

---

*A Revision of the Rotatorian Genera Brachionus and Platydios with  
Descriptions of One New Species and Two New Varieties*

BY ELBERT H. AHLSTROM

---

BULLETIN  
OF  
THE AMERICAN MUSEUM OF NATURAL HISTORY

VOL. LXXVII, ART. III, pp. 143-184

*New York*

*Issued July 30, 1940*

---





# Article III.—A REVISION OF THE ROTATORIAN GENERA *BRACHIONUS* AND *PLATYIAS* WITH DESCRIPTIONS OF ONE NEW SPECIES AND TWO NEW VARIETIES

BY ELBERT H. AHLSTROM

PLATES II TO XX

## THE ROTIFER GENUS *BRACHIONUS*

*Brachionus* is the oldest valid generic name applied to rotifers. It was first used by Pallas in 1766, eleven years before the publication of *Rotaria*, the next oldest generic name. Pallas included in this genus a varied assortment of animals, many of which were not even rotifers. The eighteenth century naturalists: O. F. Müller, Schrank, Hermann, and a few later workers (Blainville, Costa) placed rotifers of widely separated affinities in this genus. Thus we find rotifers in the following genera were described as brachionids by the above-mentioned workers: *Collothea*, *Epiphanes*, *Filina*, *Floscularia*, *Keratella*, *Lacinularia*, *Lecane*, *Lepadella*, *Monommata*, *Mytilina*, *Notholca*, *Rotaria*, *Squatinella*, *Testudinella*, and *Trichocerca*. As a result there was early a multiplication of species in the genus. Added to this is the marked variability within species of

*Brachionus*, leading to the multiplication of synonyms. In 1838 when Ehrenberg published his classical "Die Infusionsthierehen" he found at that early date that "In ganzen sind allmählig 69 artnamen gegeben, von denen hier nur 9 angewendet werden konnten." Since 1838 there have been a few over 69 additional species added, as well as numerous varieties. In this paper but 25 species are considered valid. The multiplication of synonyms indicates poignantly the marked variability within species of this genus.

In this paper the known variation tendencies of the species of *Brachionus* will be indicated. It is hoped that by portraying the variability found within species identification of species will be facilitated, while a curb will be placed upon the multiplication of synonyms.

## DISTRIBUTION

The genus *Brachionus* is world-wide in distribution. However, it is not potentially "cosmopolitan" as it is confined to waters with a hydrogen ion concentration above pH 6.6. It is entirely absent from acid waters. Myers (1937) states: "During a period of over twenty years collecting among the various bodies of acid water in Atlantic County, New Jersey, only four stragglers of the genus *Brachionus* have been recorded: *Brachionus capsuliflorus* (*quadridentatus*), three times, and *Platyias* (*Brachionus*) *patulus* (Müller), once" (p. 15). Some species of *Brachionus* are very widely distributed, being found in all parts of the world in favorable habitats, as *B. quadridentatus*, *B. angularis*, *B. calyciflorus*, and *B. urceolaris*. Other species are found in many parts of the world but less commonly, as *B. bidentata*, *B. rubens*, and *B. bennini*. Some species appear to be

subtropicopolitan, as *B. falcatus* and *B. mirabilis*; while *B. leydigii*, on the other hand, is confined apparently to cold waters (hibernal and vernal). Some species seem to have a definitely localized distribution. Thus *B. havanaensis*, one of the commonest species in North American waters, is apparently not found in the Old World; while *B. diversicornis* and *B. forficula* are common in eastern Europe, and adjoining parts of Asia while entirely absent from the American fauna. *B. plicatilis* has a world-wide distribution in highly alkaline or brackish waters: in fact, it is so often encountered in brackish situations that it is a valuable "indicator" species.

A number of the species of *Brachionus* have been found in very few habitats. Thus *B. variabilis* is known from a few widely separated localities in the United States, *B. pterodinoides* from several brackish

American waters, *B. novae zelandiae* from New Zealand and South Africa, *B. zahneri* from Florida, Texas, and North Carolina, *B. dimidiatus* from three localities in Africa, etc. Many of these rare species will probably be found to have a localized geographic distribution.

#### VARIATION

Species of *Brachionus* vary markedly, so much so that it is at times rather difficult to decide upon specific limits. A species may show considerable variation in a habitat on the same date of collection (as is usually the case with *B. calyciflorus*, *B. quadridentatus*, and *B. variabilis*) or, if variability of a species on a given date of collection is not marked, the species may present considerable seasonal variation in the same habitat.

Species of *Brachionus* usually show greater variability from habitat to habitat than they do in the same body of water. This may be true of neighboring bodies of water that are quite different ecologically. Thus in the Bass Island region of Lake Erie there is a marked difference in size, ornamentation, etc., of the species of *Brachionus* found in shallow bays of the lake proper and the same species found in the true ponds on the Bass Islands. Variability is likely to be more marked between bodies of water that are rather widely separated geographically. Thus the form of *B. caudatus* found everywhere in northern Ohio has little resemblance to the form of this variety found in a number of collections from northeast Brazil.

A species of *Brachionus* usually presents considerable variation in the size, shape, and ornamentation of the lorica, in the relative size and shape of the occipital spines, and in the development, length, and shape of posterior spines (if present).

The widely distributed species of *Brachionus* are found to differ at least 100 per cent in the size of mature individuals between extreme habitats. Thus mature *Brachionus plicatilis* in a brackish creek near Bayboro, N. C., is only 125 $\mu$  long and 105 $\mu$  wide; while the same species in a pool near Tso Kar in northern India is 315 $\mu$  long and 260 $\mu$  wide. In the other locali-

ties from which material of this species was available the mature individuals were intermediate in size between the two extremes. Several species, viz., *B. angularis*, *B. caudatus*, *B. calyciflorus*, *B. quadridentatus*, *B. bidentata*, *B. forficula*, and *B. havanaensis* show greater differences in size between extreme habitats than 100 per cent.

Occipital spines are quite variable in length, both in the same habitat and in different habitats. However, in most species of *Brachionus* the proportions between occipital spines are constant enough to be an important taxonomic character. Thus in *B. calyciflorus* and *B. quadridentatus* the median spines are always longer than the laterals, in *B. bidentata*, *B. forficula*, and *B. havanaensis* the laterals are always longer than the median spines, while in *B. falcatus* the intermediate pair of occipital spines are much longer than either of the other two pairs.

To illustrate the great variation in length of occipital spines in different habitats two examples of extreme cases will be cited: *B. calyciflorus* in Buckeye Lake in central Ohio (February, 1933) had anterior median spines 220 $\mu$  long, and anterior lateral spines 100 $\mu$  long, while a reduced form of this species from Staffelfelden, France, had anterior median spines only 25 $\mu$  long and anterior lateral spines only 15 $\mu$  long; *B. bidentata* from W. Bloemfontein, S. Africa, had anterior lateral spines 97 $\mu$  long, medians 34 $\mu$  long, while a reduced form of the species from a roadside ditch near Palmdale, Florida, had anterior lateral spines only 16 $\mu$  long, medians 12 $\mu$ . In reduced forms of *Brachionus* the length of occipital spines is usually more reduced proportionately than is the lorica.

Posterior spines are present on more than half of the species of *Brachionus*. Several



of the species which normally have postero-lateral spines do have reduced forms lacking posterior spines, as *B. bidentata*, *B. quadridentatus*, and *B. variabilis*. In *B. calyciflorus* the form lacking postero-lateral spines is the more common form, and is often larger in size than the form with well-developed posterior spines. Several species often have an asymmetric development of the posterior spines, as *B. diversicornis* and *B. havanaensis*, and on such forms the right spine is longer. In *B. havanaensis* and *B. forficula* forms do occur in which both posterior spines are greatly reduced, while in *B. falcatus* and *B. zahniseri* the posterior spines are apparently al-

ways well developed.

Body ornamentation on *Brachionus* may consist of any of the following or combinations thereof: fine stippling of the lorica; tuberculate or pustulate lorica, at times with the tubercules arranged in regular rows and patterns; patterns of cuticular ridges; patterns of irregular polygonal areolations; or a pattern of irregular wavy lines, which when foreshortened may give the illusion of pitting. Fine stippling or patterns of cuticular ridges are the more common types of ornamentation. The lorica of most species of *Brachionus* may be, on some individuals, but lightly stippled to nearly smooth.

#### CHARACTERS IMPORTANT TAXONOMICALLY

The internal anatomy of brachionids is rather uniform from species to species, and is of little aid in drawing taxonomic distinctions. The trophi, of such importance in the taxonomy of notammatid rotifers, are too uniform in the various species of *Brachionus* to be used as a taxonomic character. The wrinkled foot, present in all species of *Brachionus*, is of some slight importance in separating species of *Brachionus*. The lorica, on the other hand, is exceedingly variable in size, shape, and ornamentation in the genus *Brachionus*, and it is upon the size, shape, and ornamentation of the lorica that species of *Brachionus* are separated.

The lorica in *Brachionus* is usually rather rigid and divided into a dorsal and a ventral plate. In a few species the lorica is not separated into definite plates (*B. calyciflorus*, *B. plicatilis*); and in several species there is a third plate, the basal, more or less developed (esp. *B. bidentata* and *B. leydigii*).

The anterior dorsal edge of the lorica usually carries several spines, most often six. The number, shape, and relative length of the dorsal occipital spines is of taxonomic importance.

The anterior ventral edge (mental or pectoral margin) of the lorica is usually rigid, elevated, with an undulate margin and a central sinus, often flanked by a papilla-like process. However, it may be

flexible and lack the median sinus (as in *B. bidentata* and *B. pterodinoides*); or it may have a different appearance from that noted (*B. plicatilis*, *B. satanicus*). The form of the mental edge is an important taxonomic character.

Usually the foot opening is at the posterior end of the lorica in *Brachionus* and is formed by a small sub-square aperture in the dorsal plate and a larger usually oval aperture in the ventral. However, the shape and position of the foot opening vary from species to species and are important taxonomic characters. In several species there is a definite foot sheath surrounding the opening (*B. quadridentata*, *B. bidentata*, *B. mirabilis*), usually accompanied by spine-like protuberances on either side of the foot opening, which are very long in *B. mirabilis*.

The presence of posterior spines is an important taxonomic character, coupled with the point of origin of the posterior spines. Thus in *B. havanaensis* and *B. diversicornis* the posterior spines are close together at their bases, while in *B. forficula*, *B. zahniseri*, *B. falcatus*, *B. mirus*, etc., they are wide apart at their bases.

Other characters of importance taxonomically are the position of the lateral antennae, the type of ornamentation of the lorica, the shape and ornamentation of the resting (mictic) eggs.

## REPRODUCTION

The sexes are separate in *Brachionus*, and the usual form encountered in nature is the female. All forms illustrated in this paper are females. The male of *Brachionus* is much smaller than the female, lacks spines, trophi, digestive system, and has a large sperm sac in place of an ovary. The male of *Brachionus*, as of most rotifers, may be considered a degenerated form.

In *Brachionus* (and many other genera of rotifers) two kinds of eggs are formed by distinct categories of females. One type of egg is absolutely parthenogenetic, lacking a meiotic reduction division, retaining two complete complements of chromosomes, and developing without fertilization into a female. This type of propagation is spoken of as amixis, and the females that produce such parthenogenetic, diploid eggs, are called amictic females.

Some females produce a second type of egg, smaller than the amictic, in which a true meiotic division has occurred. Such eggs have a haploid number of chromosomes and are facultatively parthenogenetic, developing into males if unfertilized. If such eggs are fertilized during their early development they become somewhat larger, thick-shelled resting eggs on which the shell is ornamented with papillae, or pitted. Resting eggs eventually develop into females.

Although it has been known that one type of female produces only one type of egg, either mictic or amictic, it was assumed that the only difference between the females was physiological. Recently Hauer (1937) has reported a case of morphological dimorphism between the mictic and amictic females of *Brachionus leydigii*. There is both a sexual dimorphism and a morphological dimorphism between the two types of females. I noted this same phenomenon in *Brachionus angularis* in 1934. The material on which my observations were based was collected in Swan Creek in northwestern Ohio in 1931. It contained both mictic and amictic females of *Brachionus angularis*, together with a few males of the species. Mictic females could readily be distinguished from amictic

females by the type of egg they were carrying. Mictic eggs have a thick, pustulated surface. Amictic eggs are larger, with a thinner, clear surface. The mictic females were noticeably different from the amictic morphologically, having pronounced markings on the dorsal plate and having the intermediate occipital spines quite obliterate (Pl. V, fig. 6). The amictic females had small intermediate occipital spines, had the dorsal markings on the lorica very indistinct (if indeed it was present at all), the lorica was a little larger in size, more pointed posteriorly, and had a differently shaped foot opening than the amictic (Pl. V, fig. 8). The mictic females were carrying two types of eggs: numerous small unfertilized male eggs, or a few somewhat larger resting eggs; amictic females were usually carrying but a single, large, smooth egg.

*Brachionus angularis* is a very variable species, as most rotifer workers know. The dimorphism found will not account for all the variability in form known for this species, but it will aid in clearing up the variability found for this species within a given habitat.

In experiments conducted by Moro and Whitney upon *Brachionus calyciflorus* it was found when the general cultural conditions were constant and uniform only female-producing females are produced. This was true of both nutrition and temperature. When the cultural conditions were suddenly changed by the disappearance of an abundant diet, by a marked increase in the food supply, or by a rise or fall in temperature, male-producing females were produced at once. Jen-Pao Chu, working on the life span of *Brachionus calyciflorus*, found the length of the embryonic period to vary from 2 to 5 days (mean: 3 days for females, 2 days for males), the life span to vary from 12 to 19 days for females (av. 14.7 days) and 3 to 6 days for males (av. 4 days).

Species of *Brachionus* cannot be dried and later revived by placing in water, as can the bdelloid rotifers. This inability to withstand desiccation seems to hold for



all species of rotifers that produce mictic eggs.

An artificial key to the species of *Brachionus* is proposed. It must be used with caution due to the great variability displayed by species of this genus. For most species of *Brachionus* the number of occipi-

tal spines is constant, and this character is used as the basis for separating groups of species in the key. However, in *B. angularis* and especially in *B. caudatus* the development of the occipital margin is extremely variable, hence, it is necessary to key these out under a number of divisions.

#### KEY TO SPECIES OF *Brachionus*

- A.—Occipital spines six
  - B.—Anterior lateral spines longest
    - C.—Basal plate present, mental margin flexible, median sinus lacking. . . *B. bidentata*.
    - CC.—Basal plate wanting, mental margin rigid
      - D.—Posterior spines wide apart at base. . . . . *B. mirus*.
      - DD.—Posterior spines quite close together
        - E.—Extension of dorsal plate overhanging foot opening. . . . . *B. caudatus* var. *personatus*.
        - EE.—No extension of dorsal plate over foot opening
          - F.—Anterior medians seldom more than 20 $\mu$  long. . . *B. havanaensis*.
          - FF.—Anterior medians more than 30 $\mu$  long. . . *B. havanaensis* *trahea*.
    - BB.—Anterior intermediate spines longest. . . . . *B. falcatus*.
    - BBB.—Anterior median spines longest
      - C.—Posterior spines developed
        - D.—Sheath surrounding foot opening
          - E.—Foot sheath prolonged into long spines. . . . . *B. mirabilis*.
          - EE.—Foot sheath not prolonged into long spines. . . . *B. quadridentatus*.
        - DD.—No definite foot sheath
          - E.—Both anterior laterals and medians quite long, laterals about equal in length to medians. . . . . *B. zahniseri*.
          - EE.—Anterior laterals much shorter than medians, or both pairs quite short
            - F.—Mental margin with four spine-like protuberances. . . . . *B. satanicus*.
        - FF.—Mental margin irregularly elevated toward the center
          - G.—Extensions of dorsal plate overhanging foot opening
            - H.—Sub-square extension. . . . . *B. variabilis*.
            - HH.—Extension triangular or rounded. . . *B. caudatus*.
          - GG.—No extension overhanging foot opening. . . . . *B. novae zelandiae*.
    - CC.—Posterior spines wanting
      - D.—Sheath surrounding foot opening
        - E.—Sheath but slightly developed, mental margin without median sinus. . . . . *B. pterodinoides*.
        - EE.—Sheath more or less well developed, mental margin with median sinus. . . . . *B. quadridentatus*.
      - DD.—No definite foot sheath
        - E.—Sub-square extension of dorsal plate overhanging foot opening. . . . . *B. variabilis*.
        - EE.—Sub-square extension wanting
          - F.—Mental margin divided into 4 lobes. . . . . *B. plicatilis*.
          - FF.—Mental margin not so divided
            - G.—Lorica with a pattern of irregular polygonal areolations. . . . . *B. leydigii*.
            - GG.—Lorica with a different type of ornamentation, if present
              - H.—Lorica with a pattern of wavy lines
                - J.—Lorica truncate posteriorly in lateral view. . . . . *B. bennini*.
                - JJ.—Lorica pointed posteriorly in lateral view. . . . . *B. urceolaris*.
              - HH.—Lorica usually lightly stippled
                - J.—Occipital spines saw-tooth. . . . *B. rubens*.
                - JJ.—Occipital spines thin, not saw-tooth. . . . . *B. nilsoni*.

- AA.—Occipital spines less than six  
 B.—Occipital spines four  
   C.—Lorica not separated into definite dorsal and ventral plates  
     D.—Posterior spines often developed, anterior spines broad-based, medians longer..... *B. calyciflorus*.  
   DD.—Posterior spines wanting, anterior spines not broad-based, laterals usually longer, size small..... *B. dimidiatus*.  
 CC.—Lorica definitely separated into dorsal and ventral plates  
   D.—Laterals much longer than medians  
     E.—Posterior spines close together at their point of origin, and lacking knee-like swellings on inner side near base..... *B. diversicornis*.  
     EE.—Posterior spines wide apart at base, and with knee-like swellings on inner side..... *B. forficula*.  
   DD.—Anterior medians longer than laterals  
     E.—Both anterior medians and laterals well developed..... *B. budapestinensis*.  
     EE.—Either laterals or intermediates may be present as weakly developed spines  
       F.—Posterior spines present..... *B. caudatus*.  
       FF.—Posterior spines wanting..... *B. angularis*.  
 BB.—Occipital spines two  
   C.—Foot opening flanked by anchor-shaped spines..... *B. dolabratus*.  
 CC.—Foot opening without anchor-shaped spines  
   D.—Posterior spines usually well developed..... *B. caudatus*.  
   DD.—Posterior spines wanting..... *B. angularis*.  
 BBB.—Occipital spines wanting..... *B. dimidiatus* var. *inermis*.

As a further aid in separating groups of species of *Brachionus*, and thus facilitating identification, the following characters common to groups of species are listed.

Species lacking posterior spines: *Brachionus plicatilis*, *dimidiatus*, *dimidiatus* var. *inermis*, *budapestinensis*, *angularis*, *pterodinoidea*, *urceolaris*, *rubens*, *bennini*, *nilsoni*, and *leydigii*.

Species always possessing posterior spines: *Brachionus caudatus*, *caudatus personatus*, *caudatus aculeatus*, *forficula*, *havanaensis*, *havanaensis trahea*, *diversicornis*, *zahniseri*, *falcatus*, *satanicus*, *mirabilis*, *novae zelandiae*, *mirus*, *dolabratus*.

Species lacking posterior spines on some individuals: *Brachionus quadridentatus*, *bidentata*, *variabilis*, *calyciflorus*.

Occipital spines wanting: *Brachionus dimidiatus* var. *inermis*.

Occipital spines usually two: *Brachionus angularis*, *dolabratus*.

Occipital spines four: *Brachionus calyciflorus*, *budapestinensis*, *dimidiatus*, *diversicornis*, *forficula*.

Occipital spines six: Laterals longest—*Brachionus havanaensis*, *bidentata*, *mirus*, *havanaensis trahea*.

Intermediates longest—*Brachionus falcatus*.

Medians longest—*Brachionus plicatilis*,

*zahniseri*, *satanicus*, *mirabilis*, *quadridentatus*, *variabilis*, *novae zelandiae*, *pterodinoidea*, *urceolaris*, *nilsoni*, *bennini*, *rubens*, *leydigii*.

Lorica usually smooth or lightly stippled: *Brachionus plicatilis*, *dimidiatus*, *pterodinoidea*, *rubens*, *nilsoni*, *havanaensis*, *havanaensis trahea*, *diversicornis*, *falcatus*, *satanicus*, *mirabilis*, *novae zelandiae*, *variabilis*, *calyciflorus*.

Lorica usually with a pattern of cuticular ridges: *Brachionus angularis*, *caudatus*, *forficula*, *budapestinensis*, *bidentata*, *leydigii*.

Lorica often heavily stippled to tuberculate: *Brachionus quadridentatus*, *angularis*, *caudatus*, *dolabratus*, *budapestinensis*, *forficula*, *mirus*, *zahniseri*.

Lorica with a pattern of wavy lines: *Brachionus urceolaris*, *bennini*.

Lorica with a pattern of irregular polygonal areolations: *Brachionus leydigii*.

Lorica not sharply separated into dorsal and ventral plates: *Brachionus plicatilis*, *calyciflorus*, *dimidiatus*.

Basal plate more or less developed: *Brachionus bidentata*, *leydigii*, *urceolaris*, *bennini*, *rubens*, *nilsoni*.

Species commonly occurring in, or confined to, brackish or highly alkaline habitats: *Brachionus plicatilis*, *calyciflorus*, *dimidiatus*, *dimidiatus* var. *inermis*, *angularis*, *caudatus*, *havanaensis*, *havanaensis*



*trahea*, *zahniseri*, *quadridentatus*, *satanicus*, *pterodinoides*, *urceolaris*.

I am greatly indebted to Mr. Frank J. Myers for material and notes on *Brachionus*, to Mr. W. T. Edmondson and Dr. G. E. Hutchinson for essential material from South Africa and northern India, to Dr. R. W. Miner of The American Museum of Natural History for the loan of the *Brachionus* collection of the museum, to the late David Bryce for material from Abyssinia, to G. Garner of London, England, for material of *Brachionus urceolaris* (*sericus*), to Dr. P. de Beauchamp for material and friendly advice, to Dr. Carlin-Nilson for material from Sweden, Austria, and Czechoslovakia, to Dr. Jerzy Wiszniewski for appreciated bibliographical and literature aids, to Dr. Stillman Wright for material from Brazil and Argentina, to John Hauer for material of his new variety, *Brachionus angularis aculeatus*, and to Dr. R. C. Petrie, Larry Whitford, and R. K. Salisbury for American material. I am indebted to Leota E. Ahlstrom for help in preparing the manuscript for publication.

Although an extensive synonymy is given under the more common species of *Brachionus* and *Platytias*, it is complete in only some cases. One is referred to Harring (1913) for a more complete synonymy. Wherever I could not agree with Harring's disposition of synonyms, I have always indicated it in this paper. The list of synonyms since 1913 is as complete as I have been able to make it.

I have been fortunate in obtaining material of all recognized species and varieties but *Brachionus mirus* Daday. For many of the rarer species I have seen the material from all the localities in which they are known to occur. Because *Brachionus* is undoubtedly the most variable genus of rotifers (only *Keratella* and *Notholca*, genera related to *Brachionus*, can compare with it in variability), I have thought it best to illustrate the variation range found in the species, and give a discussion of the variation tendencies under each species.

Examples of all species recorded are in the collection of The American Museum of Natural History.

## BRACHIONUS PALLAS

PALLAS, 1766, p. 89.

*Brachionid* rotifers with illoricate, retractile head and loricate body, usually separated into a dorsal and a ventral plate (in some species a basal plate is also developed) more or less compressed dorso-ventrally. Anterior dorsal margin with a variable number of spines, usually six or four; mental margin usually rigid, elevated, with a medium sinus. Postero-lateral spines developed on some species, postero-median spines also present on a few species. Foot opening usually at posterior end of lorica, between bases of posterior spines if present, seldom with a surrounding sheath. Foot long, wrinkled, retractile (not jointed), toes two.

TYPE OF THE GENUS (by present designation).—*Brachionus calyciflorus* Pallas.

SYNONYMS.—*Noteus* Ehrenberg; *Schizocerca* Daday.

The generic name *Noteus* was first applied by Ehrenberg to *Noteus bakeri* (*Brachionus quadridentatus*). As *Noteus bakeri* is a true *Brachionus*, it invalidates this generic name. The later extension of the generic name to the three species now included in the genus *Platytias* is therefore unjustifiable, and led Harring to create the genus *Platytias*.

## *Brachionus plicatilis* Müller

Plate II, figures 1-9

MÜLLER, 1786, p. 344, Pl. I, figs. 1-8.

*Brachionus Mülleri* EHRENBURG, 1834, p. 200; 1838, p. 513, Pl. LXIII, fig. 5.

*Brachionus hepatotomus* GOOSE, 1851, p. 203.

*Brachionus rubens* var. *Werneri* DADAY, 1903, p. 151, Pl. I, fig. 12.

*Brachionus spatiosus* ROUSSELET, 1912, p. 373, Pl. XIII, fig. 2.

*Brachionus plicatilis* var. *spatiosus* FADEEV, 1925A, p. 22.

*Brachionus Mülleri* var. *rotundiformis* TSCHUGUNOFF, 1921, p. 120, Pl. I, fig. 12. FADEEV, 1925A, p. 22. RODEWALD, 1937, p. 239, Fig. 5.

*Brachionus plicatilis* forma *longicornis* FADEEV, 1925A, p. 22, Pl. IV, fig. 6.

*Brachionus plicatilis* forma *decemcornis* FADEEV, 1925 A, p. 22, Pl. IV, fig. 7.

*Brachionus plicatilis* var. *ecornis* FADEEV, 1925A, p. 22.

*Brachionus plicatilis* var. *Murrayi* FADEEV, 1925A, p. 22, Pl. IV, fig. 4.

*Brachionus orientalis* RODEWALD, 1937. p. 242, fig. 7a, b.

*Brachionus plicatilis*

	Length	Width	Ant. Pt. <sup>1</sup>	Occip. Sp. <sup>2</sup>
Creek, Bayboro, N. C.	125 $\mu$	105 $\mu$	65 $\mu$	10-8-13 $\mu$
Butler Lake near Dune- din, Florida	150 $\mu$	124 $\mu$	82 $\mu$	14-13-15 $\mu$
Near Tarpon Springs, Florida	160 $\mu$	123 $\mu$	80 $\mu$	12-12-16 $\mu$
Lake Rudolph, Kenya	212 $\mu$	145 $\mu$	90 $\mu$	12-16-17 $\mu$
Etang Bois Neuf, Haiti	225 $\mu$	175 $\mu$	99 $\mu$	14-15-20 $\mu$
Açude Simão, Parahyba, Brazil	240 $\mu$	170 $\mu$	108 $\mu$	18-21-23 $\mu$
Shore of Malmö, Sweden	275 $\mu$	210 $\mu$	130 $\mu$	12-15-15 $\mu$
Tso Nyak, N. India	285 $\mu$	230 $\mu$	136 $\mu$	22-20-17 $\mu$
Tso Kar, N. India	315 $\mu$	260 $\mu$	178 $\mu$	15-16-16 $\mu$

Lorica rather flexible, oval, not sharply separated into a dorsal and a ventral plate; but little compressed dorso-ventrally. Anterior dorsal margin with six, broad-based, acutely pointed, saw-tooth spines, nearly equal in length. Mental margin rigid, separated into four lobes. Lorica without posterior spines; smooth or lightly stippled. Foot opening with small sub-square aperture dorsally, longer V-shaped aperture ventrally.

MALE.—GOSSE, 1858.

DISTRIBUTION.—Widely distributed in brackish or salt waters.

I have seen material from Devils Lake, N. D., Florida, California, North Carolina, British Columbia, Haiti, Brazil, Argentina, northern India, Sweden, France, and Kenya, Africa.

