981); *B. quadridentatus* f. *rhenanus* (Lauterborn): *Fig. 61,* ventral view, from Panjab (Sharma 1981); *B. quadridentatus* f. *melheni* (Barrois & Daday): *Fig. 62,* dorsal view, from Orissa (Sharma 1980a); *B. mirabilis* Daday: *Fig. 63,* ventral view, from West Bengal (Sharma 1979a); *B. urceolaris* (O. F. Müller): *Figs. 64 & 65,* dorsal and lateral views, from West Bengal (Sharma 1979a); *Fig. 66,* ?'v. *urwaensis*', ventral view, from Andhra Pradesh (Naidu 1967).

with stippled lorica, as 'v. *punctatus*'. In view of the documented variations in the ornamentation of the lorica (Ahlstrom 1940; Koste 1978), Arora's material may not be treated as a separate variety.

Brachionus caudatus Barrois and Daday: A considerable variable species; represented by various taxonomic categories, as has been recognised by Ahlstrom (1940), Kutikova (1970) and Koste (1978). The author follows Pejler (1977a) and desists from using the term 'variety' but prefers to differentiate the morphological variants reported from India, as formae – *'aculeatus'* (Figs. 27–30), *'personatus'* (Fig. 31), *'apsteini'* (Fig. 32) and *'vulgatus'* (Fig. 33). Specimens (Figs. 34–38) from Baroda (Wulfert 1966) and those (Fig. 39) from Rajasthan (Nayar 1968) apparently seem identical with 'f. *personatus*'.

Brachionus calyciflorus Pallas: Because of great morphological variations, Indian workers have designated various infraspecific categories in this species. *B. calyciflorus* is represented from India by f. *typica* (Fig. 40), f. *anuraeiformis* (Fig. 41), f. *amphiceros* (Fig. 42), f. *dorcas* (Fig. 43) and f. *borgerti* (Figs. 44, 45). Of these, f. *dorcas* has been invariably designated as a 'variety'.

Dhanapathi (1974) described 'v. *hymani*' from Andhra Pradesh; it (Fig. 46) differed from f. *borgerti* only in the shape of its mental spines. However, *borgerti* samples collected from West Bengal (Sharma, 1979a) and Panjab (Sharma, 1981) also contained forms identical with Dhanapathi's taxon. In view of such variations, 'v. *hymani*' Dhanapathi is proposed to be a synonym of f. *borgerti* (Apstein).

Brachionus dimidiatus (Bryce): Distributed in Africa, South America and Europe; in India, it has been reported from Rajasthan only (Nayar 1968) but no illustration was given. Specimens of this brachionid were not available for present examination so as to confirm the earlier report.

Brachionus durgae Dhanapathi: This species (Figs. 47 & 48) was described from Andhra Pradesh (Dhanapathi 1974) and was compared with *B. pterodinoides* and *B. plicatilis.*

No specimen of *B. durgae* was available to ascertain the validity of this taxon. However, Dr. W. Koste (pers. comm.) considers it to be a doubtful species. In my opinion, it may probably be synonymous with *B. pterodinoides.*

Type locality: Hussain Sagar lake, Hyderabad (Andhra Pradesh).

Type specimens: not designated.

Brachionus falcatus Zacharias: Fairly common in the peninsular region and is represented by the typical form (Fig. 49). Arora (1963) identified Nagpur material as 'v. *lyratus*' but it seems identical with the typical specimens. Forms (Fig. 50) from Kerala (Nair & Nayar 1971) and some specimens (Fig. 51) from Bihar (Nasar 1973) refer to f. *lyratus* Lemmermann.

Brachionus forficula Wierzejski: This species is fairly widespread in India and is represented by the typical form (Fig. 52). In addition, f. *minor* (Fig. 53) has been reported from West Bengal (Sharma 1979a) and Panjab (Sharma 1981).