The chief variation tendencies in this species are in the size, shape of lorica, and the character of the anterior margins. The greatest width is usually about two-thirds of the length of the lorica from the anterior end, though in some individuals the greatest width occurs just below the middle of the lorica and in some extreme individuals the greatest width is four-fifths of the length from the anterior end. The lorica usually narrows rather markedly toward the anterior end. The anterior point/width ratio varies from 0.52–0.70. Specimens from Devils Lake, N. D., mounted by Rousselet and named by him *B. spatiosus*, had an anterior point/width ratio of 0.52, not much more narrowed at the anterior end than forms of this species from other localities.

There is marked variation in the shape of the anterior dorsal spines. In some individuals the occipital spines narrow markedly above the broad, inflated base and end in thin, acutely pointed tips; in other individuals the spines narrow rather uniformly from base to tip; dorsal spines occasionally with rounded tips; Murray, 1913, reported finding individuals on which the dorsal spines were obsolete, but no other investigator has observed this phenomenon. There is quite some variation in the width of the sinus between the median spines. The scalloped mental edge presents considerable variation in irregularity of the four rounded projections.

Rodewald, 1937, described an aberrant form with a very deep dorsal foot orifice (55–60 $\mu$ ) as *B. orientalis*. Although this is an unusual variation, it is not of specific significance.

This species is readily distinguishable by the scalloped mental edge with four lobes, and the saw-tooth occipital spines.

*Brachionus calyciflorus* Pallas

Plate III, figures 1–9; Plate XX, figures 7, 8

PALLAS, 1766, p. 93.

*Brachionus pala* EHRENBERG, 1838, p. 511, Pl. LXIII, fig. 1.—WEBER, 1898, p. 669, Pl. XXIII, figs. 14–16.—WIERZEJSKI, 1893, p. 249, Pl. VI, figs. 64–67.—WEBER, 1906, p. 208, Figs. A–C.—DIFFENBACH AND SACHSE, 1912, p. 77, Pl. XIII, figs. 8–9.

*Brachionus amphiceros* EHRENBERG, 1838, p. 511, Pl. LXIII, fig. 2.—PLATE, 1886, p. 65, Pl. II, figs. 22–24, Pl. III, fig. 25.—DIFFENBACH AND SACHSE, 1912, p. 78, Pl. XIII, fig. 13.

*Brachionus oon* GOSSE, 1851, p. 202.

*Brachionus dorcas* GOSSE, 1851, p. 203; 1858, p. 318, Pl. xv, figs. 17–19.

*Brachionus margoï* DADAY, 1883, p. 290; 1884, p. 19, Figs. 1, 14, 19.

*Brachionus decipiens* PLATE, 1886, p. 73.

<sup>1</sup> By anterior points is meant the width at the tips of the anterior lateral spines.

<sup>2</sup> In recording occipital spines the figures read from laterals, then intermediates, to medians.



*Brachionus dorcas* var. *spinosus* WIERZEJSKI, 1891, p. 52, Fig. 4.—SKORIKOV, 1896, p. 132, Pl. VIII, fig. 53.—DIFFENBACH AND SACHSE, 1912, Pl. XII, fig. 11.

*Brachionus tridens* HOOD, 1893, p. 283, Pl. XII, fig. 3.

*Brachionus pentacanthus* FRANCÉ, 1894, p. 172, Pl. v, figs. 3, 4.

? *Brachionus quadristriatus* KERTÉSZ, 1894, p. 50, Pl. I, fig. 4.

*Brachionus amphiceros borgei* APSTEIN, 1907, p. 211, Figs. G, H.

*Brachionus pala villeyi* APSTEIN, 1907, p. 213, Fig. J.

*Brachionus pala anuraeiformis* (*Brachionus anuraeiformis*) BREHM, 1909, p. 210, Fig.

*Brachionus pala mucronatus* SPANDL, 1922, p. 275.

*Brachionus pala brycei* DE BEAUCHAMP, 1932A, p. 161, Fig. 1d.

Lorica rather flexible, oval, not separated into a dorsal and a ventral plate, body but little compressed dorso-ventrally. Anterior dorsal margin with four, broad-based spines of variable length, medians longer than laterals. Mental margin rather flexible, usually somewhat elevated with a shallow V- or U-shaped notch which is unflanked. Posterior spines present or absent. Lateral posterior spines commonly absent, spines flanking foot opening usually present though they may be but slightly developed. Lorica smooth or lightly stippled.

MALE.—Gosse, 1858; Plate, 1886; Weber, 1898; Whitney, 1916B; Wesenberg Lund, 1923.

DISTRIBUTION.—Cosmopolitan in alkaline habitats.

*Brachionus calyciflorus* is an exceedingly variable species. Especially is this true of size, length of occipital spines, and the presence and length of posterior spines.

In the same habitat one can often find individuals lacking postero-lateral spines together with a complete series of intermediates to forms with well-developed postero-lateral spines. The work of Whitney, 1916C, and de Beauchamp, 1928, show that postero-spined forms can develop from parthenogenetic eggs of non-spined forms and vice versa. Forms with postero-lateral spines often have longer occipital spines than non-spined forms, and much longer postero-median spines. On forms lacking postero-lateral spines the postero-median spines are usually nearly obliterate, though not necessarily so. Forms lacking posterior spines are commonly larger in size than forms possessing postero-lateral spines.

Occipital spines are very variable in length and relative proportion. Usually the anterior median spines are between 35–60 $\mu$  long, with the laterals varying from about an equal length to only half as long. There is no sharp line of demarcation between *Brachionus calyciflorus* and the *dorcas* form. A form with exceptionally long antlers was collected in Buckeye Lake,

*Brachionus calyciflorus*

	Total Length	Width	Occip. Sp.	Post.-Lat. Sp.
Staffelfelden, France	180 $\mu$	124 $\mu$	15–25 $\mu$	
Pond, Bass Island Region, Ohio	230 $\mu$	130 $\mu$	19–38 $\mu$	11 $\mu$
Fleninge, Sweden	{ 250 $\mu$ 324 $\mu$	190 $\mu$ 192 $\mu$	24–33 $\mu$ 50–56 $\mu$	88 $\mu$
Village Pond, Hodko- vičky, Czechoslovakia	{ 260 $\mu$ 290 $\mu$	190 $\mu$ 170 $\mu$	25–36 $\mu$ 44–51 $\mu$	65 $\mu$
Oklahoma City, Okla., Reservoir	262 $\mu$	160 $\mu$	55–58 $\mu$	58 $\mu$
Terwilliger's Pond, Put- in-Bay, Ohio	287 $\mu$	150 $\mu$	40–56 $\mu$	45 $\mu$
Barberspan, S. Afr.	360 $\mu$	245 $\mu$	43–82 $\mu$	
Westlake, Los Angeles, Calif.	370 $\mu$	174 $\mu$	56–70 $\mu$	102 $\mu$
Açude Simão, Parahyba, Brazil	390 $\mu$	290 $\mu$	90–96 $\mu$	
Lake Yddingen, Sweden	395 $\mu$	246 $\mu$	70–78 $\mu$	
Mathias, Ohio	400 $\mu$	270 $\mu$	61–92 $\mu$	
Lake, Quilmes near Buenos Aires, Arg.	405 $\mu$	214 $\mu$	53–95 $\mu$	115 $\mu$
Buckeye Lake, Ohio	570 $\mu$	300 $\mu$	95–200 $\mu$	

central Ohio, in February, 1933: 215 $\mu$  long on some individuals, with the laterals a little less than half as long. Large forms lacking postero-lateral spines commonly have the antlers 70–95 $\mu$  long. In any single collection the relative proportion between antlers and laterals is rather constant. Apstein, 1907, records an unusual variation from Ceylon in which there are small accessory spines (intermediates?) near the base of the antlers (Pl. XX, figs. 7, 8, this form from Formosa). Reduced forms of this species have been reported by various investigators (Rousselet, 1910; de Beauchamp, 1932A).

**Brachionus dimidiatus** (Bryce)  
new comb.

Plate IV, figures 1–5

*Brachionus calyciflorus dimidiatus* BRYCE, 1931, p. 873, Pl. I, figs. 3a–c.—DE BEAUCHAMP, 1932A, p. 160, Figs. 1a–c.

*Brachionus pala* var. *quartaria* DE BEAUCHAMP, 1932B, p. 236, Figs. 2b, c.

Lorica rather firm, small, oval, not distinctly separated into a dorsal and a ventral plate, but little compressed dorso-ventrally. Anterior dorsal margin with four small spines nearly equal in length, though the lateral spines are usually a little longer than the medians; spines may be nearly obliterate on some specimens. Mental margin rigid, with a shallow, unflanked median sinus. Foot opening with small sub-square aperture dorsally, small V-shaped aperture ventrally. Lorica without posterior spines, smooth or lightly stippled.

Lake	Total Length	Great. Width	Occip. Sp.
Rudolph			
Kenya	115 $\mu$	83 $\mu$	6–6 $\mu$
Abyssinia	156 $\mu$	102 $\mu$	14–11 $\mu$
Lake Elementeita	170 $\mu$		

MALE.—Unknown.

DISTRIBUTION.—Africa: Abyssinia; Lake Elementeita and Lake Nakuru, Kenya; Lake Rudolph, Kenya.

*Brachionus dimidiatus* differs from reduced forms of *Brachionus calyciflorus* in the following characters: smaller size; more rigid lorica which has indications of division into a dorsal and a ventral plate; in the occipital spines, the laterals being usually longer than medians in *B. dimidia-*

*tus*, while the reverse is true of *B. calyciflorus*; in lacking posterior spines of any sort; and in the shape of the foot opening.

The occipital spines of *B. dimidiatus* are not broad-based. In the material from Abyssinia and Lake Elementeita the occipital spines are always well developed. In Lake Rudolph the material is uniformly smaller than from the other localities, and the occipital spines are but weakly developed, being nearly obliterate on some individuals.

**Brachionus dimidiatus** var. *inermis*  
(Schmarda) new comb.

Plate IV, figures 10–12, 14

*Brachionus inermis* SCHMARDA, 1854, p. 12, Pl. IV, fig. 2.

*Brachionus pala* var. *inermis* DE BEAUCHAMP, 1932B, p. 236, Figs. 2d,e.

*Brachionus edentatus* BRYCE, 1931, p. 873, Pl. V, fig. 4.

Differs from the species in having the occipital spines quite obliterate.

	Total Length	Great. Width	Ant. Pts.
Lake Hora			
Shala	123 (140) $\mu$	84 $\mu$	63 $\mu$
Argentina	124 $\mu$	83 $\mu$	40 $\mu$
Kenya	103 $\mu$	?	?

DISTRIBUTION.—Known from Natron Lakes, Egypt (Schmarda); alkaline Lake Hora Shala, Abyssinia; Kenya, East Africa; and several lagunas in San Luis Province, Argentina.

The material from Lake Hora Shala has accretions along the anterior margins and foot opening which give the appearance of serrations but which are probably deposits from the highly alkaline medium in which the species lives; the material from Kenya had such accretions covering much of the body and foot. The finding of excellent material of this form in material from Argentina confirmed my opinion that the form is very closely allied to *B. dimidiatus*; the material that is clearly intermediate in character from Lake Rudolph adds weight to this conclusion.

**Brachionus budapestinensis** Daday

Plate IV, figures 6–9

DADAY, 1885, pp. 131, 211, Pl. XI, figs. 1–4, 8, 10.—SKORIKOV, 1896, Pl. VIII, fig. 25.—ZACHARIAS, 1898B, p. 134, Pl. IV, figs. 1, 2.



*Brachionus budapestinensis*

	Total Length	Width	Ant. Lat.	Ant. Med.
Vallés, Mexico	115 $\mu$	70 $\mu$	15 $\mu$	23 $\mu$
Açude Tararé, Parahyba, Brazil	138 $\mu$	86 $\mu$	26 $\mu$	29 $\mu$
Caloosahatchee R. near La Belle, Fla.	140 $\mu$	80 $\mu$	24 $\mu$	31 $\mu$
Terwilligers Pond, Put-in-Bay, Ohio.	153 $\mu$	95 $\mu$	30 $\mu$	38 $\mu$
Duckpond, Lövestad, Sweden.	170 $\mu$	105 $\mu$	24 $\mu$	37 $\mu$
Lake Xochimilco near Mexico City, Mexico.	160 $\mu$	101 $\mu$	42 $\mu$	56 $\mu$

*Brachionus lineatus* SKORIKOV, 1896, p. 350, Pl. VIII, fig. 26.

*Brachionus punctatus* HEMPEL, 1896, p. 311, Pl. XXIII, figs. 3-5.

*Brachionus similis* LEISSLING, 1914, p. 253, Fig. 1.

*Brachionus budapestinensis* var. *cristatus* SKORIKOV, 1914, p. 32, Fig. 8 (*Brachionus cristatus* Skorikov, 1914, p. 11).

Lorica firm, oval, divided into a dorsal and a ventral plate, dorso-ventral depth about two-thirds of width. Anterior dorsal margin with four spines, median pair somewhat longer than the laterals, their distal ends curve ventrally; outer pair of spines not quite lateral. Mental edge nearly straight, with a small unflanked median notch. Foot opening with small V-shaped aperture dorsally, and a larger, oval opening ventrally. Lorica ornamented with a pattern of cuticular ridges on both dorsal and ventral plates, and a dense covering of minute tubercules; lorica may be nearly smooth, however.

MALE.—Unknown.

DISTRIBUTION.—Probably cosmopolitan in alkaline fresh waters. I have seen material from Sweden, Brazil, Mexico, and a number of localities in the United States.

In some habitats this species has a relatively flexible lorica with little ornamentation. The usual pattern of cuticular ridges is apparently lacking and the lorica is only lightly stippled. *B. budapestinensis* does not vary greatly in size. There is quite some variation in length and curving of anterior spines, and in the ratio of width to length of the lorica.

Although *B. budapestinensis* has a superficial resemblance to *B. calyciflorus*, it is probably more closely related to *B. angularis*.

*Brachionus dolabratus* Harring

Plate IV, figures 13, 15, 16

HARRING, 1915, p. 529, Pl. XVI, figs. 1, 2.

Lorica firm, divided into a dorsal and a ventral plate, much compressed dorso-ventrally. Anterior dorsal edge of lorica with a small median spine on either side of the antennal sinus, intermediate spines quite obliterate, and only a faint suggestion of lateral spines, anterior dorsal edge but slightly elevated toward the center. Anterior ventral margin firm, with a shallow median notch which may be flanked by two small teeth-like protuberances. Foot opening flanked by two well-developed, anchor-shaped spines. At the posterior lateral angles there are two prominent knobs which may also have anchor-shaped spines; there are also present two blunt lateral spines. Lateral antennae project through blunt knob-like protuberances on dorsal plate near edge of lorica. Lorica finely stippled, lacks cuticular ridges, about as broad as long (width/length ratio, 1), often surrounded by a gelatinous sheath.

	Bohio, Panama	Parahyba, Brazil
Total Length	114 $\mu$	158 $\mu$
Width	105 $\mu$	160 $\mu$
Ant. Pts.	62 $\mu$	80 $\mu$

MALE.—Unknown.

DISTRIBUTION.—Known from Panama, a number of açudes in north-east Brazil, and Devils Lake, N. D.

In Ahlstrom, 1934B, a form of *B. angularis* from Florida was referred to this species and the species was reduced to a variety of *B. angularis*. This Florida form resembles *B. dolabratus* in the possession of blunt knobs at the postero-lateral

angles; otherwise it is very similar to *B. angularis*. I do not now consider this Florida form to be *B. dolabratus*. It differs from typical *dolabratus* in a number of details: it does not possess anchor-shaped spines on either side of foot opening; it possesses the foot-shield on dorsal plate (typical of *B. angularis*) which is lacking in *B. dolabratus*; and it differs in various details in the anterior dorsal margin.

*B. dolabratus* is sharply separable from *B. angularis* in the localities in which it occurs. It is rather common in northeast Brazil and there has the distinctive features accentuated. Particularly is this true of the anchor-shaped spines on either side of the foot opening, which are strongly developed, and the postero-lateral spines which are also well developed and anchor-shaped. It is often surrounded by a mucilaginous envelope, a feature shared by no other species of *Brachionus* of which I am aware. In Açude Bodocongo and Açude Puxinana in Parahyba, Brazil, this species occurs at all seasons of the year. In the same açudes *B. angularis* is common only in the March collections and is absent during most of the year.

### *Brachionus angularis* Gosse

Plate V, figures 1-13

GOSSE, 1851, p. 203.—DIFFENBACH AND SACHSE, 1912, p. 82, Pl. XII, figs. 17-20.—FADEEV, 1926, Fig. 3.—ARÉVALO, 1918, p. 42, Fig. 35.

*Brachionus testudo* EHRENBURG, 1853, pp. 190, 193.

*Brachionus minimus* BARTSCH, 1877, p. 49, Pl. I, fig. 7, 8.—DADAY, 1885, p. 210, Pl. XI, figs. 8, 11.

*Brachionus bidens* PLATE, 1886, p. 72, Pl. III, fig. 30.

*Brachionus papuanus* DADAY, 1897, p. 142, Fig. 9.

*Brachionus angularis* var. *rotundata* SELIGO, 1907, p. 68, Fig. 111.

*Brachionus lyratus* SHEPHARD, 1911, p. 57, Pl. XXI, figs. 5, 6.

*Brachionus angularis* f. *aestivus* SKORIKOV, 1914, p. 31, Fig. 7.

*Brachionus angularis* var. *aestivus* FADEEV, 1926, p. 7, Fig. 5.

*Brachionus angularis* f. *apicata* TSCHUGUNOFF, 1921, p. 117, Pl. I, fig. 7.

*Brachionus angularis* var. *ecornis* VORONKOV, 1913, p. 101.

*Brachionus angularis* var. *rotundus* FADEEV, 1926, p. 7, Fig. 4.

*Brachionus angularis* var. *bidens* f. *punctatus* FADEEV, 1926, p. 7, Fig. 2.—TARNOGRADSKY, 1926, p. 10, Pl. II, figs. 16-20.

Lorica firm, divided into a dorsal and a ventral plate, lorica moderately compressed dorso-ventrally. Anterior dorsal margin with two median spines divided by a U-shaped sinus; lateral and median occipitals usually obliterate, may be weakly developed, intermediates more commonly developed than laterals. Mental margin rigid, somewhat elevated, with a shallow median sinus. Foot opening rather large, somewhat variable in shape, larger aperture in ventral plate, flanked laterally by cuticular protuberances. Posterior spines wanting. Lorica lightly or heavily stippled, rarely tuberculate; dorsal plate with a pattern of cuticular ridges, which, while often pronounced, may be nearly obliterate.

	Total Length	Great. Width	Ant. Pts.
Sholavaram Lake, Madras, India	91 $\mu$	71 $\mu$	54 $\mu$
Lake Xochimilco, Mexico	112 $\mu$	80 $\mu$	66 $\mu$
Açude Tararé, Parahyba, Brazil	121 $\mu$	97 $\mu$	65 $\mu$
Stromberg Junction Dam, South Africa	134 $\mu$	107 $\mu$	81 $\mu$
Swan Creek, northern Ohio	138 $\mu$	113 $\mu$	78 $\mu$
Lake, Winter Park, Fla.	145 $\mu$	126 $\mu$	80 $\mu$
Staffelfelden, France	156 $\mu$	118 $\mu$	93 $\mu$
Near Kissimmee, Fla. (pseudo - <i>dolabratus</i> form)	168 $\mu$	150 $\mu$	88 $\mu$
Lake Yddingen, Sweden	182 $\mu$	132 $\mu$	92 $\mu$
Pond, Čerádice, Czechoslovakia	202 $\mu$	145 $\mu$	90 $\mu$

MALE.—GOSSE, 1858; WESBERG-LUND, 1923.

DISTRIBUTION.—Cosmopolitan in alkaline fresh waters.

*Brachionus angularis* is one of the more variable species of *Brachionus*. Some variation may be explained as due to a sexual dimorphism between mictic and amictic females (how far this holds true is not known). Variation in this species is of both a polymorphous and a fluctuating nature. Both anterior margins are quite variable, as is the size and shape of the lorica, prominence of ornamentation, and the shape of the foot opening and adjacent cuticular protuberances.

There are two common series of variants in this species. Series  $\alpha$  (Pl. V, figs. 2-7) usually lack intermediate spines, they have the occipital margin elevated and rounded toward the median spines. The pattern on the lorica is often quite distinct, though it may be nearly or quite obliterate. The lorica is lightly to heavily stippled. The most characteristic feature of series  $\alpha$  is the shape of the posterior portion of the lorica. The cuticular protuberances on either side of the foot opening are rather wide apart and more or less parallel (may be slightly convergent). The lorica is "angular" only on forms with pronounced patterns, otherwise the lateral edges are broadly rounded.

The other common series of variants, series  $\beta$  (Pl. V, figs. 8-11), always have intermediate spines weakly developed, the pattern is indistinct, and the cuticular protuberances on either side of the foot opening are relatively close together and markedly convergent. Forms of this series are invariably "angular." The "angular" appearance is not due to the pattern of cuticular ridges, but to the development of two angular protuberances on either side of the lorica in the posterior half. The more posterior of these protuberances is about three-fourths of the length of the lorica from the anterior end, and is often quite pronounced. In some Florida habitats these protuberances are very pronounced (Pl. V, fig. 11). This results in a form having a superficial resemblance to *Brachionus dolabratus*, and may be called the pseudo-dolabratus form. However, the development of postero-lateral prominences I believe to be but an orthogenetic variation, paralleling that in *dolabratus*. A similar type of lateral prominences is also developed on *Brachionus caudatus* var. *aculeatus*.

The largest form of the species encountered was in material from Sweden and Czechoslovakia, on which the pattern is very distinct and the lorica pustulate. It is not typical of either series but probably is a variant of series  $\alpha$ .

A small form of *angularis* found in material from Sholavaram Lake in India (Pl. V, figs. 12-13) had the cuticular prominences on either side of the foot opening bent ven-

trally, so that they were not visible in dorsal view. Skorikov, 1914, described a somewhat similar form as *f. aestivus*.

***Brachionus angularis* var. *chelonis*,  
new variety**

Plate V, figures 14, 15

Differs from the species in its consistently smaller size, in having the lateral occipital spines developed, and in a differently shaped foot opening. The anterior occipital margin has four spines, the laterals being as long as the medians, while the intermediates are quite obliterate. The lorica has a pattern of cuticular ridges, usually somewhat indistinct; lorica lightly stippled. Foot opening but shallowly developed in dorsal plate, U-shaped in ventral plate; cuticular prominences on either side of foot opening but weakly developed.

	Total Length	Width	Ant. Pts.
Near New Orleans, La.	75 $\mu$	58 $\mu$	36 $\mu$
Swamp, Kinston, N. C.	85 $\mu$	59 $\mu$	38 $\mu$
Açude Simão, Parahyba, Brazil	102 $\mu$	72 $\mu$	57 $\mu$

DISTRIBUTION.—Above localities, as well as several other açudes in Parahyba, Brazil, often occurring with species *vera*, without evidence of intergrading.

This is the smallest known form of *Brachionus*.

Para type in The American Museum of Natural History, Cat. No. A. M. N. H. 1058.

***Brachionus caudatus* Barrois and Daday**

Plate VI, figures 1-11; Plate VII, figures 3, 4  
BARROIS AND DADAY, 1894A, p. 232, Pl. VII, figs. 9, 10, 13; 1894B, p. 407, Pl. V, figs. 10, 13, Text Figs. 12-14.—DADAY, 1905B, Pl. VII, fig. 17.

*Brachionus tetracanthus* COLLIN, 1897, p. 7, Fig. 8.

*Brachionus forficula* var. *apsteini* FADEEV, 1925C, p. 289, Fig. 11.

Lorica firm, divided into a dorsal and a ventral plate, moderately compressed dorso-ventrally. Anterior dorsal margin with two median spines separated by a U-shaped sinus, lateral spines developed in some forms, and rarely the intermediate spines are also developed. Mental margin rigid, slightly elevated, at times undulate, with a shallow median sinus. Lorica terminates in two stout posterior spines, separated at their bases by about half the width of the lorica, usually divergent and

strongly flexed ventrally. Foot opening between bases of posterior spines, with a U-shaped aperture in the ventral plate, dorsal plate overhangs foot opening with a V-shaped extension of lorica. Lorica usually heavily stippled, with a pattern of cuticular ridges which may be more or less obliterate.

MALE.—Not figured as yet by investigators.

DISTRIBUTION.—Widely distributed in North and South America; apparently not common in Europe; may be cosmopolitan.

This species is usually recorded as a variety of *Brachionus angularis*. It is closely related to that species, and in some habitats in eastern North America grades into a form without posterior spines. Even the non-spined form can be distinguished from *B. angularis* occurring in the same habitats by the larger size, somewhat different pattern on the lorica, and details of the posterior portion of the lorica. In sub-tropical and warm temperate regions *Brachionus caudatus* is always sharply separable from *Brachionus angularis*; the posterior spines are always developed, and the species is uniformly larger and usually differs in a great number of particulars from *Brachionus angularis*, with which it is often associated. Because this species is strikingly distinct from *Brachionus angularis* over a large part of its range I am forced to consider it a distinct and valid species.

*Brachionus caudatus* is perhaps the most variable species of *Brachionus*. It has a very extensive size range and is very variable in a number of characters, particularly in the mode of origin and length of posterior spines, in the occipital margin, and in the ornamentation of the lorica. Much of the variation in this species is of a polymorphous (discontinuous) nature, and there seem to be distinct geographic variants. However, the species commonly presents but little variation in any given habitat. To stress the discontinuous nature of the variation observed I will discuss the more common forms of the species as units.

The two outstanding variation tenden-

cies in this species are (1) the degree of development of the occipital margin, and (2) the mode of origin of the posterior spines. With regard to the occipital margin: there are variants which have only the medians, variants which have both median and lateral spines developed, and variants which have all six occipital spines developed. With regard to the posterior spines: one series of forms has the posterior spines originating at an angle with the plane of the rather thick body, bending ventrally; another series has the stout posterior spines in the same plane as the axis of the more compressed body. Much of the variation in *Brachionus caudatus* is unusual among species of *Brachionus* because of its polymorphous nature. Some of the forms also appear to be geographically isolated, making a taxonomic designation of the forms desirable for students of limnology and zoögeography.

#### KEY TO THE FORMS AND VARIETIES OF *Brachionus caudatus*

##### Occipital spines six

Anterior lateral spines longest.....  
..... var. *personata*.

##### Anterior median spines longest

Posterior spines divergent, bowed, arise at an angle ventrally, pattern distinct.....  
..... f. *insuetus*.

Posterior spines long, in same plane as axis of body, pattern indistinct..... f. *austrogenitus*.

##### Occipital spines four, laterals and medians developed

An accessory spur-like spine arising from inner dorsal side of each posterior spine.....  
..... var. *aculeatus*.

Accessory spine not developed on posterior spines

Posterior spines relatively short, arise at an angle ventrally..... f. *apsteini*.

Posterior spines long, in same plane as axis of body..... f. *majusculus*.

##### Occipital spines two, medians developed

Posterior spines relatively short, arise at an angle ventrally, pattern on lorica distinct.....  
..... f. *vulgatus*.

Posterior spines long, in same plane as axis of body, pattern indistinct..... f. *protractus*.

Form *vulgatus* (Pl. VI, figs. 6, 8-11).—The common form of *Brachionus caudatus* found in the United States. It has only the median spines developed on the occipital margin, though rarely the intermedicates are somewhat developed. It is not



Form *vulgatus*

	Total Length	Width	Post. Sp.	Ant. Pts.
Near New Orleans, La.	136 $\mu$	95 $\mu$	32-32 $\mu$	71 $\mu$
Portage River, Port Clinton, Ohio	165 $\mu$	108 $\mu$	44-44 $\mu$	76 $\mu$
Oklahoma City, Okla., Reservoir	200 $\mu$	124 $\mu$	58-58 $\mu$	88 $\mu$
Maumee River at Texas, Ohio	232 $\mu$	130 $\mu$	62-60 $\mu$	84 $\mu$
West Lake, Los Angeles, Calif.	236 $\mu$	113 $\mu$	98-96 $\mu$	82 $\mu$
Echo Park Lake, Los Angeles, Calif.	265 $\mu$	113 $\mu$	128-120 $\mu$	78 $\mu$

Form *provectus*

	Total Length	Width	Post. Sp.	Ant. Pts.
Lagunas, Chascomus, Buenos Aires Prov., Argentina	354 $\mu$	147 $\mu$	174-161 $\mu$	107 $\mu$
Near Buenos Aires, Argentina	330 $\mu$	134 $\mu$	164-156 $\mu$	95 $\mu$
Lagunas Ranquel, San Luis Prov., Argentina	302 $\mu$	135 $\mu$	130-128 $\mu$	78 $\mu$
Rio Santiago, Mexico	276 $\mu$	139 $\mu$	123-117 $\mu$	92 $\mu$
Lagunas Talca, San Luis Prov., Argentina	248 $\mu$	122 $\mu$	95-95 $\mu$	80 $\mu$

uncommon to find a series of forms in the same habitat grading from individuals with rather long posterior spines to specimens on which the posterior spines are almost obliterate. In some habitats, particularly in southern United States, the posterior spines are never greatly reduced. The pattern of cuticular ridges on the dorsal plate is quite prominent and distinctive, and is rather similar from habitat to habitat. The lorica is heavily stippled (at times almost tuberculate); the body is often dark brown in color. Débris often adheres to the lorica, particularly the elevated posterior portion. In lateral view the dorsal plate is seen to be quite elevated, and the posterior spines arise at an angle ventrally. Posterior spines are almost always divergent and bowed. This form is also found in Asia Minor and Africa.

Form *provectus* (Pl. VI, figs. 1, 2).—Occipital margin with laterals and intermediates quite obliterate. Posterior spines commonly as long as the body. A large form with rather indistinct pattern on lorica, not as elevated as form *vulgatus*, but with the stout posterior spines arising in the same plane as the axis of the body. Common in San Luis and Buenos Aires provinces in Mexico; a similar form also observed from the Rio Santiago in Mexico.

Form *apsteini* (Pl. VI, fig. 5).—Both lateral and median occipital spines developed, medians somewhat longer. Pattern rather indistinct, lorica lightly to heavily stippled. Animal in lateral view rather similar to form *vulgatus*; dorsal plate quite elevated and the posterior spines arise at an angle ventrally. Posterior spines divergent, usually somewhat bowed, nearly as variable in length as in form *vulgatus*. In the United States this form has been observed in several localities in Florida. This variant is the form figured by Apstein, 1907, from the Colombo Sea in Ceylon, and placed by Fadeev, 1925C, as a variety of *Brachionus forficula*. It is probably widely distributed in Malaysia: it is recorded for Java (Hauer, 1937-38) and Formosa (Ueno, 1938).

Form *apsteini*

Caloosahatchee River near  
La Belle, Fla.

Total Length	202 $\mu$
Width	118 $\mu$
Ant. Sp.	7-0-12 $\mu$
Post. Sp.	74-69 $\mu$
Ant. Pt.	75 $\mu$

Form <i>majusculus</i>					
	Total Length	Width	Ant. Sp.	Post. Sp.	Ant. Pts.
Near Kissimmee, Florida	318 $\mu$	164 $\mu$	10-0-17 $\mu$	125-114 $\mu$	84 $\mu$
Form <i>insuetus</i>					
	Total Length	Width	Ant. Sp.	Post. Sp.	Ant. Pts.
Punta Lara, Argentina	230 $\mu$	136 $\mu$	6-5-13 $\mu$	58-58 $\mu$	105 $\mu$
Form <i>austrogenitus</i>					
	Total Length	Width	Ant. Sp.	Post. Sp.	Ant. Pts.
Açude Bodocongo, Parahyba, Brazil	285 $\mu$	142 $\mu$	9-7-18 $\mu$	128-126 $\mu$	85 $\mu$
Açude Baixa de Pau, Parahyba, Brazil	310 $\mu$	145 $\mu$	10-7-17 $\mu$	147-143 $\mu$	78 $\mu$

Form *majusculus* (Pl. VI, fig. 7).—Both lateral and median occipital spines developed. Lorica large, posterior spines long and stout, pattern indistinct, lorica heavily stippled, in lateral view similar to form *proectus*. Posterior spines arise in the same plane as the axis of the body. Found only near Kissimmee, Florida.

Form *insuetus* (Pl. VI, figs. 3-4).—Occipital margin with six spines, medians longest, intermediates and laterals about equal in length. Lorica with prominent pattern of cuticular ridges, rather heavily stippled. In side view lorica rather similar to form *vulgatus*, posterior spines arise at an angle ventrally. Observed in several habitats in Buenos Aires Province, Argentina.

Form *austrogenitus* (Pl. VII, figs. 3-4).—Occipital margin with six spines, medians longest. Lorica large, posterior spines well developed, the pattern of cuticular ridges indistinct on dorsal view, lorica finely stippled. Posterior spines are always long on all individuals, and the form is rather constant from habitat to habitat, and throughout the year in the same habitat. In lateral view the dorsal plate is but moderately elevated, the posterior spines arise in the same plane as the axis of the body. Common in northeast Brazil. Murray, 1913, figures somewhat similar form from the vicinity of Rio de Janeiro. A form figured by Daday, 1905B, from Paraguay having six occipital spines does not fit exactly under this form; he figures two small spines between bases of posterior spines, so unusual a feature that one is led to doubt the accuracy of the observation.

***Brachionus caudatus* var. *personatus*,  
new variety**

Plate VII, figures 1, 2, 5-7

*Brachionus havanaensis* var. *ahlstromi* LINDEMAN, 1939, p. 213, Pl. I, fig. 9.

Lateral occipital spines longer than the median, at times over twice as long. Lorica heavily stippled, with a pattern of cuticular ridges more or less distinct. In side view the lorica is moderately compressed, posterior spines in the same plane as the axis of the body.

From a pool at Punta Lara, Argentina, connected at high water with Rio de la Plata, an extreme form of this variety was collected. The posterior spines terminate in rounded knobs, the lateral occipitals are more than twice the length of the medians, and the lorica projects over the foot opening dorsally as a sub-quadrate plate.

From Lake Xochimilco near Mexico City, Mexico, a form of this variety is found with lateral occipitals about one and a half times as long as the medians; the posterior spines end in acute points. The pattern is quite distinct on the dorsal plate, and the dorsal projection over the foot opening is less marked than in the form from Argentina.

From Açude Maria de Paes in Parahyba, Brazil, a smaller form of this variety was observed intermediate in its characters between the two forms already discussed.

It is possible that *Brachionus mirus* Daday is an extreme form of this variety.

This variety might be confused with *Brachionus havanaensis*. However, the posterior spines are more widely separated at their bases, the lorica has a pattern of cuticular ridges (cuticular ridges are never present on *B. havanaensis*), is more heavily

*Brachionus caudatus* var. *personatus*

	Total Length	Width	Ant. Sp.	Post. Sp.	Ant. Pts.
Açude Maria de Paes, Brazil	196 $\mu$	86 $\mu$	20-3-15 $\mu$	73-72 $\mu$	62 $\mu$
Lake Xochimilco, Mexico	220 $\mu$	100 $\mu$	21-3-12 $\mu$	86-83 $\mu$	84 $\mu$
Pool, Punta Lara, Argentina	250 $\mu$	110 $\mu$	42-4-18 $\mu$	78-76 $\mu$	108 $\mu$

*Brachionus caudatus* var. *aculeatus*

	Total Length	Width	Ant. Sp.	Post. Sp.	Ant. Pts.
Form $\alpha$	122 $\mu$	87 $\mu$	10-2-8 $\mu$	20-20 $\mu$	73 $\mu$
Form $\beta$ ( <i>lateralis</i> )	147 $\mu$	97 $\mu$	11-2-9 $\mu$	35-35 $\mu$	76 $\mu$

stippled than *B. havanaensis*, and has a prominent extension of the dorsal plate over the foot opening. *Brachionus havanaensis* accompanied this variety in Lake Xochimilco, and *Brachionus havanaensis* var. *trachea* in Argentina. The form from Lake Xochimilco is figured in Carlin-Nilson, 1935.

Paratype in The American Museum of Natural History; Cat. No. A. M. N. H. 1043.

*Brachionus caudatus* var. *aculeatus* (Hauer), new comb.

Plate VII, figures 9-12

*Brachionus angularis* var. *aculeatus* HAUER, 1937, p. 18, Fig. 1a.

*Brachionus angularis* var. *aculeatus* f. *lateralis* HAUER, 1937, p. 19, Fig. 16.

Differs from the species in possessing on the inner dorsal side of each posterior spine an accessory spur-like spine.

DISTRIBUTION.—Known only from Sholavaram and Almati Lakes (Madras), India.

The anterior dorsal margin has six spines of which the laterals and medians are about equally developed, the intermediates rudimentary. The body is heavily stippled and has a pattern of cuticular ridges. On end view the dorsal plate appears to have a median keel, rather like that of *Platytias polyacanthus*. In side view the lorica is seen to be moderately compressed dorso-ventrally, the posterior spines bend ventrally, while the spur-like processes extend dorsally.

The variety has a form with lateral prominences on the lorica below the lateral antennae, a feature shared by certain forms of *Brachionus angularis*. It is somewhat larger than the form lacking lateral protuberances.

*Brachionus havanaensis* Rousselet

Plate VIII, figures 1-15; Plate XX, figures 4, 6

ROUSSELET, 1911, p. 163, Pl. VII, fig. 3a-c; LINDEMAN, 1939, p. 210, Pl. I, figs. 3, 4.

*Brachionus havanaensis* f. *invernensis* LINDEMAN, 1939, p. 211, Pl. I, fig. 8.

*Brachionus havanaensis* f. *okobojii* LINDEMAN, 1939, p. 211, Pl. I, fig. 5.

*Brachionus havanaensis* var. *minnesotensis* LINDEMAN, 1939, p. 212, Pl. I, figs. 11, 12.

Lorica firm, divided into a dorsal and a ventral plate, quite compressed dorso-ventrally. Anterior dorsal margin with six spines; laterals longest, medians rather short, intermediates very short. Mental margin rigid, raised, with a median sinus flanked by two small teeth-like protuberances. Posteriorly the lorica narrows and terminates in two spines, rather close together at their bases, the right spine invariably longer, often markedly so. Foot opening between bases of posterior spines. Lorica smooth or lightly stippled and unornamented, except for strengthening ridges from bases of papilla-like protuberances on ventral plate.

MALE.—Unknown.

DISTRIBUTION.—Known from many localities in the United States, from Mexico and British Columbia. Various American investigators have listed this form as *Schizocerca diversicornis*. The latter species does not occur in the United States.

*Brachionus havanaensis* is one of the very variable species of *Brachionus*. It has a very considerable size range, marked variation in the length of spines, both occipitals and posteriors; and in the shape of the lorica.

The posterior portion of the lorica narrows markedly in *B. havanaensis* before the origin of the posterior spines, so that the spines are usually rather close together at their bases. The right spine is always

*Brachionus havanaensis*

	Length	Width	Ant. Sp.	Ant. Pts.	Post. Sp.
Near New Orleans, Louisiana	135 $\mu$	73 $\mu$	15-2-10 $\mu$	52 $\mu$	26-26 $\mu$
Rio Valles, Mexico	163 $\mu$	77 $\mu$	19-2-11 $\mu$	73 $\mu$	58-50 $\mu$
McCarron's Pond near St. Paul, Minn.	{ 174 $\mu$ 204 $\mu$	{ 73 $\mu$ 75 $\mu$	{ 12-1-12 $\mu$ 20-2-15 $\mu$	{ 47 $\mu$ 60 $\mu$	{ 52-19 $\mu$ 66-28 $\mu$
Pool, Riverby, Ohio	232 $\mu$	88 $\mu$	28-2-18 $\mu$	70 $\mu$	105-55 $\mu$
Lake Xochimilco near Mexico City, Mexico	255 $\mu$	93 $\mu$	34-2-18 $\mu$	80 $\mu$	108-81 $\mu$
Pond, Asheboro, N. C.	260 $\mu$	114 $\mu$	29-3-14 $\mu$	86 $\mu$	107-95 $\mu$
Lexington, Ky.	266 $\mu$	105 $\mu$	35-2-21 $\mu$		124-118 $\mu$
Lake, Winter Park, Fla.	286 $\mu$	110 $\mu$	25-2-17 $\mu$	63 $\mu$	134-72 $\mu$
Caloosahatchee R. near La Belle, Fla.	280 $\mu$	99 $\mu$	31-2-21 $\mu$	86 $\mu$	129-56 $\mu$
Pond, Cincinnati, Ohio	290 $\mu$	100 $\mu$	35-2-20 $\mu$	72 $\mu$	138-128 $\mu$
Beaver Lake, Vancouver, B. C.	300 $\mu$	111 $\mu$	45-2-17 $\mu$	85 $\mu$	120-90 $\mu$
Illinois River at Havana, Illinois	328 $\mu$	110 $\mu$	57-2-20 $\mu$	108 $\mu$	147-85 $\mu$
Pond, Mathias, Ohio	350 $\mu$	118 $\mu$	50-2-20 $\mu$	64 $\mu$	172-75 $\mu$

longer than the left: at times only slightly longer, on other individuals more than twice as long. The posterior spines are usually parallel or slightly divergent toward their tips, though they may be markedly divergent or convergent. The posterior spines in *B. havanaensis* never have knee-like swellings on the inner side near their bases, as does *B. forficula*. On reduced forms of *B. havanaensis* the posterior spines are often quite short. Posterior spines are usually bluntly pointed, rarely rounded.

The occipital spines show considerable variation in length. Laterals are usually one and a half to three times as long as the medians; material from McCarron's Pond in Minnesota had the laterals on some specimens only as long as the medians (not shorter, however, as Lindeman claims); other specimens from the same collection had the laterals over a third longer than the medians (Lindeman based his var.

*minnesotensis* on this material). Lateral spines are usually somewhat divergent, rarely straight or slightly convergent; lateral spines are proportionately longer on large individuals than are the median spines. Intermediates are only slightly developed, but are always present.

*Brachionus havanaensis* var. *trahea* (Murray)

Plate IX, figures 1-5

*Brachionus trahea* MURRAY, 1913, p. 451, Pl. XVIII, fig. 48 a, b.—AHLSTROM, 1932, p. 243, Pl. XXXIV, figs. 1, 2; 1938, p. 33, Pl. I, figs. 1, 2.

Variety *trahea* is separable from *Brachionus havanaensis* by the following characters: it has the anterior lateral spines longer, and the anterior median spines much longer than in *B. havanaensis*, it is uniformly larger in size than is usual for the species *vera*, and it has the posterior spines always subequal, the left spine never greatly reduced as is often the case

*Brachionus havanaensis* var. *trahea*

	Total Length	Width	Ant. Sp.	Post. Sp.
Lagoon, Rio de Janeiro, Brazil	296 $\mu$	104 $\mu$	34-2-32 $\mu$	132-112 $\mu$
Lagunas Florida, San Luis Prov., Argentina	340 $\mu$	107 $\mu$	49-2-29 $\mu$	163-158 $\mu$
Lagunas Garcia, San Luis Prov., Argentina	348 $\mu$	108 $\mu$	65-2-36 $\mu$	156-146 $\mu$
Lagunas Julia, San Luis Prov., Argentina	350 $\mu$	108 $\mu$	55-2-30 $\mu$	165-148 $\mu$
Lagunas Pozos, San Luis Prov., Argentina	362 $\mu$	110 $\mu$	56-2-30 $\mu$	175-172 $\mu$
Rio Santiago, Mexico	362 $\mu$	127 $\mu$	73-3-38 $\mu$	157-155 $\mu$
Açude Simão, Parahyba, Brazil	320 $\mu$	101 $\mu$	55-2-34 $\mu$	140-127 $\mu$
Açude Bodocongo, Parahyba, Brazil	346 $\mu$	105 $\mu$	70-2-46 $\mu$	155-140 $\mu$
Açude Puxinã, Parahyba, Brazil	390 $\mu$	120 $\mu$	72-2-48 $\mu$	174-162 $\mu$



in *B. havanaensis*. The anterior lateral spines are often convergent, while in *B. havanaensis* they are almost always divergent. Posterior spines are usually more or less parallel and are bent dorsally, occasionally very much so. The variety is regionally isolated from the species.

**DISTRIBUTION.**—Known from Mexico, Brazil, and Argentina. It is apparently widely distributed in South America.

In açudes in northeast Brazil var. *trahea* is the most common rotifer in the plankton, and is abundant at all seasons of the year. It is very common in lagunas in San Luis Province, Argentina. Specimens from Argentina have the anterior median spines shorter than on specimens from Brazil, and are intermediate between extreme forms of the variety and the species *vera*.

***Brachionus diversicornis* (Daday),  
new comb.**

Plate IX, figures 6, 7; Plate XX, figures 3, 5

*Schizocerca diversicornis* DADAY, 1883, p. 291; 1884, p. 26, Figs. 4, 7, 8; 1885, p. 132, Pl. XI, figs. 5-7.—WIERZEJSKI, 1893, p. 254, Pl. VI, figs. 72, 73.—ROUSSELET, 1896, p. 267, Pl. XI, fig. 3.—SKORIKOV, 1896, p. 146, Pl. IX, figs. 58-59.—DADAY, 1903, p. 152, Figs. 13-16.—UENO, 1936, p. 522, Fig. K; 1938, p. 138, Fig. 9.

*Brachionus amphifurcatus* IMHOF, 1887, p. 578; 1891A, p. 125.

*Schizocerca diversicornis* var. *homoceros* WIERZEJSKI, 1891, p. 51, Fig. 2; 1893, p. 254, Figs. 74, 75.—DADAY, 1910, Pl. III, fig. 10.

Lorica firm, divided into a dorsal and a ventral plate, quite compressed dorso-ventrally. Occipital margin with four spines: medians short, laterals long, intermediates completely obliterate. Mental margin more or less rigid, somewhat elevated, median sinus shallowly developed. Posteriorly the lorica becomes narrowed, and carries two diverging spines, the right

spine usually long, the left short, or nearly equal in length to the right. Foot opening between bases of posterior spines; rounded tongue-like projection of dorsal plate overhangs foot opening. Toes elongated, shouldered at the end, each terminating in two soft fleshy points (the so-called bifurcation). Lorica lightly stippled.

**MALE.**—Nitardy, 1912; Wesenberg-Lund, 1923.

**DISTRIBUTION.**—Many records for Europe, several from Asia and Africa. No authentic record for either of the Americas.

*Brachionus diversicornis* is one of the largest species of *Brachionus*. The posterior spines may be nearly equal in length (form *homoceros*), or the left spine may be markedly shorter than the right. Occasionally both posterior spines are quite reduced. Anterior laterals are usually very long. Skorikov, 1896, figures specimens with relatively short anterior laterals, however. The length of the body proper is usually as long as (or longer than) the combined lengths of the anterior and posterior spines.

Daday created a monotypic genus for this species on the character of a bifurcate toe. As Rousselet (1896) pointed out, the bifurcation is simply the greatly elongated toes, shouldered at the end, each terminating in two soft fleshy points, at the base of which is situated the aperture for the escape of the secretion of the foot glands. *Brachionus angularis*, *Brachionus caudatus*, and probably other species of *Brachionus* have a similar structure of the toe, though not as prominent as in *B. diversicornis*. The character is certainly insufficient to justify the separation of this species in a separate genus.

*Brachionus diversicornis*

	Total Length	Great. Width	Ant. Sp.	Post. Sp.
Pond, Takao, Formosa	304μ	151μ	60-13μ	49-20μ
Liaoyang, south of Mukden, Manchoukuo	386μ	150μ	74-16μ	102-28μ
Dalai-nor, west of Chingan mt., Manchoukuo	440μ	186μ	94-15μ	112-45μ
Globonoia, U. S. S. R.	430μ	157μ	92-11μ	128-24μ
	540μ	185μ	120-15μ	162-145μ
Nungho, north of Tsitsihar, Manchoukuo	565μ	204μ	134-16μ	172-170μ

*Brachionus diversicornis* can be readily distinguished by its large size, by the peculiar structure of the toes, and by the occipital margin with only four spines, the laterals being very long, the medians very short. A rounded extension of the dorsal plate overhangs the foot opening. Such an extension is almost always present on forms of *B. caudatus*, is at times somewhat developed in *B. forficula*, and is never present in *B. havanaensis*. The *havanaensis-forficula-diversicornis* group is closely related to *B. caudatus*.

### *Brachionus forficula* Wierzejski

Plate VII, figure 8; Plate XX, figures 1, 2

WIERZEJSKI, 1891, p. 51, Fig. 3; 1893, p. 253, Fig. 3.—DADAY, 1903, p. 150, Pl. I, figs. 8, 10, 11; 1910, Pl. IV, fig. 21.—SLONIMSKI, 1923, p. 584, Fig.—FADEEV, 1925C, p. 286, Figs. 1, 2.—GRESE, 1926, p. 57, Figs. 1, 2.

*Brachionus forficula* var. *laevis* APSTEIN, 1907, p. 214, Fig. K.—FADEEV, 1925C, p. 289, Fig. 10.—UENO, 1938, p. 138, Figs. 1-6.

*Brachionus forficula* var. *volgensis* SKORIKOV, 1914, p. 32, Fig. 9; *Br. forficula* f. *volgensis* FADEEV, 1925C, p. 286, Figs. 3, 4.

*Brachionus forficula* f. *voronkowi* FADEEV, 1925C, p. 287, Fig. 5.

*Brachionus forficula* f. *divergens* FADEEV, 1925C, p. 287, Figs. 6, 7.

*Brachionus forficula* var. *minor* VORONKOV, 1913, p. 103; *Br. forficula* f. *minor* FADEEV, 1925C, p. 288, Figs. 8, 9.

*Brachionus forficula* f. *reducta* GRESE, 1926, p. 57, Figs. 3, 4 (in part).

Lorica firm, divided into a dorsal and a ventral plate, moderately compressed dorso-ventrally. Occipital margin with four spines: laterals longer than medians, intermediates quite obliterate; spines pointed or rounded at tips. Mental margin rigid, elevated, undulate, with a shallow, unflanked median sinus. The lorica terminates posteriorly in two stout, usually long, subequal spines, widely separated at their bases, and tapering to blunt points; on the inner side of the posterior spines near their bases are knee-like swellings. Foot opening between the bases of the posterior spines. Lorica finely stippled,

coarsely stippled, rarely tuberculate, sometimes with a pattern of cuticular ridges.

MALE.—Unknown.

DISTRIBUTION.—Eastern Europe, Africa (Victoria-Nyanza), Asia Minor, Ceylon, Formosa, Japan. Apparently does not occur in western and northern Europe nor the Americas. Found usually in subtropical regions.

*Brachionus forficula* is a quite variable species. Its variation tendencies are rather similar to those of *Brachionus havanaensis*. The species varies markedly in size in different habitats. The posterior spines may be greatly reduced (Grese, 1926); they are usually parallel or bowed, convergent toward their free ends, rarely divergent; they are often very stout; on large specimens posterior spines are proportionately longer than on small-sized forms. The knee-like swellings on the inner side of the posterior spines near their base are usually present, may be lacking on reduced forms. Posterior spines are wider apart at their bases on large specimens, relatively closer together on reduced forms. The reverse is usually true of *Brachionus havanaensis*, where the posterior spines are relatively closer together on large forms than reduced. Reduced forms of *Brachionus forficula* approach reduced forms of *Brachionus havanaensis* rather closely. However, reduced forms of the latter always have six occipital spines. In *B. forficula* posterior spines are almost always subequal. Grese, 1926, figures several forms on which the left spine is noticeably shorter, however.

Fadeev, 1925C, discusses the varieties of *Brachionus forficula*. He bases his forms on size, length and shape of posterior spines, and ornamentation of the lorica. All these characters are too variable to be of much taxonomic significance.

The following analysis is given as an aid in differentiating between the *havanaensis*, *forficula*, and *diversicornis* series of variants:

### *Brachionus forficula*

	Total Length	Width	Ant. Sp.	Post Sp.	Ant. Pts.
Pond, Takao, Formosa	192 $\mu$	100 $\mu$	13-10 $\mu$	82 $\mu$	54 $\mu$
Bohemia	215 $\mu$	92 $\mu$	26-14 $\mu$	95 $\mu$	54 $\mu$
Size range given by Fadeev, 1925C	106-256 $\mu$			24-120 $\mu$	

	<i>B. havanaensis</i>	<i>B. diversicornis</i>	<i>B. forficula</i>
Length:	Less than 400 $\mu$ long, usually between 250–350 $\mu$ , though much shorter forms do occur	Often longer than 400 $\mu$ , may be as long as 600 $\mu$	Less than 250 $\mu$ long
Anterior lateral spines:	May be as long as 60 $\mu$ , usually between 25–45 $\mu$ long and somewhat divergent	About 60–130 $\mu$ long, usually parallel or convergent	Usually between 12–30 $\mu$ long
Anterior median spines:	Usually between 15–25 $\mu$ long	Very short, about 10–16 $\mu$ long	About 10–15 $\mu$ long
Intermediates:	Short, but present	Obliterate	Obliterate
Mental edge:	Elevated, median sinus well defined and flanked	Somewhat elevated, median sinus shallow or lacking	Elevated, median sinus present, unflanked
Posterior spines:	Close together at base, parallel, convergent or divergent; left spine nearly equal to, or varying amounts shorter than right spine. Both may be reduced	Close together at base, divergent; left spine very short or about equal in length to right.	Wide apart at base, parallel, divergent, bowed, or convergent. Knee-like swellings on inner side of spines near base; spines always subequal; both spines may be reduced
Ornamentation:	Lorica smooth or lightly stippled	Lorica smooth or lightly stippled	Lorica lightly stippled to tuberculate, often with a pattern of cuticular ridges on dorsal plate

### *Brachionus mirus* Daday

DADAY, 1905A, p. 330; 1905B, p. 124, Pl. VII, figs. 14, 15.

Lorica firm, divided into a dorsal and a ventral plate. Anterior dorsal margin with six spines: laterals very long and divergent, medians short, intermediates almost obliterate. Lorica terminates posteriorly in two somewhat divergent spines, very wide apart at their bases, and about a fourth the total length of the organism. Foot opening between bases of posterior spines, rounded ventrally. Lorica heavily stippled.

**DIMENSIONS.**—Total length, 240–260 $\mu$ ; width, 85–90 $\mu$ .

**DISTRIBUTION.**—Known only from Paso Barreto, Paraguay.

I have not seen material of this species. It resembles *Brachionus diversicornis* in the character of the occipital spines but differs in having the intermediates developed, in having the posterior spines very wide apart at their bases, and in lacking the *diversicornis* type of toe. It is closely allied to *Brachionus caudatus* and may be an extreme form of var. *personatus*. Daday records the presence of small spines on either side of the foot opening; I think more likely that there is a prolongation of

the dorsal plate overhanging the foot opening, as is usual in this whole group of species.

### *Brachionus zahniseri* Ahlstrom

Plate XI, figures 1–4

AHLSTROM, 1934B, p. 256, Pl. XXV, figs. 1, 2.