Nayar & Nair (1969) collected five specimens, with intermediate occipital spines and without swellings at the base of the posterior spines, from Irinjalakuda (Kerala); these were assigned to a new 'variety', *keralaiensis* (Fig. 54). Identical specimens (Fig. 55) from the same locality were subsequently identified (Nair & Nayar 1971) as *B. forficula.* Chengalath *et al.* (1973) reported almost identical forms from Sri Lanka (Fig. 56) that differed from the Irinjalakuda material in the absence of intermediate occipital spines. Such variations are also mentioned by Sudzuki (1964). In view of the above-mentioned facts, 'v. *keralaiensis*' appears not to be a valid taxon.

Brachionus quadridentatus Hermann: Perhaps the most variable species of *Brachionus.* It is represented from India by the typical form (Figs. 57 & 58), f. *cluniorbicularis* (Figs. 59 & 60) and f. *rhenanus* (Fig. 61).

B. quadridentatus specimens from Orissa (Sharma 1980a) are identical (Fig. 62) with 'subspecies *melheni*'; as the distribution of the latter is not geographically restricted, it is at present treated as f. *melheni.*

Brachionus mirabilis Daday (Fig. 63): It is a tropical form; proposed as subspecies of *B. quadridentatus* by Koste (1978). From India, it is known only from West Bengal (Sharma 1979a) and was identified following Koste's nomenclature. However, the author now prefers to retain it as a distinct species.

Brachionus urceolaris (O. F. Müller): Though cosmopolitan, this species has not been commonly reported from India. Specimens from

West Bengal (Figs. 54 & 65) refer to the typical form. Naidu (1967) reported (Fig. 66) 'v. *urawensis*' Sudzuki from Vijayawada (Andhra Pradesh). It may be mentioned that Sudzuki (1964) established *'urwaensis'* as a subspecies. However, Naidu's material broadly resembles typical *urceolaris* forms reported from India.

Brachionus sessilis Varga: This species is reported from India only from West Bengal (Sharma 1979b). *B. sessilis* has recently been treated as a subspecies of *B. urceolaris* (Koste 1978; Fernando & Zankei 1981). However, I prefer to designate it as a distinct species.

List of Indian taxa of *Brachionus*

As a result of the above-mentioned comments, the following Indian taxa of the genus *Brachionus* are recognized:

B. angularis (Gosse 1851)
Syn.: *B. angularis* v. *bidens* (Plate): Arora 1963, p. 117, Text – Fig. 5.
B. bidentata Anderson 1889
Syn.: *B. furculatus* Thorpe: Edmondson & Hutchinson 1934, p. 158.
B. bidentata f. *crassispineus* (Hauer 1963)
Syn.: *B. bidentata* Anderson: Sharma 1979a, p. 240, Figs. 7 & 8; Sharma 1981, p. 250, Fig. 5.
B. bidentata f. *testudinarius* (Jakubski 1912)
Syn.: *B. bidentata* Anderson: Vasisht & Battish 1971, p. 184, Fig. 21.
B. bidentata f. *adorna* Wulfert 1966
B. budapestinensis Daday 1885
Syn.: *B. budapestinensis* v. *punctatus* Daday: Arora 1963, p. 112, Text – Fig. 6.
B. caudatus f. *aculeatus* (Hauer 1937)
B. caudatus f. *personatus* (Ahlstrom 1940)
Syn.: *B. caudatus* Barrois & Daday: Wulfert 1966, p. 60–61, Abb. 5a–e.
B. caudatus f. *majusculus* Ahlstrom: Nayar 1968, p. 172, Fig. 9.
B. caudatus f. *apsteini* (Fadeew 1925)
B. caudatus f. *vulgatus* Ahlstrom 1940
B. calyciflorus Pallas, 1766
Syn.: ? *B. calyciflorus* v. *pala* (Ehrb.): Arora 1966a, p. 5, Text – Fig. 1d.
B. calyciflorus v. *brycei* De Beauchamp: Arora 1963a, p. 5, Text – Fig. 1e.
B. calyciflorus f. *anuraeiformis* (Brehm 1909)
Syn.: *B. calyciflorus* Pallas: Vasisht & Battish 1971, p. 180, Fig. 1.
B. calyciflorus f. *amphiceros* (Brehm 1909)
B. calyciflorus f. *dorcas* (Gosse 1851)
B. calyciflorus f. *borgerti* (Apstein 1909)
Syn.: *B. calyciflorus* v. *hymani* Dhanapathi 1974, p. 364, Plate II, Figs. 3 & 4.
B. dimidiatus (Bryce 1931)
B. diversicornis (Daday 1883)
B. donneri Brehm 1951
? *B. durgae* Dhanapathi 1974
B. falcatus Zacharias 1898
Syn.: *B. falcatus* v. *lyratus* (Lemmermann): Arora 1963, p. 119, Text – Fig. 7.
B. falcatus f. *lyratus* (Lemmermann 1908)
Syn.: *B. falcatus* Zacharias: Nair & Nayar 1971, p. 35, Fig. 41; Nasar 1973, p. 59, Plate II, Fig. 2.
B. forficula Wierzejski, 1891
B. forficula f. *minor* (Voronkov 1913)
? *B. forficula* v. *keralaiensis* Nayar & Nair 1969
B. leydigi Cohn 1862
B. mirabilis (Daday 1897)
Syn.: *B. quadridentatus mirabilis* (Daday): Koste 1978, p. 75, T. 11, Abb. 5a–d; Sharma 1979a, p. 244, Plate II, Figs. 12 & 13.
B. patulus (O. F. Müller 1786)
B. plicatilis (O. F. Müller 1786)
B. pterodinoides (Rousselet 1913)
B. quadridentatus (Hermann 1783)
B. quadridentatus f. *cluniorbicularis* (Skorikov 1894)
B. quadridentatus f. *rhenanus* (Lauterborn 1893)
B. quadridentatus f. *melheni* (Barrois & Daday 1894)
B. rubens Ehrenberg 1838
B. sessilis Varga 1951
Syn.: *B. urceolaris sessilis* (Varga): Koste 1978, p. 79, T. 9, Abb. 6a–c.
B. urceolaris (O. F. Müller 1773)
Syn.: ? *B. urceolaris* v. *urwaensis* Sudzuki: Naidu 1967, p. 385, Plate I, Fig. 3.