Lorica firm, divided into a dorsal and a ventral plate, much compressed dorso-ventrally. Anterior dorsal margin with six spines: medians and laterals quite long, the intermediates almost obliterate; medians are usually somewhat longer than the lateral spines, being from a fourth to a sixth the total length of the lorica. Both median and lateral spines are often recurved at their ends, bending ventrally. Mental edge rigid, elevated, with a median sinus flanked on either side by a small tooth-like papilla. Posteriorly the lorica terminates in two long, stout posterior spines, wide apart at their bases, about equal in length, bowed and usually converging toward their apices; posterior spines are about two-fifths the total length of the lorica. Foot opening between bases of the posterior spines, oval, flanked laterally by small cuticular thickenings. Lorica finely stippled, rarely coarsely stippled or tuberculate.

*Brachionus zahniseri*

	Total Length	Width	Ant. Sp.	Post. Sp.
Dunedin Isle, Fla.	230 $\mu$	108 $\mu$	35-2-35 $\mu$	95 $\mu$
Bayboro, N. C.	256 $\mu$	122 $\mu$	44-2-42 $\mu$	108 $\mu$
Near Odessa, Fla.	298 $\mu$	139 $\mu$	60-3-72 $\mu$	130 $\mu$
Keystone Lake, Fla.	315 $\mu$	144 $\mu$	95-3-95 $\mu$	125 $\mu$

MALE.—Unknown.

DISTRIBUTION.—Southern United States. Material from several habitats in Florida, North Carolina, and from Texas.

This species is readily distinguished by the long median and lateral occipitals—no other species of *Brachionus* with six occipital spines having both laterals and medians markedly long.

*Brachionus falcatus* Zacharias

Plate X, figures 1-3

ZACHARIAS, 1898B, p. 133, Pl. IV, fig. 4.—WEBER, 1906, pp. 211, 218, Figs. G-O, T-Y.

*Brachionus falcatus* var. *hamatus* LEMMERMANN, 1908, p. 403, Fig. 33.

*Brachionus falcatus* var. *lyratus* LEMMERMANN, 1908, p. 401, Figs. 28-31, 34, 35.—APSTEIN, 1907, p. 215, Fig. L.

? *Brachionus dichotomus* SHEPHARD, 1911, p. 57, Pl. XXII, figs. 3, 4.

Lorica firm, divided into a dorsal and a ventral plate, quite compressed dorso-ventrally. Anterior dorsal margin with six spines: intermediates much longer than other spines, curve ventrally, lateral and median spines short and of about equal length. Mental edge moderately firm, with lateral sinuities, and a somewhat undulate raised portion, at times with a slight median sinus. Body terminates posteriorly in two long spines, widely separated at their bases, bowed, and usually converging toward their free ends, often markedly so. Apices of posterior spines often somewhat twisted. Foot opening between bases of posterior spines, a small dorsal aperture present on some specimens. Lorica lightly stippled, extremities of spines somewhat serrate.

MALE.—Unknown.

DISTRIBUTION.—This species is apparently subtropicopolitan in distribution. I have seen abundant material from Panama and northeast Brazil.

The variability of this species has been widely commented upon by investigators. In reality it is not nearly as variable as many other species of *Brachionus*. The size range is not extensive, the posterior spines are always well developed, as are also the anterior intermediate spines; the chief variability is in the shape of the posterior spines, which may be almost parallel, or bow outward and then converge and twist markedly toward their apices, or rarely may be divergent at their extremities. The original figure of this species by Zacharias is not typical, and is rather inaccurate. *Brachionus dichotomus* Shephard could well be a form of this species on which the Australian overlooked the other occipital spines. If, on the other hand, Shephard's description is accurate, *Brachionus dichotomus* is a distinct species.

*Brachionus satanicus* Rousselet

Plate X, figures 4-6

ROUSSELET, 1911, p. 162, Pl. VII, fig. 2a, b; 1913, Pl. VI, figs. 2a-f.

Lorica firm, divided into a dorsal and a ventral plate, much compressed dorso-ventrally. Lorica narrowest in front, widening posteriorly, terminating in two stout, and often long, curved spines. Dorsal margin with six small spines, medians slightly longer than laterals or intermediates; sulcus between medians rectangular. Mental margin rigid, with four saw-tooth spines, middle pair separated by a U-shaped sinus. Foot opening between bases of posterior spines, situated at times somewhat forward on the dorsal plate. Lorica lightly stippled, or pustulate.

MALE.—Unknown.

DISTRIBUTION.—Known from Devils Lake, N. D., from British Columbia, and from a very brackish lagunas at Encadenadas (Este), San Luis Province, Argentina.

*Brachionus falcatus*

	Total Length	Width	Ant. Sp.	Post. Sp.	Ant. Pts.
Panama	315 $\mu$	114 $\mu$	13-80-14 $\mu$	134 $\mu$	77 $\mu$
Parahyba, Brazil	380 $\mu$	133 $\mu$	18-85-18 $\mu$	160 $\mu$	80 $\mu$



*Brachionus santanicus*

	Total Length	Width	Ant. Sp.	Post. Sp.	Ant. Pts.
Devils Lake, N. D.	375 $\mu$	120 $\mu$	5-10-15 $\mu$	188 $\mu$	66 $\mu$
Encadenadas, Argentina	250 $\mu$	121 $\mu$	4-7-8 $\mu$	69-58 $\mu$	71 $\mu$

On *Brachionus satanicus* the posterior spines may be as long as the rest of the lorica, and symmetrically curved. Rousset called this the "winter form." However, the posterior spines vary greatly at different seasons, being at times rather short and irregularly curved. On the so-called "winter form" the posterior spines are about equal in length; on the reduced form the right spine is usually somewhat longer than the left. The general shape of the reduced form is barrel-shaped, and the body is as large as in the long-spined form; the rather short posterior spines are always convergent. The reduced form only was found in the Argentina material.

This species has no near relative. It is the only species of *Brachionus* with pronounced spines on the mental margin. It has been found in highly brackish habitats only.

*Brachionus quadridentatus* Hermann

Plate XI, figure 9; Plate XII, figures 1-9;  
Plate XIII, figure 3

HERMANN, 1783, p. 47, Pl. II, fig. 9.

*Brachionus bakeri* MÜLLER, 1786, p. 359, Pl. XLVII, fig. 13, Pl. L, figs. 22, 23.—EHRENBERG, 1838, p. 514, Pl. LXIV, fig. 1.—WIERZEJSKI, 1893, p. 252, Pl. VI, figs. 68-69.—SKORIKOV, 1896, p. 137, Figs. 46-47.—ROUSSELET, 1897B, pp. 328-332, Pl. XVI.—WEBER, 1898, p. 679, Pl. XXIV, figs. 1-4.—JENNINGS, 1900, p. 96, Figs. 45, 46.—WEBER, 1906, pp. 210, 217, Figs. D, E, F, R, S.—DIFFENBACH AND SACHSE, 1912, p. 75, Pl. XII, fig. 6.—ARÉVALO, 1918, p. 41, Figs. 32-34.

*Brachionus latissimus* SCHMARD, 1854, p. 18, Pl. IV, fig. 4.

*Brachionus bakeri* var. *latissimus* DADAY, 1910, p. 91, Pl. IV, figs. 7, 8.

*Brachionus chilensis* SCHMARD, 1859, p. 64, Pl. XV, fig. 136.

*Brachionus ancylognathus* SCHMARD, 1859, p. 65, Pl. XV, fig. 137.

*Brachionus polyceros* SCHMARD, 1859, p. 65, Pl. XV, fig. 138.

*Brachionus pustulatus* SCHMARD, 1859, p. 65, Pl. XV, fig. 139.

*Brachionus brevispinus* EHRENBERG, 1832, p. 146; 1838, p. 513, Pl. LXIII, fig. 6.—WIERZEJSKI, 1893, p. 252, Pl. VI, fig. 70.—SKORIKOV, 1896, p. 138, Pl. VIII, fig. 48-51, Pl. IX, figs. 54, 55.

*Brachionus longipes* ANDERSON, 1889, p. 357, Pl. XXI, fig. 12.

*Brachionus tuberculus* TURNER, 1892, p. 65 Pl. I, fig. 6.

*Brachionus rhenanus* LAUTERBORN, 1893, p. 269, Pl. XI, fig. 3.

*Brachionus melheni* (*melhemi*) BARROIS AND DADAY, 1894A, p. 233, Pl. VII, figs. 18, 19; 1894B, p. 400, Pl. V, figs. 18, 19.

*Brachionus obesus* BARROIS AND DADAY, 1894A, p. 236, Pl. VII, figs. 21, 22; 1894B, p. 406, Pl. V, figs. 21, 22.

*Brachionus entzii* FRANCÉ, 1894, p. 166, Pl. V, figs. 1, 2.

*Brachionus cluniorbicularis* SKORIKOV, 1894, p. 33; 1896, p. 140, Pl. VIII, fig. 24.

*Brachionus granulatus* KERTÉSZ, 1894, p. 51, Pl. I, fig. 5.

*Brachionus bakeri* var. *cornutus* (*anisitsi*) DADAY, 1905, p. 121, Pl. VII, fig. 8.

*Brachionus bakeri* var. *zernovi* VORONKOV, 1907, p. 115.

*Brachionus bakeri* var. *fülleborni* DADAY, 1908, p. 37; 1910, p. 92, Pl. IV, figs. 11, 12.

*Brachionus bakeri* var. *michalseni* DADAY, 1910, p. 92, Pl. IV, fig. 14.

*Brachionus bakeri* var. *rectangularis* LUCKS, 1912, p. 140, Fig. 53B.

*Brachionus bakeri* var. *convergens* JAKUBSKI, 1915, p. 41.

*Brachionus bakeri* var. *hyphalmyros* (and forms *curvata* and *divergens*) TSCHUGUNOFF, 1921, pp. 117-119, Figs. 8-10.

*Brachionus bakeri* var. *congolense* VAN OYE, 1926, p. 53, Fig. 9.

Lorica firm, divided into a dorsal and a ventral plate, moderately compressed dorso-ventrally. Occipital margin with six spines: medians longest, curve outward, and, when quite long, are, in addition, bent downward over the head of the animal; laterals longer than intermediates, at times nearly as long as the medians, often curve outward. Mental margin rigid, elevated, wavy, with a median notch flanked on either side by a small tooth-like papilla. The lorica usually terminates posteriorly in two lateral spines, very variable in length on different individuals. The ventro-posterior portion of the lorica is prolonged and forms a tubular foot sheath around the base of the retractile foot; on the dorsal side of this sheath a sub-square piece is cut out. Body usually stippled or pustulate, ornamentation arranged in regular lines or patterns, or scattered.

*Brachionus quadridentatus*

	Total Length	Width	Ant. Sp.	Post. Sp.	Ant. Pts.
Lagoon, Catawba, Ohio	188 $\mu$	134 $\mu$	20-12-28 $\mu$	26 $\mu$	102 $\mu$
Klippoortje Dam, South Africa	208 $\mu$	158 $\mu$	21-13-33 $\mu$	20 $\mu$	108 $\mu$
Malmöhus, Sweden	216 $\mu$	188 $\mu$	17-13-25 $\mu$	20 $\mu$	107 $\mu$
Pool, Riverby, Ohio	220 $\mu$	196 $\mu$	24-22-30 $\mu$		120 $\mu$
Pool, Mathias, Ohio	233 $\mu$	223 $\mu$	19-14-21 $\mu$		109 $\mu$
Near New Orleans, La.	242 $\mu$	168 $\mu$	20-16-43 $\mu$	60 $\mu$	114 $\mu$
Near La Belle, Fla.	264 $\mu$	168 $\mu$	23- 9-47 $\mu$	73 $\mu$	104 $\mu$
Pool near Palmdale, Fla.	265 $\mu$	156 $\mu$	23-12-46 $\mu$	80 $\mu$	110 $\mu$
Buckeye Lake, Ohio	270 $\mu$	171 $\mu$	23-11-48 $\mu$	90 $\mu$	98 $\mu$
Pool, Port Clinton, Ohio	290 $\mu$	188 $\mu$	36- 3-44 $\mu$	56 $\mu$	128 $\mu$
Near Wimauma, Fla.	303 $\mu$	192 $\mu$	31-15-41 $\mu$	92 $\mu$	130 $\mu$
Terwilliger's Pond, Put-in-Bay, Ohio	418 $\mu$	234 $\mu$	49-17-72 $\mu$	156 $\mu$	200 $\mu$

MALE.—Gosse, 1858; Rousselet, 1897.

DISTRIBUTION.—Cosmopolitan in alkaline waters. This is perhaps the most common species of *Brachionus*.

*Brachionus quadridentatus* is very variable, which has resulted in an extensive synonymy for this species. The most characteristic features of the species are the tubular foot sheath, outward curving antlers, and the postero-lateral spines. The ventro-posterior portion of the lorica is prolonged into a tubular sheath around the base of the foot; the sheath stands out at nearly right angles to the ventral plate and is subject to much variation, but is always distinctly present on all forms of the species. Harring's contention that all stages of development of the foot sheath might be found between *Brachionus urceolaris* and *Brachionus quadridentatus* is not borne out by the facts. On the dorsal side of the foot sheath a sub-square piece is cut out, the edge of which forms the so-called spines bounding the foot opening. The foot sheath is often asymmetric, particularly on forms having long postero-lateral spines, and the right side has the longer cuticular process. Only two other species of *Brachionus* possess a well-developed foot sheath: *Brachionus bidentata* and *Brachionus mirabilis*.

The postero-lateral spines are subject to the greatest possible variation: they may be very long and narrow, or short and stout, or totally obsolete, divergent, parallel, or convergent. The character of the postero-lateral spines has often been used in redescribing this common species under new specific or varietal names.

The antlers vary markedly in size and shape. On the forms with well-developed posterior spines the antlers are long and

diverge markedly, especially in the outer half of their length, and, in addition, bend downward over the head; on such forms the lateral spines are often only half as long as the antlers. On forms with short postero-lateral spines the antlers are shorter and only moderately divergent, and the lateral spines may be nearly equal in length to the antlers. The intermediates are rarely almost obliterate. Occipital spines are usually acutely pointed, rarely rounded; on some individuals the intermediate spines are rounded while the other occipital spines are acutely pointed.

The lorica of *Brachionus quadridentatus* is more or less stippled to pustulate, with the ornamentation often arranged in regular lines and patterns. As a rule the ornamentation is most pronounced on long-spined forms. However, a form from India lacking postero-lateral spines was markedly pustulate, and in several American habitats the brevispined forms are also prominently pustulate.

Although *Brachionus quadridentatus* is a very variable species, the various forms have many characters in common which sharply separate them from other species of *Brachionus*. Yet most investigators have lacked a critical insight into the variation limits of this species. Harring, 1913, for example, placed a heterogeneous conglomerate in the synonymy of this species: including *Brachionus variabilis* and synonyms of *Brachionus bidentata*, *urceolaris*, and *leydigii*. Rousselet, 1897B, gives an excellent discussion of this species.

*Brachionus quadridentatus* is a small pond or river form, and not a euplankton species, although it may be taken in plankton. In studying this species from a number of habitats it is possible to arrange a

complete series of intermediates from the long-spined form to the *cluniorbicularis* type, yet it is noteworthy that in any given habitat containing both long-spined and brevispined forms one finds little indication of gradation between these two series, though it is usual to find a complete series of forms in the same habitat between the brevispined and *cluniorbicularis* types.

### *Brachionus mirabilis* Daday

Plate XI, figures 5-8

DADAY, 1897, p. 140, Fig. 8; 1901, p. 24, Fig. 7; 1905, Pl. VII, figs. 9, 10.

Lorica firm, divided into a dorsal and a ventral plate, somewhat compressed dorso-ventrally. Anterior dorsal margin with six spines: medians longest, curve outward, as do also the laterals, laterals longer than intermediates. Mental margin rigid, elevated, with a shallow median sinus flanked on either side by a tooth-like papilla. The dorsal plate terminates posteriorly in two long, thin lateral spines, usually extending forward from the body at an angle. The ventral plate narrows posteriorly and terminates in two rather long, thin spines (about equal in length), extending backward from the lorica at about a forty-five degree angle. Foot opening surrounded by a sheath, between the bases of the ventral spines, usually bordered to two very short accessory spines. Egg carried on dorsal side of ventral spines. Lorica stippled; cuticular ridges arise from bases of inner anterior spines.

MALE.—Unknown.

DISTRIBUTION.—Previously reported from New Guinea, Daday, 1897; Nyasa, Daday, 1910, in Africa; Paraguay, Daday, 1905, in South America; and Panama, Harring, 1915. Seen in material from Rio de Janeiro, Brazil, and near Myakka City, Florida.

This species is apparently subtropicalopolitan. It is closely related to *Brachionus quadridentatus* differing chiefly in the long posterior ventral spines arising from the base of the foot opening.

This species is not well enough known to discuss its variation tendencies adequately. In common with most species of *Brachionus* it varies considerably in size in different habitats. The postero-ventral spines are somewhat reduced in length in some habitats, and may be quite close together at their apices or relatively widely divergent. The postero-ventral spines and adjacent foot sheath are rather symmetrical in *Brachionus mirabilis*, while the foot sheath on long-spined forms of *Brachionus quadridentatus* is usually markedly asymmetric.

### *Brachionus bidentata* Anderson

Plate XIII, figures 1, 2, 4-9

ANDERSON, 1889, p. 357, Pl. XXI, fig. 13.

*Brachionus furculatus* THORPE, 1891, p. 302, Pl. VI, fig. 3.—ROUSSELET, 1906, p. 397, Pl. XIV, figs. 1-3.—DE BEAUCHAMP, 1928, p. 96, Fig. 2.

*Brachionus bakeri* var. *areolata* DADAY, 1902, p. 205, Fig.

? *Brachionus bursarius* BARROIS AND DADAY, 1894A, p. 235, Pl. VII, fig. 20; 1894B, p. 404, Pl. V, fig. 20, Text Figs. 8-11.

*Brachionus furculatus* var. *inermis* ROUSSELET, 1906, p. 398, Pl. XIV, fig. 4.—DE BEAUCHAMP, 1927, p. 61, Fig. 1; 1928, p. 96, Fig. 2.

*Brachionus bakeri* var. *inermis* DADAY, 1908, p. 35; 1910, p. 91, Pl. IV, fig. 6.

*Brachionus furculatus* var. *testudinarius* JAKUBSKI, 1912, p. 547, Figs. 6, 7.—FADEEV, 1927, p. 145, Pl. I, fig. 10.

Lorica firm, divided into a dorsal, a ventral, and a basal plate; dorsal and ventral plates soldered together for three-fifths of the length of the lorica, where they diverge and are united to a third plate, the basal. Anterior dorsal margin with six spines: laterals always longer than medians, on some individuals two or three times as long, medians longer than intermediates. Mental margin flexible in median portion, nearly straight or slightly concave following state of contraction, lateral sinuities present. Lateral antennae are exactly marginal, surrounded by a triangular area (marks junction of basal plate with the dorsal). Posterior spines variable in length

### *Brachionus mirabilis*

	Total Length	Width	Ant. Sp.	Post.-Dor. Sp.	Post.-Ven. Sp.
Rio de Janeiro, Brazil	320 $\mu$	150 $\mu$	36-27-44 $\mu$	150 $\mu$	100 $\mu$
Near Myakka City, Fla.	200 $\mu$		24-28-34 $\mu$	108 $\mu$	65 $\mu$

<i>Brachionus bidentata</i>					
	Total Length	Width	Ant. Sp.	Post. Sp.	Ant. Pts.
Near Arcadia, Fla.	175 $\mu$	132 $\mu$	25-10-10 $\mu$		104 $\mu$
Ditch near Palmdale, Fla.	180 $\mu$	124 $\mu$	16- 8-12 $\mu$		88 $\mu$
Lagoon, Catawba, Ohio	208 $\mu$	115 $\mu$	36-13-18 $\mu$		112 $\mu$
Oklahoma City, Okla., Reservoir	218 $\mu$	180 $\mu$	33-14-23 $\mu$	42 $\mu$	119 $\mu$
Near New Orleans, La.	242 $\mu$	158 $\mu$	36-14-20 $\mu$	46 $\mu$	139 $\mu$
Dam, Stromberg Junction, S. Africa	247 $\mu$	196 $\mu$	38- 7-24 $\mu$		140 $\mu$
Lake Creve Coeur, St. Louis, Mo.	250 $\mu$	165 $\mu$	38-23-25 $\mu$	52 $\mu$	152 $\mu$
Springar, India	270 $\mu$	208 $\mu$	49-16-17 $\mu$	60 $\mu$	170 $\mu$
Buckeye Lake, central Ohio	290 $\mu$	177 $\mu$	47-17-22 $\mu$	70 $\mu$	136 $\mu$
Swan Creek, northern Ohio	300 $\mu$	184 $\mu$	58-22-28 $\mu$	52 $\mu$	102 $\mu$
W. Bloemfontein, S. Africa	455 $\mu$	220 $\mu$	97-15-34 $\mu$	168 $\mu$	?
Same Loc. (Rousselet)	578 $\mu$	265 $\mu$	?	238 $\mu$	?

and position of origin, may be obsolete. Foot opening with projecting sheath which is more or less symmetrical. Lorica lightly to coarsely stippled, with a definite pattern of cuticular ridges on dorsal plate, often indistinct.

MALE.—Thorpe, 1891; Rousselet, 1906.

DISTRIBUTION.—Apparently cosmopolitan. I have seen material from Ohio, Missouri, Florida, Oklahoma, Louisiana, Argentina, South Africa, and India. Many investigators have confused this species with *Brachionus quadridentatus*. Turner, 1892, figured this species from near Cincinnati, Ohio, as the latter species.

It is with regret that I discard the familiar name of *Brachionus furculatus* for *Brachionus bidentata*. However, *Brachionus bidentata* is obviously based on a form in this variation series. Although Anderson did not note the basal plate, nor the position of the lateral antennae, yet his species with a "nearly straight" mental edge and with laterals longer than medians can be naught else than the species to be redescribed two years later by Thorpe as *Brachionus furculatus*.

This species has a marked size variability. Material from South Africa had a much larger size than that found elsewhere. Most marked variation tendencies other than size are in the length and position of origin of postero-lateral spines, the relative proportions of occipital spines, and the general shape.

*Brachionus bidentata* presents a series of variants analogous to those found in *Brachionus quadridentatus*. A complete series of intermediates might be arranged from forms with long postero-lateral spines to

forms on which posterior spines are entirely obsolete. There is an unusual range in variation as to the origin of the postero-lateral spines; at times the lorica narrows but slightly before the origin of the spines; on other specimens the spines are set in about a fourth the width of the lorica. Usually the posterior spines are parallel or bowed with converging apices, but on specimens from Springar, India, the posterior spines arise laterally at an angle of about forty-five degrees (de Beauchamp, 1928, figures a similar form obtained in cultures of this species on *Chlamydomonas*). It is not unusual to find individuals with one posterior spine obsolete. I have seen a specimen collected by Rousselet from South Africa on which the posterior spines were 168 $\mu$  long (Rousselet indicates a size range up to 238 $\mu$  long). Usually, however, the posterior spines are only 40–70 $\mu$  long in most habitats.

The anterior lateral spines are always longer than the medians, at times markedly so. The ratio of the length of medians to laterals is 0.31–0.86, with a median of 0.53. The anterior lateral spines are usually somewhat divergent, rarely convergent. Medians may be somewhat recurved. Anterior spines are usually acutely pointed, rarely bluntly rounded. The intermediate spines join the lateral spines more or less toward their outer edge, so that the lateral spines seem more a part of the mental margin than the occipital. There is quite some variation in the shape of the foot orifice.

The following chart may be helpful in separating the *bidentata* series from the *quadridentatus*:



	<i>B. quadridentatus</i> series	<i>B. bidentata</i> series
Occipital spines:	Medians (antlers) always longer, though they may be nearly equal to laterals. Antlers always curve outward, at times markedly so	Laterals always longer, though they may be nearly equal in length to medians. Medians rarely curve outward
Mental margin:	Rigid, elevated, undulate, with a clearly defined central sinus flanked by a small tooth-like papilla on either side	Flexible, nearly straight, at times somewhat convex, never with a clearly defined central notch
Basal plate:	Absent	Present
Lateral antennae:	On dorsal plate, 1/12 width of plate inside the lateral edge	Exactly marginal, at junction of plates
Foot sheath:	Usually somewhat asymmetric, particularly so in long-spined forms	More or less symmetrical
Ornamentation:	Stippled to pustulate, arranged in somewhat regular patterns. Pattern of cuticular ridges never present	Lorica lightly stippled, but with a pattern of cuticular ridges on dorsal plate. Never pustulate
Eggs of duration:	Smooth or with fine punctations of inner surface	Rough, covered with pustules that raise above the surface

***Brachionus pterodinoides* Roussellet**

Plate XIV, figures 9-11

ROUSSELET, 1913, p. 59, Pl. VI, fig. 1a-c.

*Brachionus westphali* CARLIN-NILSON, 1935, p. 4, Figs. 8-10.

Lorica firm, oval, divided into a dorsal and a ventral plate, much compressed dorso-ventrally, body curved ventrally. Anterior dorsal margin with six spines of nearly equal length (laterals usually shorter); dorsal margin not elevated toward the center. Mental margin relatively firm, nearly straight, lacks median indentation, but has a lateral sinus on each side. Foot opening situated just below the center of the ventral plate, pear-shaped, a foot sheath is weakly developed. Lorica very finely stippled, anteriorly small ridges mark the continuation of the frontal spines.

MALE.—Carlin-Nilson, 1935.

DISTRIBUTION.—Devils Lake, N. D., several localities in British Columbia, a lake in Cordoba, Mexico, and Laguna Viejo in San Luis Province, Argentina. All of these are highly alkaline habitats.

De Beauchamp, 1927, suggests that this species is in the variation series of *Brachionus quadridentatus*. This cannot be the case as the mental edge is very different (it resembles *Brachionus bidentata*), the body is much more compressed and curves

ventrally; the antlers are never recurved, and are no longer than other occipital spines; the tubular sheath around the foot opening is but weakly developed, and there is no piece cut out of the posterior portion of the sheath (as is always the case in both *Brachionus quadridentatus* and *Brachionus bidentata*). The foot opening is farther forward than on any other species of *Brachionus*.

***Brachionus variabilis* Hempel**

Plate XIV, figures 1-3, 6-8

HEMPEL, 1896, p. 310, Pl. XXII, figs. 1, 2.—MYERS, 1917, p. 475, Pl. XL, figs. 1-5.

? *Brachionus jamaicensis* SCHMARD, 1859, p. 64, Pl. xv, fig. 135.

Lorica firm, oval, divided into a dorsal and a ventral plate, dorso-ventral depth about one-half of width. Anterior dorsal margin with six acutely pointed spines: medians longest and curve outward, intermediate and lateral spines of about equal length. Mental margin rigid, elevated, undulate, with a U-shaped central sinus flanked on either side by a papilla-like protuberance. Lorica narrows posteriorly and terminates in stout lateral spines, less than one-fourth the total length of the lorica, may be obsolete. Foot opening between the bases of the posterior spines;

***Brachionus pterodinoides***

	Total Length	Width	Ant. Sp.	Ant. Pts.
Cordoba, Mexico	230μ	172μ	16-17-15μ	94μ
Devils Lake, N. D.	256μ	196μ	17-19-19μ	74μ
San Luis Province, Argentina	260μ	211μ	18-18-17μ	80μ

*Brachionus variabilis*

	Total Length	Width	Ant. Sp.	Post. Sp.	Ant. Pts
Near Los Angeles, Calif.	{ 308 $\mu$	208 $\mu$	30-21-52 $\mu$		140 $\mu$
	{ 312 $\mu$	192 $\mu$	25-19-43 $\mu$	50 $\mu$	140 $\mu$
Oklahoma City, Okla., Reservoir	{ 268 $\mu$	182 $\mu$	19-18-38 $\mu$		130 $\mu$
	{ 376 $\mu$	250 $\mu$	19-22-44 $\mu$	90 $\mu$	142 $\mu$

dorsally a quadrate plate projects over the foot orifice. Lorica smooth, marked by a few short ridges running back from the four inner occipital spines. Free swimming or commensal on *Daphnia* or *Ceriodaphnia*.

MALE.—Unknown.

DISTRIBUTION.—Known only from the vicinity of Havana, Illinois, from Los Angeles, Calif., and from the Oklahoma City water reservoir, Oklahoma.

The principal variation noted was in the posterior spines, which may be well developed or lacking, divergent or straight, and more or less stout. This species may be readily recognized by the subquadrate plate projecting over the foot orifice. Both dorsal and ventral margins are quite elevated toward the center.

*Brachionus novae-zelandiae* (Morris)

Plate XIV, figures 4, 5

*Brachionus variabilis* var. *novae-zelandiae* MORRIS, 1913, p. 167, Text Fig.

*Brachionus capsuliflorus* var. *novae-zelandiae* (Barham?) in HUTCHINSON, et al., 1932, pp. 59, 144.

Lorica firm, divided into a dorsal and a ventral plate, somewhat compressed dorso-ventrally. Anterior dorsal margin with six acutely pointed spines: medians several times longer than other anterior spines; intermediates somewhat longer than lateral spines. Mental margin rigid, rises abruptly from the lateral sinuosities to an elevated, subquadrate central portion with a small V-shaped median sinus. Lorica terminates posteriorly in two stout, blunt spines (stouter than in any other described *Brachionus*). Foot opening between the bases of the posterior spines. Lorica smooth or finely stippled, marked by a few short ridges running back from the spines.

MALE.—Unknown.

DISTRIBUTION.—Oamaru, New Zealand;

Eilandspan, Chrissie area, South Africa.

The form of this species from South Africa is markedly smaller than in the New Zealand material; the posterior spines are quite reduced and the opening between them is nearly quadrate, giving a different appearance to the species than in the New Zealand material. No reduced forms of this species have been noted in which the posterior spines were not developed. Although closely related to *Brachionus variabilis*, it differs in lacking the subquadrate projection over the foot orifice, and in the character of the posterior spines. On a sketch of this species distributed by Dixon-Nuttall from the original material sent to Rousselet he indicates 564 $\mu$  as the total length of the specimen he illustrated.

*Brachionus rubens* Ehrenberg

Plate XV, figures 1-9

EHRENBERG, 1838, p. 513, Pl. LXIII, fig. 4.—COLLIN, 1897, Pl. VII, fig. 7.—ROUSSELET, 1907, p. 151, Pl. XII, figs. 9, 10.

? *Brachionus bidentatus* KERTÉSZ, 1894, p. 49, Pl. I, fig. 2.

*Brachionus macrocanthus* JAKUBSKI, 1912, p. 546, Fig. 5.

Lorica rather firm, oval, divided into a dorsal and a ventral plate, but little compressed dorso-ventrally. Anterior dorsal margin with six spines, of which the medians and intermediates have a peculiar unsymmetric shape, each spine showing a narrow anterior part, then rounding outward and forming a broad base, medians somewhat longer than other spines. Mental edge undulate, markedly elevated toward the center, with a central notch. Posterior spines not present. Foot opening sub-square and rather small dorsally; large, truncate-oval to V-shaped ventrally. Lorica smooth; the four inner spines of the dorsal margin have a short strengthening

*Brachionus novae-zelandiae*

	Total Length	Width	Ant. Sp.	Post. Sp.
Oamaru, New Zealand	388 $\mu$	173 $\mu$	20-30-62 $\mu$	123 $\mu$
Eilandspan, S. Afr.	260 $\mu$	130 $\mu$	7-16-35 $\mu$	40 $\mu$

*Brachionus rubens*

	Total Length	Width	Ant. Sp.	Ant. Pts.
Açude Simão, Parahyba, Brazil	154 $\mu$	120 $\mu$	17-14-24 $\mu$	96 $\mu$
Swan Creek, northern Ohio	186 $\mu$	126 $\mu$	15-14-22 $\mu$	101 $\mu$
Philadelphia, Pa. (on <i>Daphnia</i> )	190 $\mu$	142 $\mu$	11- 9-18 $\mu$	108 $\mu$
Pond, Farmersville, Pa.	235 $\mu$	188 $\mu$	17-18-30 $\mu$	135 $\mu$
Slowmarket, Suffolk, England	260 $\mu$	194 $\mu$	17-17-30 $\mu$	125 $\mu$
Pond, Fleninge, Sweden	274 $\mu$	196 $\mu$	17-20-34 $\mu$	142 $\mu$

ridge. Body may be red-colored, but not necessarily so. Commensal on *Daphnia* or free swimming.

MALE.—Rousselet, 1907.

DISTRIBUTION.—Probably cosmopolitan. Because of confusion existing in the taxonomy of this group of *Brachionus*, one cannot trust most previous records of *Brachionus rubens*. I have seen material from Wisconsin, Ohio, Pennsylvania, Brazil, Argentina, England, and Sweden.

*Brachionus rubens* might be said to have only four dorsal spines, as the intermediate spines connect with the lateral spines near their outer edge. On some individuals the lateral spines are distinctly a part of the mental edge, not the occipital. Both mental and occipital margins are quite elevated toward the center.

Besides a rather large size range, the chief variation tendency in *Brachionus rubens* is in the shape of the foot opening. The usual shape of the foot orifice in the ventral plate is truncate-oval, but in some habitats the aperture is inflated V-shaped. As the figures show, there is also some variation in shape of lorica.

This is a well-characterized species of *Brachionus*, easily distinguishable from *Brachionus urceolaris* by the character of the intermediate and median spines, and by the unornamented lorica.

*Brachionus urceolaris* Müller

Plate XVI, figures 1-11

*Brachionus urceolaris* MÜLLER, 1773, p. 131.—EHRENBERG, 1838, p. 512, Pl. LXIII, fig. 3.—COHN, 1856, p. 459, Pl. XXIV, figs. 1-12.—TOTH, 1861, p. 168, Figs. 5-9.—WEBER, 1898, p. 674, Pl. XXIII, figs. 18-20.—SKORIKOV, 1896, p. 133, Pl. VIII, figs. 42-45.—DIFFENBACH AND SACHSE, 1912, p. 76, Pl. XIII, fig. 7.—ARÉVALO, 1918, p. 39, Fig. 27.

? *Tubipora urceus* LINNAEUS, 1758, p. 796.

*Brachionus nicarguensis* SCHMARDT, 1859, p. 64, Pl. xv, fig. 134.

*Brachionus pyriformis* BARROIS AND DADAY, 1894A, p. 238, Pl. VII, figs. 23, 24, 1894B, p. 407, Pl. v, figs. 23, 24.

*Brachionus chavesi* BARROIS, 1896, p. 124, Figs. 5, 6.

*Brachionus sericus* ROUSSELET, 1907, p. 147, Pl. XI, figs. 1-5.

Lorica firm, oval, divided into a dorsal and a ventral plate (often indications of a basal plate as well), moderately to little compressed dorso-ventrally. Anterior dorsal margin with six spines: medians longest, laterals and intermediates about equal in length. Mental margin rigid, undulate, somewhat elevated toward the center, with a central sinus. Posterior spines not present. Lorica rises posteriorly to form an overhanging border, which may be simply rounded, or may extend to form a considerable projection. Foot opening with a sub-square to rectangular aperture in the dorsal (basal) plate, and a rather large

*Brachionus urceolaris*

	Total Length	Width	Ant. Sp.	Ant. Pts.
Oklahoma City, Okla., Reservoir	185 $\mu$	135 $\mu$	12-11-25 $\mu$	
Village Pond, Hodkovičky, Czechoslovakia	198 $\mu$	166 $\mu$	9-10-14 $\mu$	118 $\mu$
Butler Lake, Florida	200 $\mu$	148 $\mu$	12-14-25 $\mu$	98 $\mu$
Near Tarpon Springs, Fla.	208 $\mu$	153 $\mu$	14-13-25 $\mu$	109 $\mu$
Lago Limon, Hispaniola	220 $\mu$	144 $\mu$	8-14-22 $\mu$	98 $\mu$
Pond, Hyby, Sweden	230 $\mu$	202 $\mu$	14-12-20 $\mu$	128 $\mu$
Near Myakka City, Fla.	234 $\mu$	183 $\mu$	13-13-22 $\mu$	147 $\mu$
Springar, India	240 $\mu$	194 $\mu$	10-11-19 $\mu$	120 $\mu$
Lund, Sweden	243 $\mu$	194 $\mu$	13-11-22 $\mu$	120 $\mu$
Near London, England	270 $\mu$	225 $\mu$	14-15-25 $\mu$	160 $\mu$
Mamie Lake, Wisc.	275 $\mu$	220 $\mu$	12-20-28 $\mu$	162 $\mu$
Buckeye Lake, Ohio	280 $\mu$	225 $\mu$	26-20-32 $\mu$	142 $\mu$
Lunz, Austria	280 $\mu$	200 $\mu$	12-14-22 $\mu$	152 $\mu$

oval aperture ventrally. Lorica may be nearly smooth, usually with a pattern of wavy, longitudinal lines more or less distinct; pattern often foreshortened on the basal plate, giving the appearance of pitting. The four inner spines of the dorsal margin have short strengthening ridges, and two strengthening ridges also arise from the papilla-like process on either side of central sinus on mental margin.

There is much confusion surrounding the early names given to forms of *Brachionus* with six occipital spines and lacking posterior spines, the early descriptions being inadequate. Van Hofsten (1909) regards *Tubipora urceus* Linnaeus as being the *rubens* form. However, this is by no means certain, as there is also no assurance that the form named by Linnaeus is that under discussion. I consider *Brachionus urceus* as a doubtful species. I am using the name *urceolaris*, associated for many years with the species under consideration.

MALE.—Gosse, 1858; Cohn, 1856; Toth, 1861; Weber, 1898; Rousselet, 1907; Wesenberg-Lund, 1923.

DISTRIBUTION.—Widely distributed; apparently cosmopolitan. I have seen material from Wisconsin, Michigan, Ohio, Maine, Oklahoma, North Carolina, Florida, Nevada, Haiti, Argentina, England, Sweden, Austria, Czechoslovakia, northern India, and Japan.

I find it impossible to separate *Brachionus sericus* from *Brachionus urceolaris*. The chief distinction between the two species is in the ornamentation of the lorica: this varies from very pronounced to relatively smooth. On most specimens some trace of the ornamentation may be found on careful examination.

This species has a rather large size range. It varies quite markedly in the proportion of length to width: width/length ratio varies from 0.65–0.88, though most specimens have a ratio falling between 0.70–0.83. There is also more pronounced narrowing of the lorica anteriorly in some

habitats than in others: the anterior point/width ratio varies from 0.62–0.91, though most individuals fall between 0.62–0.76. The depth and shape of the foot aperture in the ventral plate varies from round to oval, truncate oval, or even conical. At times the median spines curve slightly outward and somewhat ventrally. The most variable of the occipital spines in length are the laterals.

Perhaps the greatest variation occurs in the posterior dorsal portion of the lorica, which, while always overhanging, may be simply rounded or prolonged into a very considerable prolongation. The side view of this species is very characteristic: the greatest depth is about three-fourths of the distance from the anterior end; the lorica thereafter narrows abruptly toward the posterior end and forms a blunt point. There is quite some variation in depth.

This species was common in a sample from the Itibisinai Sea in Japan in which the pH was allegedly 3.3! If this observation on the pH is accurate, the habitat is an unusual exception as *Brachionus* is an alkaline water fauna seldom found in waters with a pH below 6.6, and then as stragglers.

### *Brachionus bennini* (Leissling)

Plate XVII, figures 6–9

FADEEV, 1927, p. 144, Pl. II, fig. 4.

*Brachionus urceus bennini* LEISSLING, 1924, p. 22.

Lorica firm, oval, divided into a dorsal and a ventral plate (indications of a basal plate as well), but little compressed dorso-ventrally (depth 0.85 of width). Anterior dorsal margin with six short spines, the medians longest, intermediates and laterals but weakly developed. Mental margin rigid, elevated, undulate, with a V-shaped central notch. Posterior spines wanting. Foot opening with sub-square aperture in dorsal (basal) plate, larger V-shaped opening in ventral plate. Lorica marked with short, curved lines which give the appearance of pitting, ornamentation but weakly developed on ventral plate and near the

### *Brachionus bennini*

	Total Length	Width	Ant. Sp.	Ant. Pts.
Mud Creek near Port Clinton, Ohio	190 $\mu$	127 $\mu$	9-7-21 $\mu$	97 $\mu$
Lnare, Czechoslovakia	180 $\mu$	127 $\mu$	9-6-16 $\mu$	88 $\mu$
Lagoon, Catawba, Ohio	170 $\mu$	108 $\mu$	8-5-20 $\mu$	82 $\mu$

anterior ends of both plates. The four inner occipital spines have short strengthening ridges.

MALE.—Unknown.

DISTRIBUTION.—May prove to be cosmopolitan in alkaline fresh waters. I have seen material from Ohio, France, Sweden, Czechoslovakia, and India, usually in small numbers.

This species is rather closely related to *Brachionus urceolaris*. It differs in being consistently smaller, in having a different ornamentation pattern, in having much shorter occipital spines, in having a somewhat different dorso-ventral shape, especially in the posterior portion of the lorica, and in having a differently shaped foot opening.

*Brachionus bennini* has not been very variable in the material studied. The ornamentation may vary from quite pronounced in some localities to nearly obliterate in others. The shapes of the foot apertures vary little, and are quite characteristic. The greatest width is a little below the middle of the lorica. In side view the greatest depth is about two-thirds of the distance from the anterior end where the lorica is markedly elevated, though rounded (does not overhang as in *urceolaris*). The lorica narrows abruptly toward the posterior end, but the foot opening is truncate posteriorly in side view. The side view of this species is very different from that of *Brachionus urceolaris*.

#### *Brachionus nilsoni*, new species

Plate XVIII, figures 1-5

Lorica firm, oval, divided into a dorsal and a ventral plate, somewhat compressed dorso-ventrally (depth 0.6 of width). Anterior dorsal margin with six thin, acutely pointed spines: median pair longest and curve slightly outwards, intermediate pair somewhat shorter than laterals. Mental edge rather firm, elevated, with a very small median notch. Posterior spines wanting. Foot aperture small and sub-square dorsally, large, U-shaped, and wide apart ventrally. In side view the foot opening is truncate posteriorly at a marked angle; lorica has greatest depth about three-fourths of the distance from the

anterior end. Lorica lightly stippled (may at times be marked with short wavy lines). The four inner occipital spines each have a short strengthening ridge.

MALE.—Unknown.

DISTRIBUTION.—Known only from Mud and Ottawa Creeks in northwest Ohio. Found in small numbers.

This species is readily distinguishable from all brachionids lacking posterior spines by the appearance in side view, by the shape of the foot apertures and posterior portion of the lorica, and the long thin occipital spines.

I take pleasure in naming this species for Börje Carlin-Nilson, who so generously placed a number of samples at my disposal.

Paratype in The American Museum of Natural History; Cat. No. A. M. N. H. 1039.

#### *Brachionus leydigii* Cohn

Plate XVII, figures 1-5

COHN, 1862, p. 215, Pl. XXII, figs. 1-3.

*Brachionus quadratus* ROUSSELET, 1889, p. 32, Pl. IV, figs. 3-5 (non Müller).—WIERZEJSKI, 1893, p. 252, Pl. VI, fig. 71.—DIFFENBACH AND SACHSE, 1912, Pl. XII, fig. 1.

*Brachionus reticulatus* KERTESZ, 1894, p. 51, Pl. I, fig. 6.

*Brachionus quadratus* var. *tridentatus* ZERNOV, 1901, p. 31, Pl. IV, figs. 19, 20.

*Brachionus quadratus* var. *rotundus* ROUSSELET, 1907, p. 149, Pl. XII, figs. 6-8.

*Brachionus leydigii* var. *rotundus* FADAEV, 1925B, p. 8.

*Brachionus quadratus* var. *rotundatus* NACHTWEY, 1921, p. 125, Fig.

Lorica firm, nearly square in shape, divided into a dorsal, a ventral, and a basal plate, much compressed dorso-ventrally. Anterior dorsal margin with six spines, nearly equal in length, though the medians are a little longer than the other pairs and curve somewhat ventrally. Mental margin rigid, undulate, raised toward the center, with a U-shaped median sinus. Ventral plate quite flat. Small spines usually present at the lateral junction of dorsal and basal plates, and in lateral view

#### *Brachionus nilsoni*

	Total Length	Width	Ant. Sp.	Ant. Pts.
Mud Creek near Port Clinton, Ohio	145 $\mu$	100 $\mu$	16-11-16 $\mu$	81 $\mu$
Ottawa Creek near Toledo, Ohio	203 $\mu$	144 $\mu$	18-15-25 $\mu$	87 $\mu$

*Brachionus leydigii*

	Total Length	Width	Ant. Sp.	Ant. Pts.
Foo Choo, China	230 $\mu$	164 $\mu$	16-17-24 $\mu$	108 $\mu$
England	245 $\mu$	175 $\mu$	22-22-26 $\mu$	125 $\mu$
Richmond Park, Surrey, England ( <i>rotundus</i> form)	265 $\mu$	218 $\mu$	25-22-36 $\mu$	143 $\mu$
Pond, Lund, Sweden	275 $\mu$	220 $\mu$	28-24-30 $\mu$	135 $\mu$

it is seen that an elevated ridge marks the junction of the two plates. Foot opening large, nearly circular or club-shaped ventrally, guarded by three small spines, one basal and two lateral. Lorica has a minute pattern of irregular polygonal areolations, as well as a pattern (seldom very distinct, but usually present) of larger longitudinal and transverse surface markings.

MALE.—Marke and Wesche, 1903; Rousselet, 1907.

DISTRIBUTION.—I have seen material from England, Sweden, India, China, and ? Ohio.

There can be little doubt that *Brachionus quadratus* Rousselet is a synonym of *Brachionus leydigii* Cohn. Even were it a distinct species the name is preoccupied (*Brachionus quadratus* Müller, 1786).

This is a very distinct species, readily separable from other brachionids by the three spines guarding the foot opening, the nearly quadrate shape of the lorica, and the pattern of irregular polygonal areolations.

This species varies considerably in shape of lorica, prominence of pattern, shape of foot opening ventrally, and the shape of the three spines guarding the foot opening. In an extreme form the lorica has the postero-lateral angles rounded off, and the median of the three spines at the foot opening is reduced to a mere rounded projection (*rotundus* form).

This species is generally considered to be of vernal or hibernal occurrence, though Kofoid, 1908, reports it as occurring from May until August in the Illinois River.

## PLATYIAS HARRING

HARRING, 1913, p. 84.

Brachionic rotifers with illoricate, retractile head and loricate body, separated into a dorsal and a ventral plate, and somewhat compressed dorso-ventrally. Anterior dorsal margin with several spines, of which the medians are always developed and longest.

Mental margin variable. Posterior spines are developed on all described species of the genus. Foot opening in ventral plate. Foot JOINTED, retractile, toes two.

TYPE OF GENUS.—*Platytias quadricornis* (Ehrenberg) = *Noteus quadricornis* Ehrenberg.

SYNONYMS.—*Noteus* Ehrenberg; *Brachionus* (in part).

KEY TO THE SPECIES OF *Platytias*

- Pectoral (mental) margin without spines. . . . . *Platytias quadricornis*.
- Pectoral margin with spines
  - Occipital margin with four spines. . . . . *Platytias polyacanthus*.
  - Occipital margin with six spines
    - Both postero-lateral and postero-median spines quite long. Lateral antennae on knee-like swelling on postero-lateral spines near their center. . . . . *Platytias patulus* var. *macracanthus*.
    - Posterior spines, especially postero-median spines not particularly long, lateral antennae at base of postero-lateral spines. . . . . *Platytias patulus*.

*Platytias quadricornis* (Ehrenberg)

Plate XVIII, figures 6-9

HARRING, 1913, p. 84.

*Noteus quadricornis* EHRENBURG, 1832, p. 143, Pl. IV, fig. 5; 1838, p. 503, Pl. LXII, fig. 1.  
*Noteus stuhlmanni* COLLIN, 1897, p. 8, Fig. 9.  
 ? *Brachionus intermedius* HERRICK, 1885, p. 56.  
*Noteus leydigii* HAECKEL, 1900, Pl. XXXII, fig. 7.

*Noteus quadricornis* var. *brevispinus* DADAY, 1905B, p. 118, Pl. VI, fig. 15.

*Noteus quadricornis* var. *congolense* VAN OYE, 1926, p. 51, Fig. 5.

Lorica firm, circular, moderately compressed dorso-ventrally. Anterior dorsal margin with two stout median spines that taper but little and are bluntly rounded to nearly truncate at their tips, usually bending somewhat ventrally. Lateral projections at anterior end of lorica can hardly be termed spines. Mental margin rigid, depressed toward the center, serrate. Posteriorly the lorica terminates in two rather short and stout, parallel spines, a third to a half the width of the lorica apart. Foot opening in ventral plate about a



*Platytias quadricornis*

	Length	Width	Med. Sp.	Post Sp.	Ant. Pts.	Toes
Near Fort Myers, Fla.	174μ	122μ	36μ	18μ	75μ	25μ
Caloosahatchee R. near La Belle, Fla.	190μ	153μ	34μ	17μ	97μ	25μ
Pond, Bass Island Region, Ohio	265μ	208μ	36μ	42μ	124μ	33μ
Near Fort Myers, Fla.	320μ	242μ	59μ	42μ	152μ	51μ
Near Okeechobee, Fla.	360μ	225μ	70μ	80μ	126μ	59μ

fourth of the length of the lorica from the posterior margin. Lorica tuberculate, with a regular pattern of facettes, consisting of three central pentagons surrounded by eight marginal areas. Lateral antennae on dorsal plate about a sixth of width of lorica from lateral margin.

DISTRIBUTION.—Apparently cosmopolitan in alkaline fresh waters, though usually present in small numbers when found.

There are definite size varieties in this species. In material from the vicinity of Fort Myers, Florida, a small variant accompanied a large form without any evidence of intergrading. The anterior median spines are rather variable in size and shape. The posterior spines are especially variable in length; the toes are also quite variable in relative length.

*Platytias patulus* (Müller)

Plate XIX, figures 1-4

*Brachionus patulus* MÜLLER, 1786, p. 361, Pl. XLVII, figs. 14, 15.

*Brachionus militaris* EHRENBURG, 1834, p. 199; 1838, p. 515, Pl. LXIV, fig. 3.—COHN, 1856, p. 473, Pl. XXIV, figs. 13-16.—HERRICK, 1885, p. 56, Pl. x, fig. 10.—THORPE, 1893, p. 229, Fig.—WEBER, 1906, p. 222, Fig. B<sup>1</sup>.

*Brachionus conium* ATTWOOD, 1881, p. 102, Text Fig.

*Noteus militaris* DADAY, 1901B, p. 454, Pl. XXIV, figs. 7, 8.

*Noteus militaris* var. *Leopoldi* VAN OYE, 1926, p. 52, Figs. 6-8.

Lorica firm, subrectangular, somewhat compressed dorso-ventrally. Both anterior dorsal and ventral margins with pronounced spines, ten anterior spines present: occipital median spines longest, curve

over head ventrally; pectoral medians shortest, straight; intermediates on both margins and laterals about equal in length. Median sinus between pectoral medians usually broader than sinus separating occipital median spines. Posteriorly the lorica narrows but little, if at all, and terminates in two stout spines, usually quite short. Foot opening bounded by two short spines, about equal in length to postero-laterals or somewhat shorter. Foot opening in ventral plate, asymmetric in shape and position, an asymmetry which is apparent in all details of the posterior portion of the lorica. Lorica with a pattern of reticulate areolations, as well as a simple pattern of cuticular ridges on the dorsal plate; may also be tuberculate. Lateral antennae on the inner edge of the postero-lateral spines at their base.

DISTRIBUTION.—Cosmopolitan in fresh waters with a pH above 6.6. In North America it is found in more habitats than any other species of *Platytias* or *Brachionus*.

This species is not nearly so variable as many brachionids. It has a size range that is less extensive than for the common species of *Brachionus*. The anterior spines are quite constant in relative length, although they are somewhat variable in curvature of their apices. The most variable feature in this species is the postero-lateral spines, which may be quite reduced; or as long as a third the total length of the lorica. The length of postero-lateral spines is rather constant in any given habitat. The usual form of the species encountered

*Platytias patulus*

	Length	Width	Ant. Occip.	Ant. Pect.	Post. Sp.	Ant. Pts.
Bayboro, N. C.	165μ	108μ	29-27-38μ	27-21μ	24-15-19-17μ <sup>1</sup>	98μ
Pool, Cincinnati, Ohio	200μ	146μ	35-34-48μ	35-26μ	36-25-26-28μ	121μ
Pond, Bass Isl. Region, Ohio	206μ	136μ	37-35-47μ	37-26μ	52-20-28-51μ	129μ
Mud Creek near Port Clinton, Ohio.	212μ	163μ	37-34-44μ	35-27μ	24-14-25-23μ	138μ
Canal, Lak Mattamuskeet, N. C.	222μ	140μ	37-37-50μ	39-28μ	39-17-30-37μ	130μ
Minocqua, Wisc.	265μ	157μ	44-38-50μ	42-28μ	86-19-30-82μ	152μ

<sup>1</sup> Length of all four posterior spines indicated, reading from left to right on dorsal view.

*Platytas patulus* var. *macracanthus*

	Length	Width	Occip. Sp.	Pect. Sp.	Post. Sp.	Ant. Pts.
Guatemala	302 $\mu$	158 $\mu$	40-35-47 $\mu$	43-26 $\mu$	112-117- 95-109 $\mu$	152 $\mu$
Near Okeechobee, Fla.	330 $\mu$	140 $\mu$	36-35-48 $\mu$	40-25 $\mu$	120-130-110-120 $\mu$	138 $\mu$
Açude Victoria, Ceará, Brazil	345 $\mu$	172 $\mu$	47-41-55 $\mu$	46-29 $\mu$	131-134-115-126 $\mu$	164 $\mu$

has rather short posterior spines. The postero-median spines are not nearly so variable in length as the postero-laterals. The right postero-median spine is always the longer, while the left postero-lateral spine is somewhat longer than the right.

The body is covered with a pattern of reticulate areolations, somewhat similar to that found on *Brachionus leydigii*. Such a pattern is found on species in widely separated genera of loricate rotifers, and is rather common in *Lecane* and *Monostyla*.

*Platytas patulus* var. *macracanthus* (Daday)

Plate XIX, figures 5, 8

*Noteus militaris* var. *macracanthus* DADAY, 1905B, p. 119, Pl. VII, figs. 3, 4.

*Platytas patulus macracanthus* HARRING, 1915, p. 530, Pl. XVII, fig. 1.—AHLSTROM, 1934B, p. 265.

Differs from the species in that all four posterior spines are greatly elongated. The lateral antennae are situated on the latero-posterior spines about two-fifths of the length of the spines from their apices; the antennae are situated on a decuded knee.

DISTRIBUTION.—Florida; Guatemala; Panama; Ceará, Brazil; Paraguay.

It is noteworthy that the left postero-median spine is the longest posterior spine in var. *macracanthus*, whereas it is the shortest posterior spine in the species *vera*.

At times both the large-spined variety and the species are found in the same collection, but there is never any evidence of intergradation.

*Platytas polyacanthus* (Ehrenberg)

Plate XIX, figures 6, 7

*Brachionus polyacanthus* EHRENBURG, 1834, p. 201; 1838, p. 514, Pl. LXIV, fig. 2.—WIERZEJSKI, 1893, p. 253, Pl. VI, fig. 92.—LUCKS, 1912, p. 138, Fig. 52.—FADEEV, 1925A, p. 23, Pl. V, fig. 1.