Remarks

Most species of *Brachionus*, reported from India, are pantropical or cosmopolitan forms of alkaline waters. No endemism is present in this country. *B. calyciflorus, B. caudatus, B. angularis, B. forficula, B. diversicornis* and *B. rubens* are important ele-

ments in the zooplankton of Indian waters.

B. angularis, B. calyciflorus and *B. rubens* represent eutrophic indicators from this country. The last two species are known for their sporadic blooms in the rural areas of peninsular India (Sharma, unpublished). Furthermore, their occurrence often coincides with the blooming of the blue-green alga *Microcystis aeruginosa.* An ability for co-existence of *Brachionus* species with blue-green algae is considered a pre-supposition for survival in tropical lakes (Pejler 1977b). The three species mentioned are frequently found to be infested with thick growths of Chlorococcales. *B. plicatilis* is reported to be an indicator of pollution in brackish water with low alkalinity (Rao & Mohan 1977). *B. falcatus, B. forficula* and *B. diversicornis* have been collected (Sharma, unpublished) from potable waters and reservoirs of water supply departments in the Indian peninsular.

Of the various Indian species, the phenomenon of cyclomorphosis has been observed in *B. calyciflorus* and *B. patulus.* A note on the morphometric variations (Mohan & Rao 1976a) in *B. angularis* indicated Indians forms to be relatively small.

The epizoic nature of some species has been commented upon by a few workers from this country. *B. rubens* has been reported (Nayar 1968) on the fairy shrimp, *Brachinella kugenumaensis,* on dragonfly nymphs (Mohan & Rao 1976b) and on various cladocerans (Sharma 1979b), i.e., *Daphnia carinata, Moina micrura, Diaphanosoma sarsi* and *D. excisum. B. caudatus* is noted to be epizoic on damselfly nymphs (Mohan & Rao 1976b) and on dragonfly nymphs (Sharma 1979b). *B. sessilis* (= *B. sessilis urceolaris*) has been reported (Sharma 1979b) on *Diaphanosoma excisum* and *D. sarsi.* Fernando & Zankei (1981) regarded this brachionid as exclusively epizoic on the genus *Diaphanosoma.*

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