*Noteus polyacanthus* DADAY, 1901B, p. 455.

*Noteus polyacanthus* var. *micracanthus* ARÉVALO, 1918, p. 43, Fig. 36.

*Brachionus polyacanthus* var. *micracanthus* WISZNIEWSKI, 1931, p. 45, Pl. II, fig. 19.—AHLSTROM, 1934B, p. 255, Pl. XXV, fig. 3.

Lorica firm, subrectangular, but little compressed dorso-ventrally. Anterior dorsal margin with four broad-based spines: medians somewhat longer than laterals, laterals usually somewhat divergent. Mental margin concave, with three to four pairs of short spines, laterals most pronounced; shallow median sinus between the short median spines. Posteriorly the lorica terminates in two lateral spines, quite variable in length and often somewhat reduced. Foot opening in the ventral plate, guarded by two lateral and one dorsal spine of about equal length. Lorica smooth or lightly stippled. Lateral antennae nearly marginal, about a fourth of body length from the posterior end.

*Platytas polyacanthus*

R. R. Ditch,  
Minocqua, Wisc.      Near Orlando,  
Fla.

Total Length	265 $\mu$	177 $\mu$
Great. Width	167 $\mu$	123 $\mu$
Occip. Sp.	41, 47 $\mu$	23, 38 $\mu$
Post.-Lat. Sp.	57 $\mu$	24 $\mu$
Post.-Med. Sp.	25-19-25 $\mu$	21-14-21 $\mu$

DISTRIBUTION.—Widely distributed, but rather rare. It has been found in Wisconsin, Mount Desert Island, Me., and Florida in the United States, usually as a very rare organism. In a small pond in Ottawa, Ontario, F. J. Myers found a practically pure culture of this species in enormous numbers. It is not an acid water species as Haring postulated.

*Brachionus polyacanthus* is seldom found with postero-lateral spines as long as those figured by Ehrenberg, 1838. Most workers have encountered the reduced form of this species, given by Arévalo the varietal name of *micracanthus*. Thus Wierzejski, 1893, Fadeev, 1925A, Wiszniewski, 1931, Arévalo, 1918, Lucks, 1912, and Ahlstrom, 1934B, have all figured this reduced form in literature. F. R. Dixon-Nuttall made a series of sketches of this reduced form from material furnished by Rousselet, which,

though never published, has been distributed among some rotifer workers. In posterior view he shows the dorsal plate to

be elevated into a keel, somewhat like that found in *Euchlanis triquetra*. I have verified this observation.

#### TAXONOMIC UNITS SMALLER THAN SPECIES IN *BRACHIONUS* AND *PLATYIAS*

The marked variability of most species of *Brachionus* has already been discussed. This variability seems to fall into three categories: cyclic, gradational, and polymorphic.

##### CYCLIC VARIATION

By cyclic variation, I refer to the presence of forms of quite different appearance in the same strain of *Brachionus* at different seasons of the year. This may be due to a morphological dimorphism between mictic and amictic females in a species, as has been reported for *B. angularis* and *B. leydigii*, and which may be rather widespread in the genus. Another type of cyclic variability is exemplified by *Brachionus calyciflorus*, in which forms lacking postero-lateral spines may arise from forms with well-developed spines, and vice versa. Whitney, 1916C, who first noted this phenomenon, was able to effect the transformation from the "pala" into the "amphiceros" form by the addition of sodium silicate to the solution in which the species was being cultured. De Beauchamp, 1928, claims that the change readily takes place: "From my experience it is very rare that a population of this species does not contain simultaneously the two forms, and often one observes the one hatch from an egg of the other" (p. 95). This occurs in parthenogenetic eggs, so that the phenomenon is not genetic, but physiological. Some of the variability in other species, especially *B. quadridentatus*, *B. bidentata*, and *B. variabilis*, is of this type. De Beauchamp in cultures of *Brachionus bidentata* found that the "inermis" form lacking postero-lateral spines may give rise to the form with moderately long postero-lateral spines. In nature it is not at all uncommon to find this species with only one postero-lateral spine developed. The so-called *cluniorbicularis*, *rhenanus*, *entzii*, and *brevispinus* forms of *Brachionus quadridentatus* may give rise to each other. Both *B. calyciflorus* and *B. quadridentatus* are

claimed to go through seasonal cycles with respect to presence and abundance of the various so-called varieties. Cyclic variants of a species occur in the same habitat, and commonly in the same collection. This type of variability can be accurately studied in cultures of *Brachionus*. Taxonomic names applied to cyclic variants have little value, and no validity as taxonomic units.

##### GRADATIONAL VARIATION

Between the reduced and exuberant forms of many species of *Brachionus* there are numerous intermediate forms. If such transitional forms are placed in a series, it can be shown that the transition from reduced to exuberant types is gradual. The variation between extreme forms appears to be of a gradational or continuous nature. Some cyclic variation is of a gradational type, so that this category is not sharply separable from the former. However, much gradational variability cannot be explained as cyclic. Whereas cyclic variability is usually displayed in the same habitat, much of gradational variability is only evident when different habitats are compared, and may be largely due to the influence of the different ecological conditions prevailing in different localities. Much of the variability of *Brachionus* and *Platyias* is of a gradational nature. Gradational variability may be illustrated by a study of data concerning *B. calyciflorus*. A table is given in which is listed the dimensions of this species from 21 widely separated habitats in North and South America, Europe, Africa, and Asia. The ratio to the anterior lateral spines to the medians is calculated, as well as the ratio of the length of the median spines to the length of the body (without spines).

There is often recognized a var. *dorcas* of this species which is supposedly characterized by rather long median occipital spines, which are much longer than the lateral spines, and more slender than in the species proper. In analyzing the data con-

MEASUREMENTS OF *Brachionus calyciflorus*

LOCALITY	Total Length	Width	Ant. Sp.	Lat./Med.	Ratio Med./Body	Post. Sp.
Staffelfelden, France	180 $\mu$	124 $\mu$	15, 25 $\mu$	0.60	0.15	
Pond, Bass Island region, Ohio	230 $\mu$	130 $\mu$	19, 38 $\mu$	0.50	0.22	11 $\mu$
Lake Washington, Seattle, Washington	230 $\mu$	128 $\mu$	46, 54 $\mu$	0.85	0.33	32 $\mu$
Fleninge, Sweden	250 $\mu$	190 $\mu$	24, 33 $\mu$	0.72	0.15	
	324 $\mu$	192 $\mu$	50, 58 $\mu$	0.86	0.25	88 $\mu$
Village pond, Hodkovicky, Czechoslovakia	260 $\mu$	190 $\mu$	25, 36 $\mu$	0.70	0.16	
	290 $\mu$	170 $\mu$	44, 51 $\mu$	0.86	0.25	65 $\mu$
Oklahoma City, Oklahoma Reservoir	262 $\mu$	160 $\mu$	55, 58 $\mu$	0.95	0.29	58 $\mu$
Pond, Port Clinton, Ohio	265 $\mu$	138 $\mu$	46, 60 $\mu$	0.76	0.33	42 $\mu$
Terwilliger's Pond, Put-in-Bay, Ohio	287 $\mu$	150 $\mu$	40, 56 $\mu$	0.72	0.28	45 $\mu$
Pond, Takao, Formosa	288 $\mu$	195 $\mu$	41, 52 $\mu$	0.79	0.22	
Lagunas Pozos, San Luis Prov., Argentina	300 $\mu$	175 $\mu$	48, 65 $\mu$	0.74	0.27	
Maumee River at Texas, Ohio	295 $\mu$	158 $\mu$	57, 62 $\mu$	0.91	0.31	98 $\mu$
	335 $\mu$	225 $\mu$	56, 82 $\mu$	0.70	0.33	
Barberspan, S. Africa	360 $\mu$	245 $\mu$	43, 82 $\mu$	0.52	0.29	
Ottawa Creek, near Toledo, Ohio	368 $\mu$	240 $\mu$	56, 85 $\mu$	0.66	0.30	
Westlake, Los Angeles, Calif.	370 $\mu$	174 $\mu$	56, 70 $\mu$	0.80	0.30	102 $\mu$
Açude Simao, Parahyba, Brazil	390 $\mu$	290 $\mu$	90, 96 $\mu$	0.93	0.32	
Lake Yddingen, Sweden	395 $\mu$	246 $\mu$	70, 78 $\mu$	0.90	0.24	
Pond, Mathias, Ohio	400 $\mu$	270 $\mu$	61, 92 $\mu$	0.67	0.30	
Lake, Quilmes near Buenos Aires, Argentina	405 $\mu$	214 $\mu$	53, 95 $\mu$	0.56	0.34	115 $\mu$
Açude Esperanca, Parahyba, Brazil	415 $\mu$	265 $\mu$	60, 82 $\mu$	0.73	0.24	
Echo Park Lake, Los Angeles, Calif.	440 $\mu$	170 $\mu$	70, 80 $\mu$	0.88	0.40	212 $\mu$
Buckeye Lake, Ohio	570 $\mu$	265 $\mu$	95, 200 $\mu$	0.48	0.54	

tained in the chart we shall try to determine whether there is any real basis for such a variety. From the table several conclusions can be drawn.

1.—*B. calyciflorus* has an extensive size range of a gradational nature.

2.—Lateral occipital spines may vary from half as long as the medians to nearly as long. If the ratios of the length of laterals to medians are arranged in a series, they are seen to be distributed rather normally between the two extremes. The distribution of ratios is as follows:

Ratio	Number of Individuals
0.48-0.59	4
0.60-0.69	3
0.70-0.79	8
0.80-0.89	5
0.90-0.95	4

This is a unimodal distribution that does not lend support to the validity of var. *dorcas*.

3.—The proportion between the occipital spines varies independently of the size of the animals. Small-sized forms of the species are just as variable in this respect as are large-sized forms.

4.—There is some correlation between a high lateral spine/median spine ratio and the presence of postero-lateral spines. Eleven of the twenty-four sets of measurements are of forms having postero-lateral spines, yet of the eleven individuals having a lateral/median ratio larger

than 0.75, eight have postero-lateral spines. However, presence or absence of postero-lateral spines is known to be a cyclic variation.

5.—Except for very large or very small-sized forms, the ratio between the median spines and length of the body is rather uniform. Three-fourths of the specimens have the anterior median spines between 0.24-0.34 times as long as the body. The occipital spines are proportionately more reduced on small-sized forms than is the body proper, while they are proportionately longer on large-sized forms. Thus, long median spines on *Brachionus calyciflorus* are found on large individuals, and have little relation to a low lateral spine/median spine ratio.

From the above analysis it is evident that there is no taxonomic validity for var. *dorcas*. If var. *dorcas* is to be based on a low lateral/median spine ratio, then the very reduced form from Staffelfelden would have to be referred to this variety. If, on the other hand, var. *dorcas* is to include only forms with long median spines, it would include all large specimens of the species without regard to lateral/median spine ratio. If var. *dorcas* is to refer only to very exuberant forms, such as the specimens from Buckeye Lake, and the species proper is to be limited to those thick-spined forms with nearly equal occipitals—what

are we to do with the large class of intermediates? When variability is gradational as the above has been shown to be, there is little taxonomic value in varietal or form names applied to the variants. If definite names are to be given to exuberant or reduced forms of a species, the large class of intermediates should be considered as the species proper, and only the very reduced forms or very exuberant forms given *form* (not *variety*) recognition.

#### POLYMORPHIC OR DISCONTINUOUS VARIATION

A third type of variability found in *Brachionus* and *Platytias* falls into the polymorphic or discontinuous category. Polymorphic variability is most evident in *Brachionus angularis* and *B. caudatus*. This type of variation is characterized by definite hiatus in the variation series. *Brachionus caudatus*, for example, is found with two, four, or six occipital spines; and each of these have two forms based on the shape and position of the posterior spines. Between these six forms of *B. caudatus* there has been little evidence to date of intergradation. Moreover, most of the forms are geographically isolated. When variation is of this type there is some value in assigning taxonomic names to the variants. It is especially the forms and varieties in this category that should be given recognition by limnologists and zoogeographers. All varieties and forms considered in the body of the paper fall into this category.

For the use of those scientists who wish to give form recognition to reduced or exuberant variants of a species, the following names are suggested. Only the more common or conspicuous variants are considered.

##### *Brachionus plicatilis* Müller

f. *spatiosus* (Rousselet), characterized by the lorica being markedly narrowed in the anterior region. Devils Lake, N. D., Saskatchewan.

##### *Brachionus calyciflorus* Pallas

f. *dorcas* (Gosse) (Pl. III, fig. 5), characterized by long, thin anterior median spines, about twice the length of the anterior lateral spines. Postero-lateral spines may be present or lacking. Generally distributed.

f. *borgerti* (Apstein) (Pl. XX, figs. 7, 8), characterized by anterior median spines having a saw-tooth base which gives the appearance of

having rudimentary intermediates. Postero-lateral spines may be present or lacking; postero-medians always rudimentary. Material from Formosa has the lorica separated into definite dorsal and ventral plates. Ceylon, Formosa.

##### *Brachionus budapestinensis* Daday

f. *lineatus* (Skorikov) (Pl. IV, fig. 9), has the occipital spines short and more or less straight, cuticular ridges confined to a few longitudinal lines, lorica lightly stippled and more flexible than in species proper. Generally distributed, but not common.

##### *Brachionus angularis* Gosse

f. *pseudodolabratus* (Pl. V, fig. 10), has two pronounced angular protuberances on either side of the lorica in the posterior half, the more posterior of these is about three-fourths of the length of the lorica from the anterior end, and is often quite pronounced. Southeastern United States.

##### *Brachionus diversicornis* (Daday)

f. *homoceros* (Wierzejski) (Pl. IX, fig. 7), has the posterior spines subequal, and is larger in size than the form with unequal posterior spines. With the species in Eurasia, not as common apparently as the species.

##### *Brachionus quadridentatus* Hermann

f. *brevispina* (Ehrenberg) (Pl. XII, figs. 1, 5-8), characterized by having the anterior medians not so markedly curved as in the long-spined forms and relatively shorter, in having the postero-lateral spines short or nearly obliterate, the ornamentation is usually not very pronounced. Generally distributed. The form grades into:

f. *cluniorbicularis* (Skorikov) (Pl. XII, fig. 4), which lacks postero-lateral spines. Generally distributed.

##### *Brachionus bidentata* Anderson

f. *furculatus* (Thorpe) (Pl. XIII, fig. 1), characterized by having the anterior lateral spines very long, as much as 3 times as long as the medians; posterior spines very long. This is a large-sized exuberant form found in South Africa.

f. *inermis* (Rousselet) (Pl. XIII, figs. 6, 7, 9), lacks postero-lateral spines, has the anterior lateral spines not much longer than the medians. Grades into typical form. Generally distributed—more often encountered than the species *vera*.

##### *Brachionus urceolaris* Müller

f. *sericus* (Rousselet) (Pl. XVI, fig. 1), has a prominent pattern of wavy, longitudinal lines—silky appearance. Often has the lorica overhanging in the posterior portion of the dorsal plate. Grades into form with inconspicuous pattern. Generally distributed.

##### *Brachionus leydigii* Cohn

f. *rotundus* (Rousselet) (Pl. XVII, fig. 5), the postero-lateral angles of the lorica are rounded, the median of the spines at the foot opening is reduced to a mere rounded projection. Europe.

*Platytas quadricornis* (Ehrenberg)  
f. *brevispinus* (Daday) (Pl. XVIII, fig. 7),  
characterized by small size and short posterior  
spines. Florida, Brazil, Paraguay.

*Platytas polyacanthus* (Ehrenberg)  
f. *micracanthus* (Arevalo) (Pl. XIX, fig. 6),  
has the two lateral posterior spines greatly re-  
duced. Widely distributed, but uncommon.

## BIBLIOGRAPHY

- AHLSTROM, E. H.  
1932. Plankton Rotatoria from Mexico. Trans. Amer. Micro. Soc., LI, pp. 242-251.  
1934A. A quantitative study of Rotatoria in Terwilliger's Pond, Put-in-Bay, Ohio. Ohio Biol. Survey Bull., VI, 36 pp.  
1934B. Rotatoria of Florida. Trans. Amer. Micro. Soc., LIII, pp. 251-266.
- ANDERSON, H. H.  
1889. Notes on Indian rotifers. Jour. Asiatic Soc. Bengal, Calcutta, LVIII, part 2, pp. 345-358.
- APSTEIN, C.  
1907. Das Plankton in Colombo-See auf Ceylon. Zool. Jahrb. Abt. Syst., XXV, pp. 201-244.
- ARÉVALO, C.  
1918. Algunos rotíferos planktónicos de la Albufera de Valencia. Anales Inst. Gen. y Técnico de Valencia II Art. 8, 47 pp.
- ATTWOOD, H. F.  
1881. *Brachionus conium*—a new rotifer. Amer. Monthly Micro. Jour., II, p. 102.
- BARROIS, T. C.  
1896. Recherches sur la faune des eaux douces des Açores. Mém. Soc. Sci., Agr., Arts, Lille, Ser. (5), fasc. VI, 172 pp.
- BARROIS, T. C., AND DADAY, J.  
1894A. Adatok az Aegyptomi, Palaestinai, és Syriai Rotatoriák ismeretéhez. Math. Termész. Értes. Budapest, XII, pp. 222-242.  
1894B. Contribution à l'étude des Rotifères de Syrie et descriptions de quelques espèces nouvelles. Revue Biol. du Nord de la France, Lille, VI, pp. 391-409.
- BARTSCH, S.  
1877. Rotatoria Hungariae. Kir. Mag. Termész. Társulat Megbizásából. Quarto, Budapest, 52 pp.
- BEAUCHAMP, P. DE  
1924A. Sur l'apparition de la variation dans les conditions experimentales chez les Rotifères du genre *Brachionus*. C. R. Acad. Sci. Paris, CLXXIX, pp. 1207-1209.  
1924B. Sur la transmission de la variation chez les Rotifères du genre *Brachionus*. C. R. Acad. Sci. Paris, CLXXIX, pp. 1290-1291.  
1927. A propos des formes reduites de *Brachionus bakeri* Müller et *Brachionus furculatus* Thorpe. Bull. Soc. Zool. France, LII, pp. 61-67.
1928. Coup d'oeil sur les recherches recentes relatives aux Rotifères et sur les methodes qui leur sont applicables. Bull. Biol. France et Belgique, LXII, pp. 51-125.  
1932A. Rotifères des lacs de la vallée du Rift. Reports on the Percy Sladen Expedition to some Rift Valley lakes in Kenya in 1929. Annals and Mag. Nat. Hist., (10) IX, pp. 158-165.  
1932B. Scientific results of the Cambridge Expedition to the East African lakes, 1930-1931. 6. Rotifères et Gastrotriches. Jour. Linnaean Soc., Zool., XXXVIII, pp. 231-248.
- BREHM, V.  
1909. Über die Mikrofauna chinesischer und südasiatischer Süßwasserbecken. Arch. f. Hydrobiol., IV, pp. 207-224.  
1932. Notizen zur Süßwasserfauna Guatemalas und Mexikos. Zool. Anz., XLIX, pp. 63-66.
- BRYCE, D. L.  
1931. Report on the Rotifera: Mr. Omer-Cooper's investigation of the Abyssinian fresh waters. Proc. Zool. Soc. London, 1931, pp. 865-878.
- CARLIN-NILSON, B.  
1935. Rotatorien aus Mexico. Kungl. Fysio-graf. Sällsk. Lund Forhand., V, pp. 175-185.
- CHU, JEN-PAO  
1934. The reproduction, life-span, growth, and senescence of *Brachionus pala* Ehrbg. Sci. Repts. Univ. Chekiang, I, No. 1, pp. 275-284.
- COHN, F.  
1856. Über die Fortpflanzung der Räderthiere (*Brachionus urceolaris*). Zeitschr. Wiss. Zool., Leipzig, VII, pp. 430-486.  
1862. Bemerkungen über Räderthiere. III. Zeitschr. Wiss. Zool., Leipzig, XII, pp. 197-217.
- COLLIN, A.  
1897. Rotatorien, Gastrotrichen und Entozoen Ost-Afrika's. Deutsch-Ost-Afrika. Die Tierwelt Ost-Afrika's und der Nachbargebiete. Wirbellose Tiere 4, No. 15, 13 pp.
- CUNNINGTON, W. A.  
1920. The fauna of the African lakes: a study in comparative limnology with special reference to Tanganyika. Rotatoria. Proc. Zool. Soc. London, 1920, pp. 578-581.
- DADAY, E. VON  
1883. Új adatok a kerekessérgek ismeretéhez.

- Math. Termész. Értesítő, Budapest, I, pp. 290-293.
1884. Új adatok a kerekessérgek ismeretéhez. Math. Termész. Közlem, Budapest, XIX, pp. 15-44.
- 1885A. Neue Thierarten aus der Süßwasserfauna von Budapest. Termész. Füzetek, Budapest, IX, pp. 127-135, 208-215.
1891. *Schizocerca diversicornis* Daday oder *Brachionus amphifurcatus* Imhof? Zool. Anz., XIV, pp. 266-268.
1897. Új-Guineai Rotatoriák. Math. Termész. Értesítő, Budapest, XV, pp. 131-148.
- 1901A. Mikroskopische Süßwasserthiere aus Deutsch - Neu - Guinea. Termész. Füzetek, Budapest, XXIV, pp. 1-56.
- 1901B. Édesvízi mikroszkópi állatok. Mikroskopische Süßwasserthiere. Zool. Ergebnisse der dritte asiatische Forschungsreise des Grafen Eug. Zichy, II, pp. 375-479.
1902. Mikroskopische Süßwasserthiere aus Patagonien. Termész. Füzetek, Budapest, XXV, pp. 201-310.
1903. Mikroskopische Süßwasserthiere aus Kleinasien. Sitzungsber. Akad. Wiss., Wien, CXII, part 1, pp. 139-168.
- 1905A. Paraguay mikrofaunájának alaprajza. Math. Termész. Értesítő, Budapest, XXIII, pp. 312-355.
- 1905B. Untersuchungen über die Süßwasser-Mikrofauna Paraguays. Zoologica, Stuttgart, XLIV, pp. 87-130.
1907. Plankton-Tiere aus dem Victoria-Nyanza. Zool. Jahrb., Jena, Abt. Syst., XXV, pp. 245-262.
1908. Adatok Német-Kelet-Afrika édesvízi mikrofaunájának ismeretéhez. Math. Termész. Értesítő, Budapest, XXVI, pp. 1-42.
1910. Die Süßwasser-Mikrofauna Deutsch-Ost-Afrikas. Zoologica, Stuttgart, LIX, pp. 59-106.
- DIFFENBACH, H., AND SACHSE, R.  
1912. Biologische Untersuchungen an Rädertieren in Teichgewässern. Int. Rev. Hydrobiol. Suppl., (3) II, 94 pp.
- EDMONDSON, W. T., AND HUTCHINSON, G. E.  
1934. Report on Rotatoria. Art. 9 in Yale North India Expedition. Mem. Conn. Acad. Arts & Sci., X, pp. 153-183.
- EHRENBERG, C. G.  
1832. Über die Entwicklung und Lebensdauer der Infusionsthierchen, nebst ferneren Beiträgen zu einer Vergleichung ihrer organischen Systeme. Abh. Akad. Wiss. Berlin, for 1831, pp. 1-154.
1834. Dritter Beitrag zur Erkenntniss grosser Organisation in der Richtung des Kleinsten Raumes. Ibid., for 1833, pp. 145-336.
1838. Die Infusionsthierchen als vollkommene Organismen. Folio, Leipzig. 547 pp.
1853. Über die neuerlich bei Berlin vorgekommenen neuen Formen des mikroskopischen Lebens. Monatsber. Akad. Wiss. Berlin, 1853, pp. 183-194.
- FADEEV, N. N.  
1925A. Sur la connaissance de la faune de lacs du Transcaucasie. Trav. Station Biol. du Caucase du Nord I, fasc. 1, pp. 17-26.
- 1925B. Rare and undescribed rotifers from U. S. S. R. Trav. Soc. Nat. Charkow, L, part 1, 13 pp.
- 1925C. Das Rädertier *Brachionus forficula* Wierz. und seine Varietäten. Zool. Anz., LXIV, pp. 285-293.
1926. Le lac Abraou et ses habitants. Trav. Station Biol. du Caucase du Nord I, fasc. 2, pp. 1-18.
1927. Rare and undescribed rotifers from U. S. S. R. (in Russian). Proc. Nat. Soc. Kharkov L, part 2, pp. 141-155.
- FRANCÉ, R. H.  
1894. Beiträge zur Kenntniss der Rotatorienfauna Budapest's. Termész. Füzetek, Budapest, XVII, pp. 112-129, 166-184.
- GOSSE, P. H.  
1851. A catalogue of rotifers found in Britain, with descriptions of five new genera and thirty-two new species. Ann. Mag. Nat. Hist., London, (2) VIII, pp. 197-203.
1858. On the dioecious character of the Rotifera. Philos. Trans. Royal Soc. London, CXLVII, pp. 313-326.
- GRESE, B. S.  
1926. Zur Biologie und Verbreitung von *Brachionus forficula* Wierz. in der mittleren Wolga. Russische Hydrobiol. Zeitschr., V, pp. 52-58.
- HAECKEL, E.  
1900. Kunstformen der Natur. Folio, Leipzig. 100 pls.
- HARRING, H. K.  
1913. Synopsis of the Rotatoria. Bull. U. S. Nat. Mus., LXXXI, 226 pp.
1915. Report on Rotatoria from Panama with descriptions of new species. Proc. U. S. Nat. Mus., XLVII, pp. 525-564.
- HARTMANN, O.  
1918. Studien über den Polymorphismus der Rotatorien mit besonderer Berücksichtigung von *Anuraea aculeata*. Archiv f. Hydrobiol. und Plankt., XII, pp. 209-310.
- HAUER, J.  
1937A. Neue Rotatorien aus Indien. III. Zool. Anz., CXX, pp. 17-19.
- 1937B. Zur kenntnis der Rotatorienfauna des Eichener Sees. Beiträge zur naturkundlichen in Südwestdeutschland, II, pp. 165-173.
1938. Die Rotatorien von Sumatra, Java und Bali nach den Ergebnisse der Deutschen Limnologischen Sunda-



- Expedition. Archiv f. Hydrobiol., Suppl. 15, pp. 296-384, 507-602.
- HEMPPEL, A.  
1896. Descriptions of new species of Rotifera and Protozoa from the Illinois River and adjacent waters. Bull. Ill. State Lab. Nat. Hist., IV, 310-317.  
1889. A list of the Protozoa and Rotifera found in the Illinois River and adjacent lakes at Havana, Ill. Ibid., V, pp. 301-388.
- HERMANN, J.  
1783. Helminthologische Bemerkungen. Zweytes Stuck. Naturforscher, Halle, XIX, pp. 31-59.
- HERRICK, C. L.  
1885. Notes on American Rotifers. Bull. Sci. Lab. Denison U., I, pp. 43-62.
- HOFSTEN, N. VON  
1909. Rotatorien aus dem Mästermyr (Gotland) und einigen andern schwedischen Binnengewässern. Arkiv f. Zoologi, Stockholm, VI, Art. 1, pp. 1-125.
- HOOD, J.  
1893. Three new rotifers. Jour. Quekett Micro. Club, (2) V, pp. 281-283.
- HUTCHINSON, G. E., PICKFORD, G. E., AND SCHURMAN, F. M.  
1932. A contribution to the Hydrobiology of Pans and other inland waters of South Africa. Arch. f. Hydrobiol., XXIV, pp. 1-154.
- IMHOF, O. E.  
1887. Notizen über die pelagische Fauna der Süßwasserbecken. Zool. Anz., X, pp. 577-582.  
1891A. Notiz bezüglich: Liste des Rotifères observés en Galicie par le Dr. A. Wierzejski. Zool. Anz., XIV, p. 125.  
1891B. Antwort bezüglich der Rotatorien: *Polyarthra* und *Schizocerca*. Zool. Anz., XIV, pp. 446-447.
- JAKUBSKI, A. W.  
1912. Beiträge zur Kenntniss der Süßwassermikrofauna Ostafrikas. I. Die Rädertiere der Usangusteppe. Zool. Anz., XXXIX, pp. 536-550.  
1915. Opis fauny Wrotkow (Rotatoria) powiatu sokalskiego etc. Rozpr. Wiadom. Muz. Dzieduszyckich. Luoure, I, pp. 1-64.
- JENNINGS, H. S.  
1900. Rotatoria of the United States, with especial reference to those of the Great Lakes. Bull. U. S. Fish Comm., 19 (1899), pp. 67-104.
- KERTÉSZ, K.  
1894. Budapest es környékének Rotatoria-faunája. Octavo. Budapest. 55 pp.
- KOFOID, C. A.  
1908. The plankton of the Illinois River, 1894-1899. Part II. Constituent organisms and their seasonal distribution. Bull. Ill. State Lab. Nat. Hist., VIII, Art. 1, 361 pp.
- LAUTERBORN, R.  
1893. Beiträge zur Rotatorienfauna des Rheins und seiner Altwässer. Zool. Jahrb. Abt. Syst., VII, pp. 254-273.  
1898. Über die cyklische Fortpflanzung limnetischer Rotatorien. Biol. Centralblatt, XVIII, pp. 173-183.
- LEISSLING, R.  
1914. Ein Beitrag zur Rotatorienfauna der Plover Gewässer. Arch. f. Hydrobiol., IX, pp. 253-258.
- LEMMERMANN, E.  
1908. Beiträge zur Kenntniss der Planktonalgen. Arch. f. Hydrobiol., III, pp. 349-410.
- LINDEMAN, R. L.  
1939. Some affinities and varieties of the planktonic rotifers, *Brachionus havanensis* Rousselet. Trans. Amer. Micro. Soc., LVIII, pp. 210-221.
- LINNAEUS, C. VON  
1758. Systema naturae per regna tria naturae, etc. Editio decima, reformata. Octavo. Holmiae. I, 823 pp.
- LUCKS, R.  
1912. Zur Rotatorienfauna Westpreussens. Westpr. Bot.-Zool. Ver., 207 pp.
- MARKS, K. I., AND WESCHE, W.  
1903. Further observations on male rotifers. Jour. Quekett Micro. Club, (2) VIII, pp. 505-512.
- MÖBIUS, K.  
1874. Ein Beitrag zur Anatomie des *Brachionus plicatilis* Müller, eines Rädertieres der Ostsee. Zeitschr. Wiss. Zool., Leipzig, XXV, pp. 103-113.
- MORRIS, C. B.  
1913. Some notes on Rotifera not previously recorded as occurring in New Zealand. Trans. New Zealand Inst., XLV, pp. 163-167.
- MULLER, O. F.  
1773. Vermium terrestrium et fluviatilium, seu animalicum infusiorum, etc. Quarto. I, part 1, pp. 1-135, Infusoria.  
1786. Animalcula Infusoria fluviatilia et marina. Quarto, Hauniae. 367 pp.
- MURRAY, J.  
1913. South American Rotifera. III. Jour. Royal Micro. Soc., 1913, pp. 449-454.
- MYERS, F. J.  
1917. Rotatoria of Los Angeles, California, and vicinity, with descriptions of a new species. Proc. U. S. Nat. Mus., LII, pp. 473-478.  
1937. Rotifera from the Adirondack region of New York. Amer. Mus. Novitates, No. 903, 17 pp.
- NACHTWEY, R.  
1921. Ein neues Rädertier: *Brachionus quadratus* var. *rotundatus*, Zool. Anz., LII, pp. 125-127.
- PALLAS, P. S.  
1766. Elenchus zoophytorum. 451 pp.

## PLATE, L. H.

1886. Beiträge zur Naturgeschichte der Rotatorien. Jenaische Zeitschr. Naturwiss., (N. S.) XII, pp. 1-120.

## RODEWALD, L.

1937. Rädertierfauna Rumaniens. II. Neue und bemerkenswerte Rädertiere aus Rumanien. Zool. Anz., CXVIII, pp. 235-248.

## ROUSSELET, C.

1889. Note on *Brachionus quadratus*, a new rotifer. Jour. Quekett Micro. Club, (2) IV, pp. 32-33.  
 1895. Syrian rotifers. Science Gossip, (N. S.) II, pp. 29-31.  
 1896. *Rattulus collaris* n. sp. and some other rotifers. Jour. Quekett Micro. Club, (2) VI, pp. 265-270.  
 1897A. One of the male of *Rhinops vitrea*. Jour. Royal Micro. Soc., 1897, pp. 4-9.  
 1897B. *Brachionus bakeri* and its varieties. Jour. Quekett Micro. Club, (2) VI, pp. 328-332.  
 1906. Contributions to our knowledge of the Rotifera of South Africa. Jour. Royal Micro Soc., 1906, pp. 393-414.  
 1907. On *Brachionus sericus* n. sp., a new variety of *Brachionus quadratus* and remarks on *Brachionus rubens*, of Ehrenberg. Jour. Quekett Micro. Club, (2) X, pp. 147-154.  
 1910. Zoological results of the Third Tanganyika Expedition, conducted by Dr. W. A. Cunningham, F. Z. S., 1904-1905. Report on the Rotifera. Proc. Zool. Soc. London, 1910, pp. 792-799.  
 1911. On three new species of Rotifera. Jour. Quekett Micro. Club, (2) XI, pp. 161-164.  
 1912. On *Notholca triarthroides* Skorikow, *Cathypna brachydactyla* Stenroos, and a new *Brachionus* from Devils Lake, North Dakota. Jour. Quekett Micro. Club, (2) XI, pp. 371-374.  
 1913. Rotifera of Devils Lake, with descriptions of a new *Brachionus*. Jour. Quekett Micro. Club, (2) XII, pp. 57-64.

## SCHMARDA, L. K.

1854. Zur Naturgeschichte Aegyptens. Denkschr. Akad. Wiss. Wien, Math.-Naturw. Klasse VII, part 2, pp. 1-28.  
 1859. Neue wirbellose Thiere beobachtet und gesammelt auf einer Reise um die Erde 1853 bis 1857. Rotatorien. I, pp. 47-66.

## SELIGO, A.

1907. Hydrobiologische Untersuchungen. Octavo. Danzig, 103 pp.

## SHEPARD, J.

1911. A list of Victorian rotifers, with description of two new species and the males of two species. Proc. Royal Soc. Victoria, (N. S.) XXIV, pp. 46-58.

## SKORIKOV, A. S.

1894. Rapport préliminaire des recherches des Rotateurs et des Thysanoures des environs de Kharkow (in Russian). Trav. Soc. Nat. Kharkow, XXVII, pp. xxvii-xxxiii.  
 1896. Rotateurs des environs de Kharkow (in Russian). Ibid., XXX, pp. 207-374.  
 1914. Title in Russian. Arb. ichtyolog. Lab. Kaspi-Wolga. Fisch.-Verwalt. Astrachan, III, Art. 5, pp. 1-33.

## SLONIMSKI, P.

1923. Note sur *Brachionus forficula* Wierzejski. Kosmos, Bull. Soc. polonaise des Nat. a Leopold., 1923, pp. 584-589.

## SPANDL, H.

1922. *Brachionus pala* Ehrbg. var. *mucronatus* nov. var. Zool. Anz., LIV, p. 275.

## TARNOGRADSKY, D. A.

1926. Matériaux pour servir a la connaissance de la faune et de la flore des eaux du littoral persien de la mer Caspienne. Trav. Stat. Biol. du Caucase du Nord, I, fasc. 3, pp. 1-18.

## THORPE, G. V.

1891. New and foreign Rotifera. Jour. Royal Micro. Soc., 1891, 301-306.  
 1893. Note on the construction of the lorica in the genus *Brachionus*. Jour. Quekett Micro. Club, (2) V, pp. 229-231.

## TOTH, A.

1861. Rotatoria faunae Budapestiensis. Math. Termész. Közlemények, Budapest, I, pp. 159-212.

## TSCHUNGUNOFF, N.

1921. Über das Plankton des nördlichen Teiles des Kaspi-Sees (in Russian). Raboty Volzhskaja Biol. Stant. Saratovskoe, VI.

## TURNER, C. H.

1892. Notes upon the Cladocera, Copepoda, Ostracoda, and Rotifera of Cincinnati, with descriptions of new species. Bull. Sci. Lab. Denison U., VI, pp. 57-74.

## UÉNO, MASUZO

1936. Zooplankton of the Sungari River, Manchoukuo, Annot. Zool. Japonensis, XV, pp. 520-524.  
 1938. Rotatoria of Formosan Lakes. Annot. Zool. Japonensis, XVII, pp. 134-143.

## VAN OYE, P.

1926. Rotateurs nouveaux du Congo Belge. Bull. Soc. Zool. France, LI, pp. 49-54.

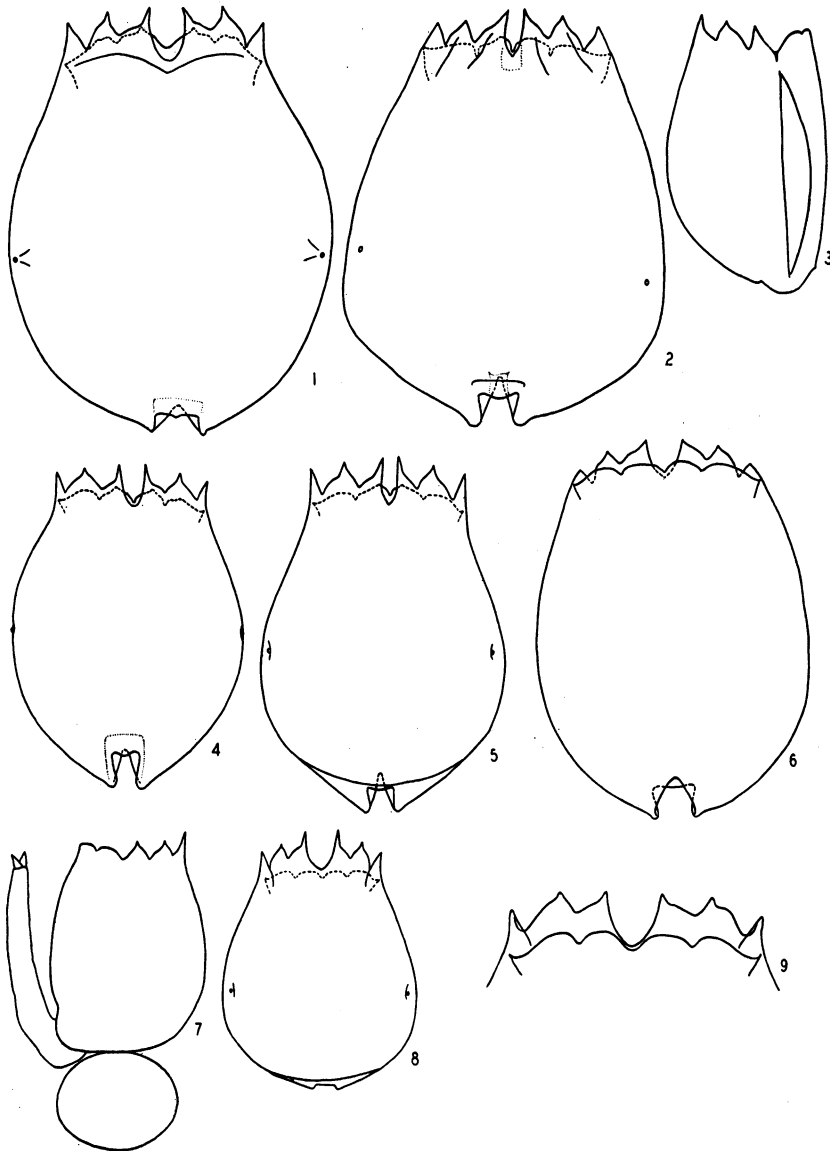
## VORONKOV, N. V.

1907. Rotatoria of the Gouvernement Moskva (in Russian). Trudy Hidrobiol. Stant. Glubokom Ozerie, II, pp. 76-126.  
 1913. Zur Rotatorienfauna Russlands (in Russian). Ibid., V.

## WEBER, E. F.

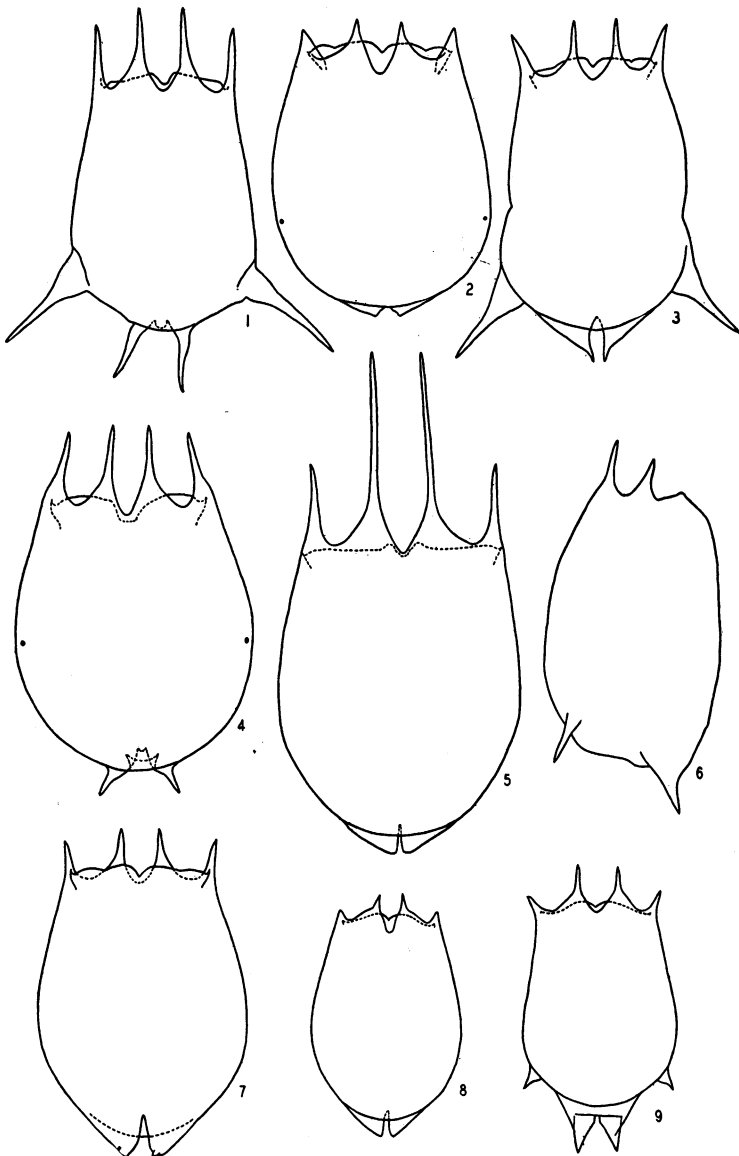
1888. Note sur quelques Rotateurs des environs de Geneve. Arch. de Biol., Liege, VIII, pp. 647-722.

1898. Faune rotatorienne du Bassin de Léman. *Revue Suisse Zool.*, V, pp. 263-785.
1906. Rotateurs. (Voyage du Dr. W. Volz.) *Zool. Jahrb. Abt. Syst.*, XXIV, pp. 207-226.
- WESENBERG-LUND, C.
1923. Contributions to the biology of the rotifers. 1. The males of the Rotifera. *Kg. Danske Vidensk. Selsk. Skrift. Naturvid. og Math. Afd.* (8), IV, pp. 191-345.
1930. Contributions to the biology of the Rotifera. 2. The periodicity and sexual periods. *Ibid. Afd.* (9) II, pp. 1-230.
- WHITNEY, D. D.
- 1916A. Parthenogenesis and sexual reproduction in rotifers. Experimental research upon *Brachionus pala*. *Amer. Nat.*, L, pp. 50-52.
- 1916B. The control of sex by food in five species of rotifers. *Jour. Exper. Zool.*, XX, pp. 263-296.
- 1916C. The transformation of *Brachionus pala* into *Brachionus amphiceros* by sodium silicate. *Biol. Bull.*, XXXI, pp. 113-120.
- 1917A. The relative influence of food and oxygen in controlling sex in rotifers. *Jour. Exper. Zool.*, XXIV, pp. 101-138.
- 1917B. The production of functional and rudimentary spermatozoa in rotifers. *Biol. Bull.*, XXXIII, pp. 305-315.
- WIERZEJSKI, A.
1891. Liste des Rotifères observés en Galicie (Autriche-Hongrie). *Bull. Soc. Zool. France*, XVI, pp. 49-52.
1893. Rotatoria (wrotki) Galicyi. *Rozp. Akad. Umiejetn., Wydziału Matem.-Przyrodn.*, Krakow, (2) VI, pp. 160-265.
- WISZNIEWSKI, J.
1931. Sur quelques rotifères trouvés en Espagne. *Archiv d'hydrobiol. et d'ichthy*, VI, pp. 41-64.
- ZACHARIAS, O.
- 1898A. Das Heleoplankton. *Zool. Anz.*, XXI, pp. 24-32.
- 1898B. Untersuchungen über das Plankton der Teichgewässer. *Forsch. Biol. Station Plön*, VI, pp. 89-139.
- ZERNOV, S. A.
1901. Notes on the Zooplankton of the Rivers Shoshma and Viatka in the district, Malmyz, gouvernement Viatka (in Russian). *Izv. Imp. Obschch. Liub. Iest.*, Moskva, XCVIII, pp. 25-36.

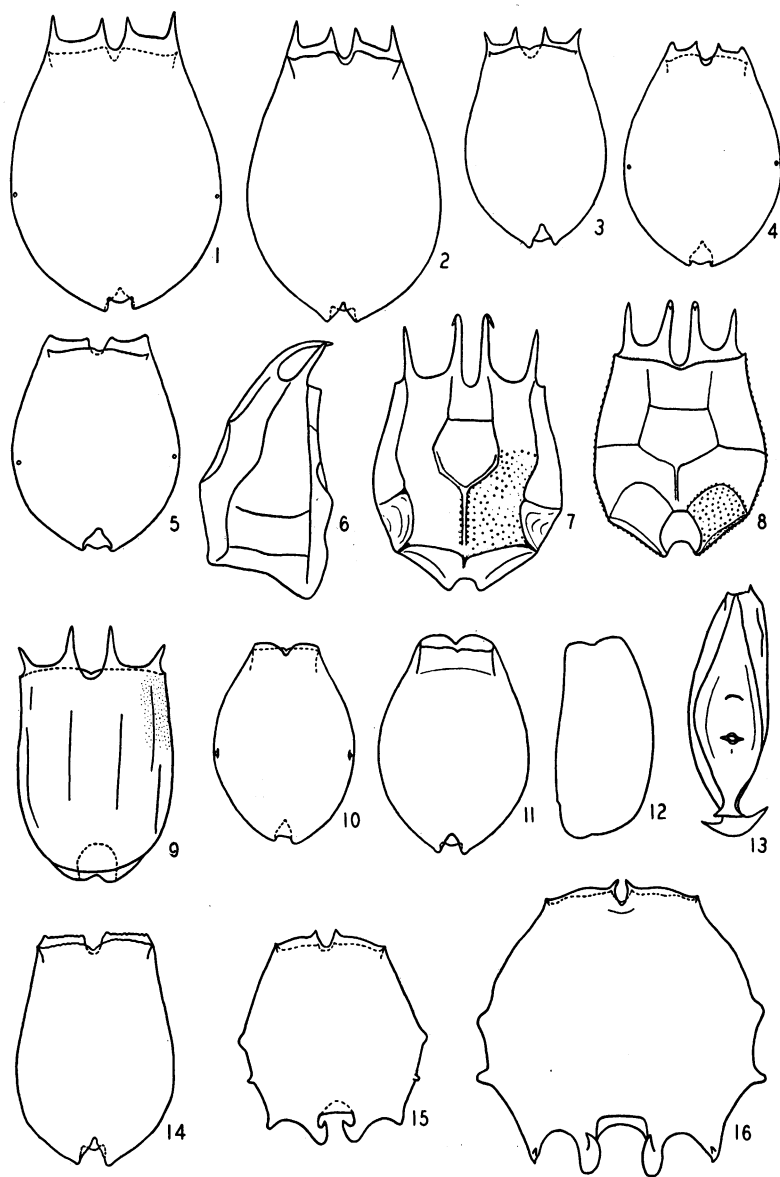


Figs. 1 to 9. *Brachionus plicatilis*: 1, dorsal view, from Tso Nyaka, northern India; 2, dorsal view, from Etang Bois Neuf, Hispaniola; 3, lateral view, 4, dorsal view, from Lake Rudolph, Kenya; 5, dorsal view, from Agude Simão, Parahyba, Brazil; 6, ventral view, near Malmö, Sweden; 7, lateral view; 8, dorsal view, from Butler Lake, Florida; 9, anterior portion of lorica, from Tso Kar, northern India.

All figures are highly magnified. Where possible all figures on a plate are magnified to the same scale to show comparative size; on some plates the larger specimens are proportionately reduced. For actual measurements see text. Because some forms of brachionids are apparently geographically distinct, the exact location is indicated for each specimen illustrated. All figures have been based on material in The American Museum of Natural History with a few exceptions.



Figs. 1 to 9. *Brachionus calyciflorus*: 1, dorsal view, from pond, Mathias, Ohio; 2, dorsal view, 3, dorsal view, from pond, Hodkovičky, Czechoslovakia; 4, dorsal view, from Açude Simão, Parahyba, Brazil; 5, dorsal view, drawn to reduced scale, from Buckeye Lake, central Ohio; 6, lateral view, from Ottawa Creek near Toledo, Ohio; 7, ventral view, from pond, Fleninge, Sweden; 8, dorsal view, Staffelfelden, France; 9, dorsal view, from pond, Bass Island region, Ohio.



Figs. 1 to 5. *Brachionus dimidiatus*: 1, dorsal view; 2, ventral view, from Abyssinia (type locality); 3, ventral view, 4, dorsal view, 5 ventral view, from Lake Rudolph, Kenya.

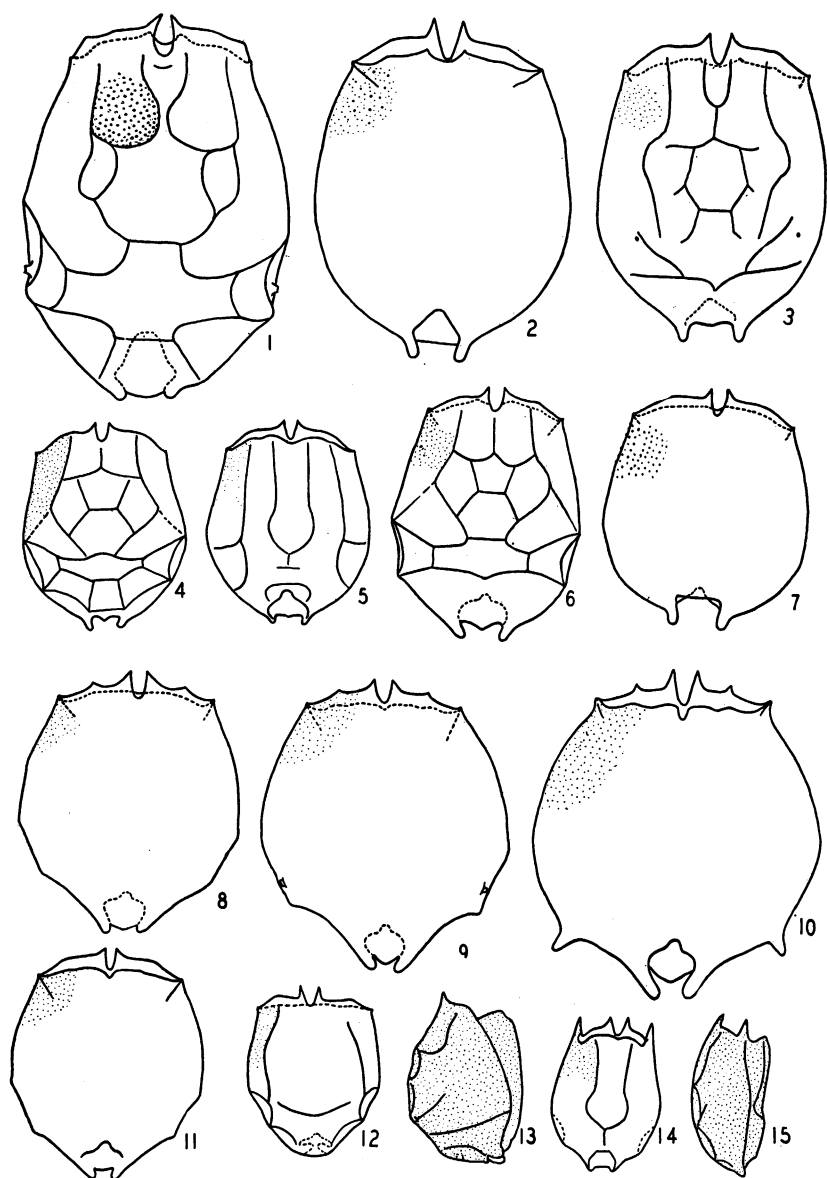
Figs. 6 to 9. *Brachionus budapestinensis*: 6, lateral view, 7 dorsal view, 8 ventral view, from lagoon, Catawba, Ohio; 9, dorsal view, from Lövestad, Sweden.

Figs. 10 to 12. *Brachionus dimidiatus* var. *inermis*: 10, dorsal view, 11, 12, ventral views, from San Luis Province, Argentina.

Fig. 13. *Brachionus dolabratus*: lateral view, from Açude Bodocongo, Parahyba, Brazil.

Fig. 14. *Brachionus dimidiatus* var. *inermis*, ventral view, from Abyssinia; serrations along anterior margins are probably accretions.

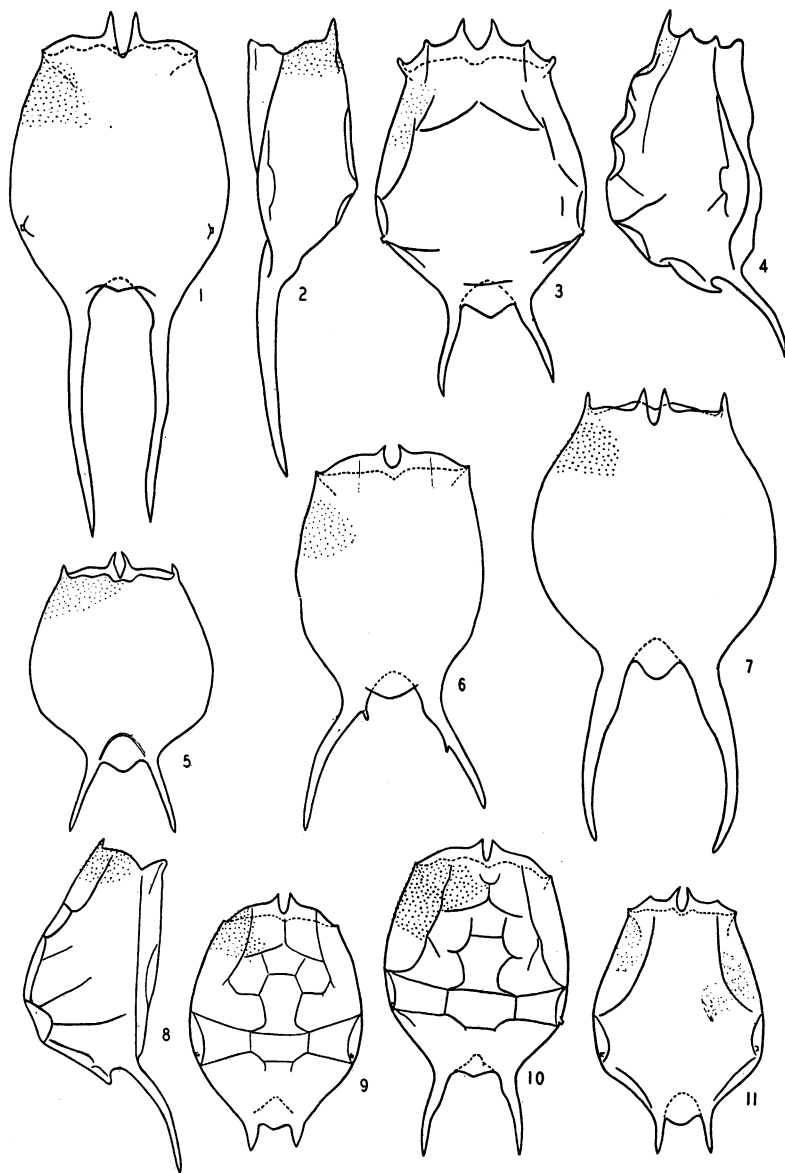
Figs. 15 and 16. *Brachionus dolabratus*: 15, dorsal view, specimen from Bohio, Panama (type locality); 16, dorsal view, from Açude Puxinãã, Parahyba, Brazil.



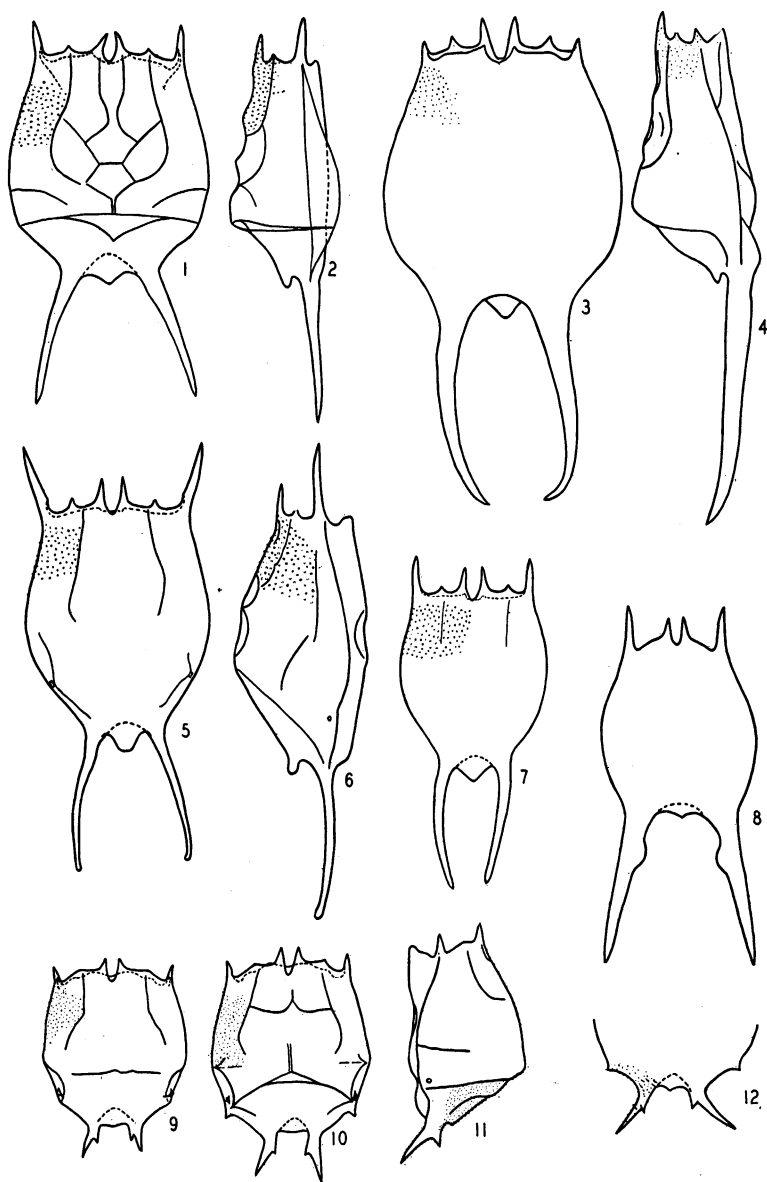
Figs. 1 to 13. *Brachionus angularis*: 1, dorsal view, from pond, Čeradice, Czechoslovakia; 2, ventral view, from pond, Hyby, Sweden; 3, dorsal view, from Staffelfelden, France; 4, dorsal view, 5, ventral view, from Lake Xochimilco, Mexico; 6, dorsal view, from Swan Creek, northwest Ohio, mictic female; 7, dorsal view, from Stromberg Junction Dam, South Africa; 8, dorsal view, from Swan Creek, northwest Ohio, amictic female; 9, dorsal view, from lake at Winter Park, Fla.; 10, ventral view, from Kissimmee, Fla. (pseudo-dolabratus form); 11, ventral view, from pond, Asheboro, N. C.; 12, dorsal view, 13, lateral view, from Sholavaram Lake (Madras), India.

Figs. 14 and 15. *Brachionus angularis* var. *chelonis*: 14, ventral view, 15 lateral view, from swamp at Kinston, N. C.





Figs. 1 to 11. *Brachionus caudatus*: 1, f. *provectus*, dorsal view, 2, f. *provectus*, lateral view, from near Buenos Aires, Argentina; 3, f. *insuetus*, dorsal view, 4, f. *insuetus*, lateral view, from pool at Punta Lara, Argentina; 5, f. *apsteini*, ventral view, from Caloosahatchee River near La Belle, Fla.; 6, f. *vulgatus*, dorsal view, from Echo Park Lake, Los Angeles, Calif.; accessory growths from posterior spines such as those figured are rare; 7, f. *majusculus*, dorsal view, from vicinity of Kissimmee, Fla.; 8, f. *vulgatus*, lateral view, from Maumee R. at Texas, Ohio; 9, f. *vulgatus*, dorsal view, from lagoon, Catawba, Ohio; 10, f. *vulgatus*, dorsal view, from Oklahoma City water reservoir; 11, f. *vulgatus*, dorsal view, from Buckeye Lake, central Ohio.



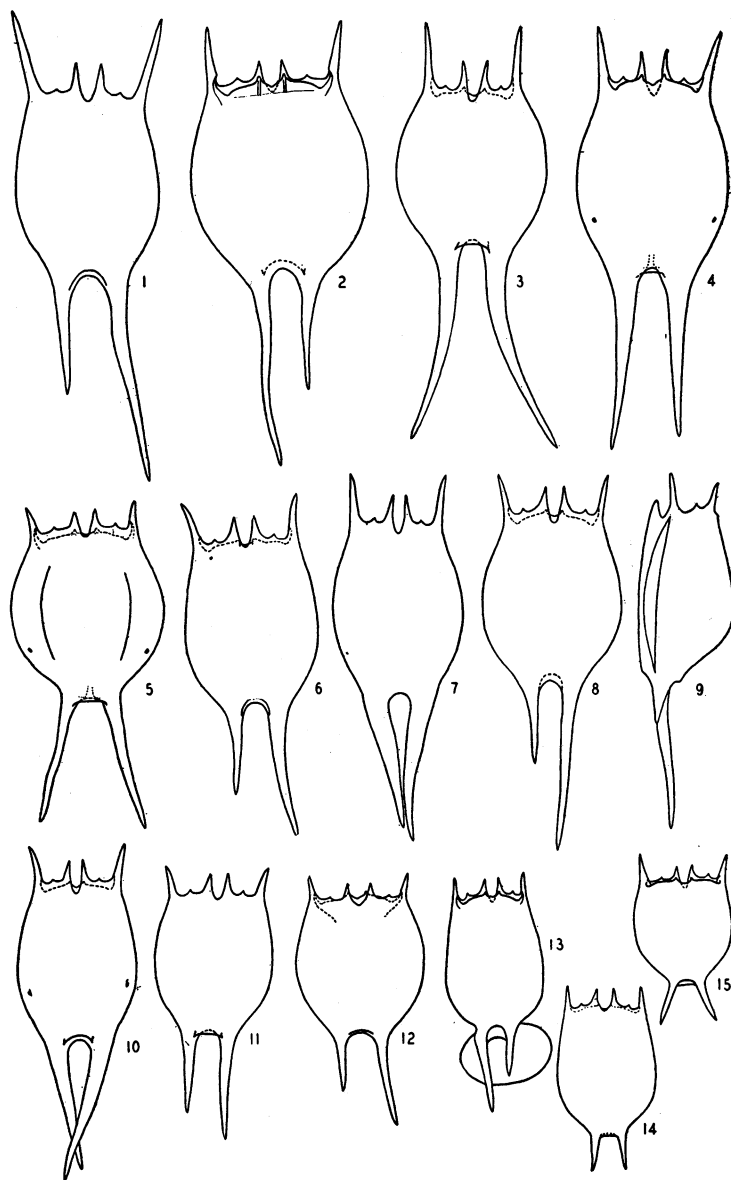
Figs. 1 and 2. *Brachionus caudatus* var. *personatus*: 1, dorsal view, 2, lateral view, from Lake Xochimilco, Mexico.

Figs. 3 and 4. *Brachionus caudatus*: 3, f. *austrogenitus*, ventral view, 4, f. *austrogenitus*, lateral view from Açude Puxinãã, Parahyba, Brazil.

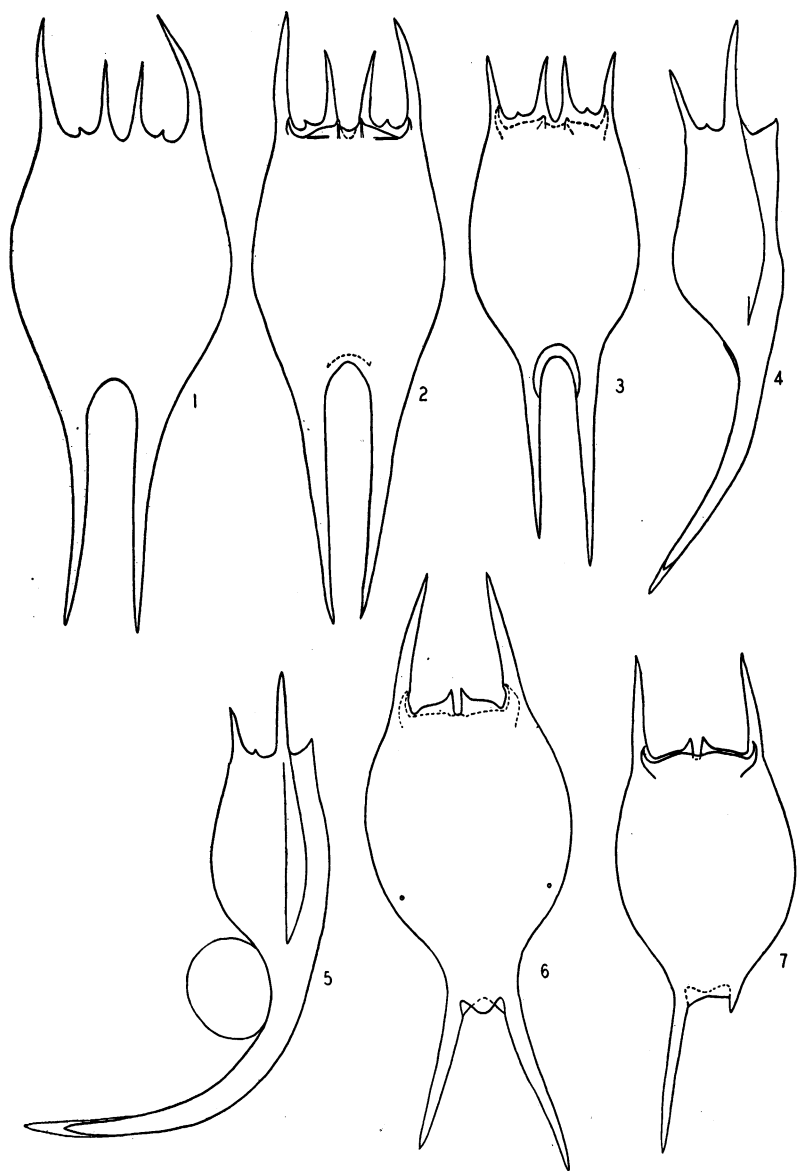
Figs. 5 to 7. *Brachionus caudatus* var. *personatus*: 5, dorsal view, 6, lateral view, aberrant form from Punta Lara, Argentina; 7, dorsal view, from Açude Maria de Paes, Parahyba, Brazil.

Fig. 8. *Brachionus forficula*: dorsal view, from Bohemia.

Figs. 9 to 12. *Brachionus caudatus* var. *aculeatus*: 9, 10, dorsal views, 11, lateral view from Sholavaram Lake, India (type locality); 12, dorsal view of posterior portion of lorica, same locality.

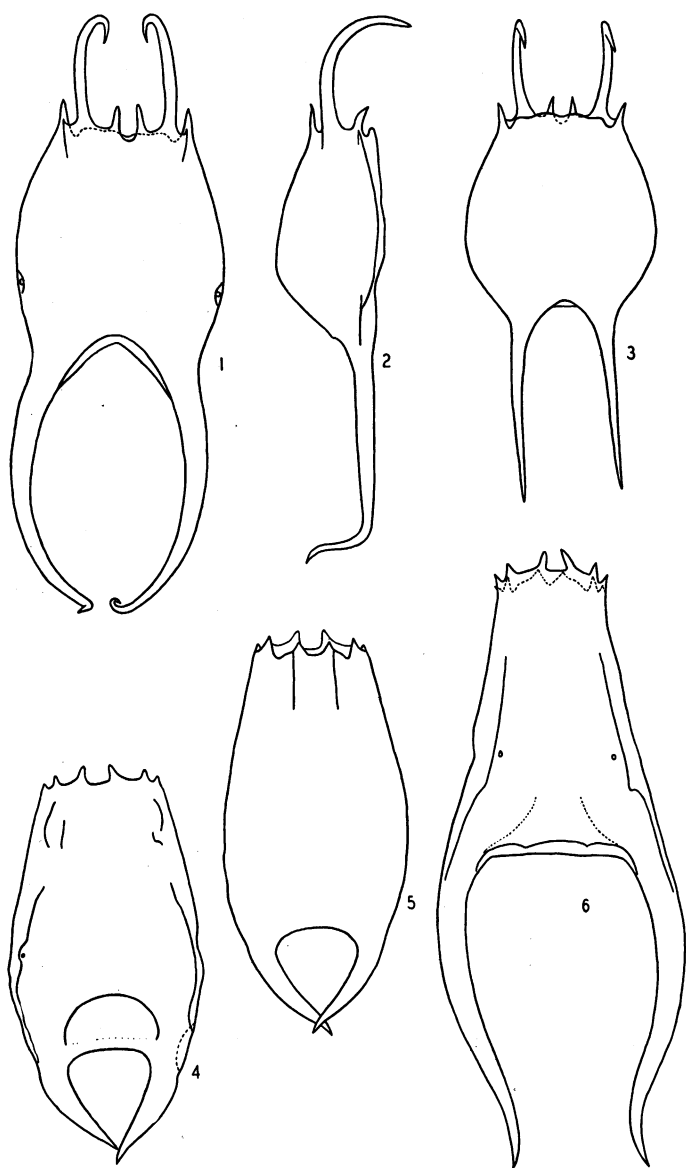


Figs. 1 to 15. *Brachionus havanaensis*: 1, dorsal view, from Illinois R. at Havana, Illinois (type locality); 2, ventral view, from Ottawa Creek, near Toledo, Ohio; 3, dorsal view, from near Arcadia, Fla.; 4, ventral view, from pool, Cincinnati, Ohio; 5, dorsal view, from pond, Asheboro, N. C.; 6, dorsal view, from Lake Xochimilco, near Mexico City, Mexico; 7, dorsal view, from near Brighton, Fla.; 8, dorsal view, 9, lateral view, from Caloosahatchee R. near La Belle, Fla.; 10, dorsal view, from near Palmdale, Fla.; 11, dorsal view, from pond, Russellville, Ohio; 12, dorsal view, from Rio Saltes at Valles, Mexico; 13, ventral view, from near Englewood, Fla.; 14, dorsal view, from near New Orleans, La.; 15, ventral view, from New Bern, N. C.



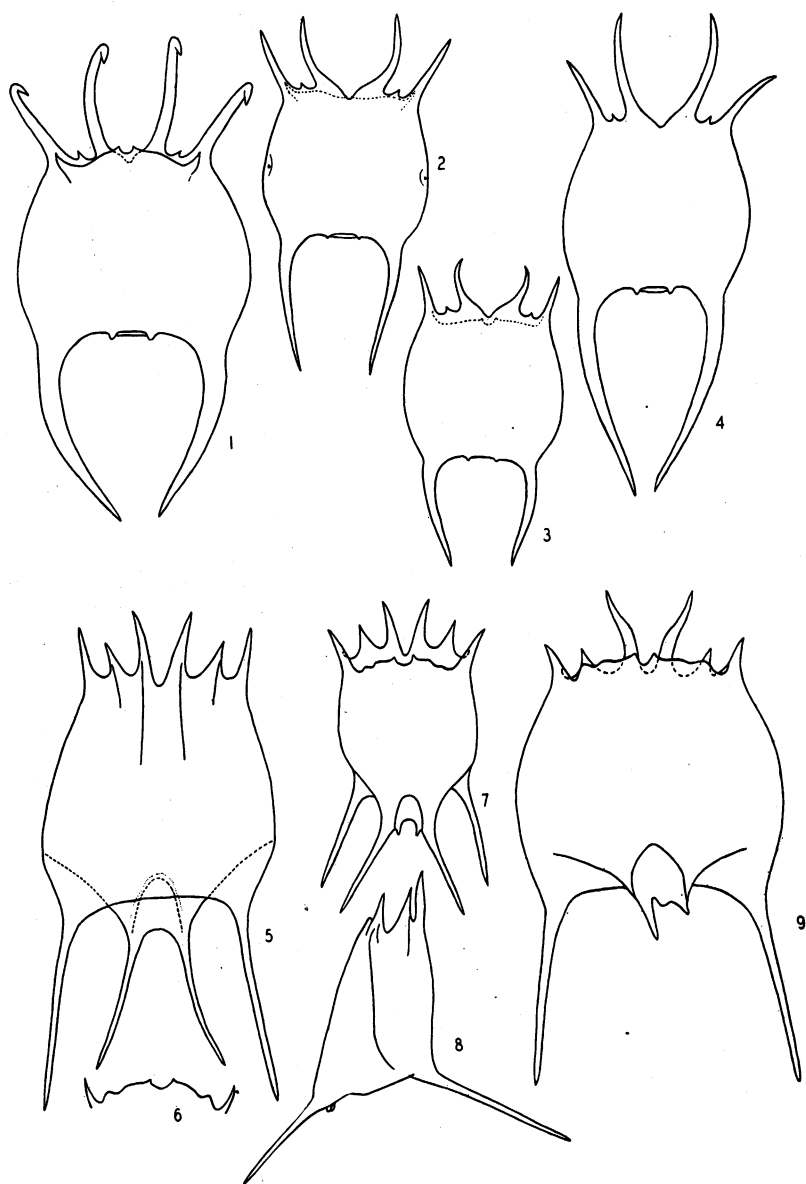
Figs. 1 to 5. *Brachionus havanaensis* var. *trahea*: 1, dorsal view, from Rio Santiago, Mexico; 2, ventral view, from Açude Bodocongo, Parahyba, Brazil; 3, dorsal view, from lagoon, Rio de Janeiro, Brazil (type locality); 4, lateral view, from Açude Bodocongo, Parahyba, Brazil; 5, lateral view, specimen with posterior spines very recurved, from Cisnes, Argentina.

Figs. 6 and 7. *Brachionus diversicornis*: dorsal and ventral views, from Globonoia, U. S. S. Russia



Figs. 1 to 3. *Brachionus falcatus*: 1, dorsal view, 2, lateral view, from Açude Bodocongo, Brazil; 3, ventral view, from Panama.

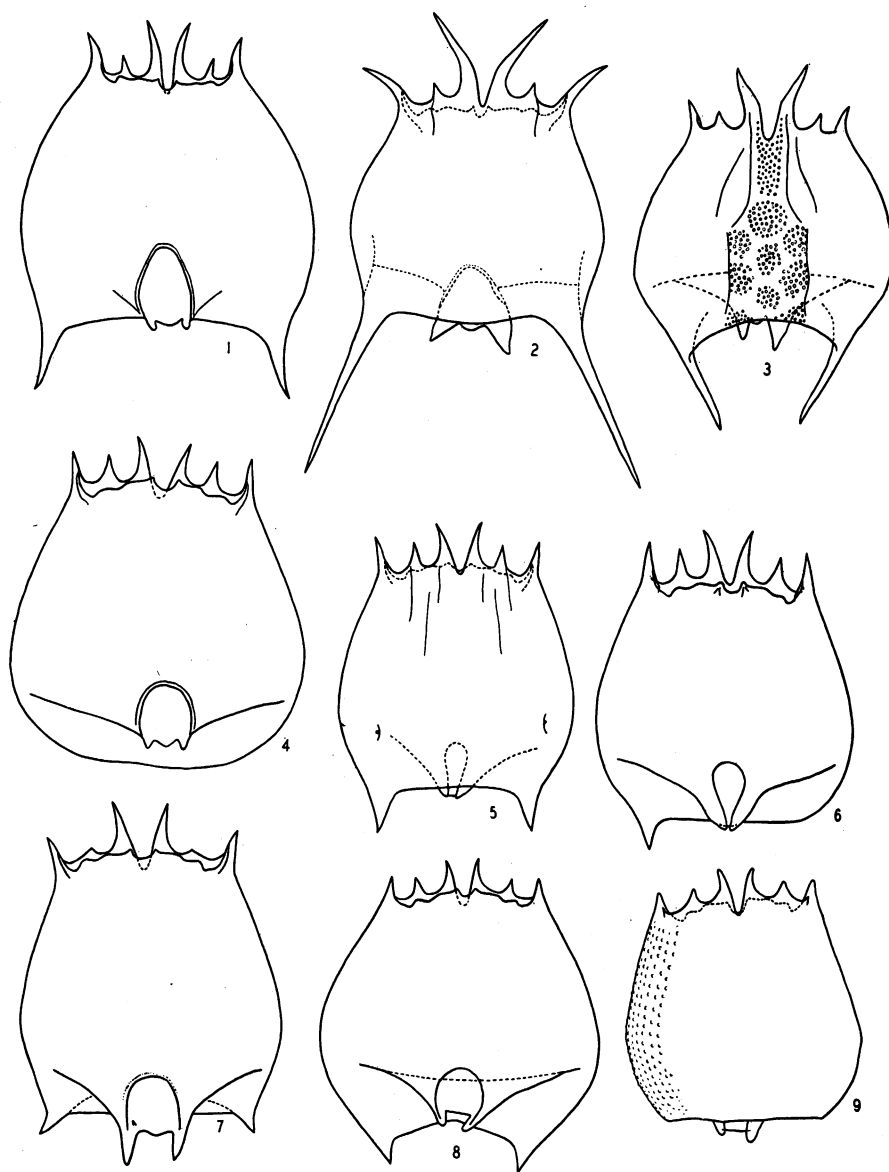
Figs. 4 to 6. *Brachionus satanicus*: 4, dorsal view, 5, ventral view, from San Luis Province, Argentina; 6, dorsal view, from Devils Lake, N. D. (type locality).



Figs. 1 to 4. *Brachionus zahniseri*: 1, ventral view, from near Odessa, Fla. (type locality); 2, dorsal view, from Newport, N. C.; 3, dorsal view, from Dunedin Isle, Fla.; 4, dorsal view, from Polk Co., Fla.

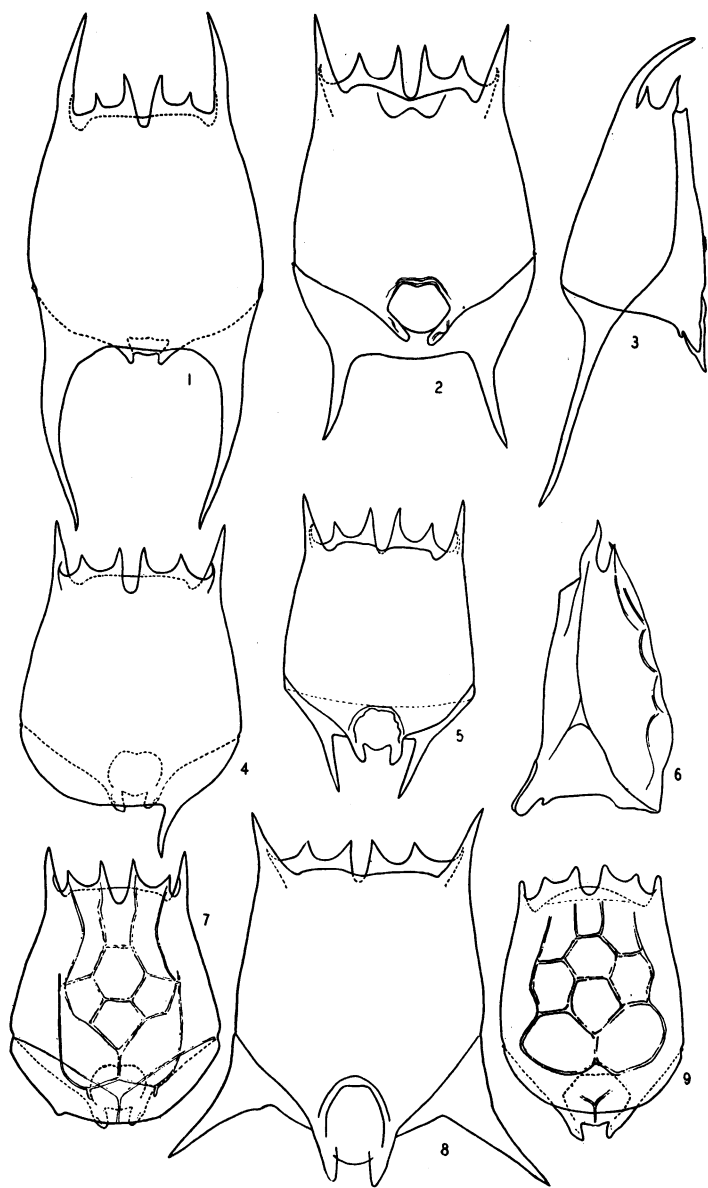
Figs. 5 to 8. *Brachionus mirabilis*: 5, dorsal view, 6, mental margin, from Rio de Janeiro, Brazil; 7, ventral view, 8, lateral view, from near Myakka City, Fla.

Fig. 9. *Brachionus quadridentatus*: ventral view, from near Elfers, Fla.



Figs. 1 to 9. *Brachionus quadridentatus*: 1, ventral view, from pond, Bass Island region, Ohio; 2, dorsal view, from Terwilliger's Pond, Put-in-Bay, Ohio; 3, dorsal view, from pool at Mathias, Ohio, showing central arrangement of ornamentation pattern; 4, ventral view, from pool, Riverby, Ohio; 5, dorsal view, 6, ventral view, from Swan Creek, northwest Ohio; 7, ventral view, from Delaware Creek, near Toledo, Ohio; 8, ventral view, from castle moat, Malmöhus, Sweden; 9, dorsal view, from Pangur tso, northern India, ornamentation shown for one side.

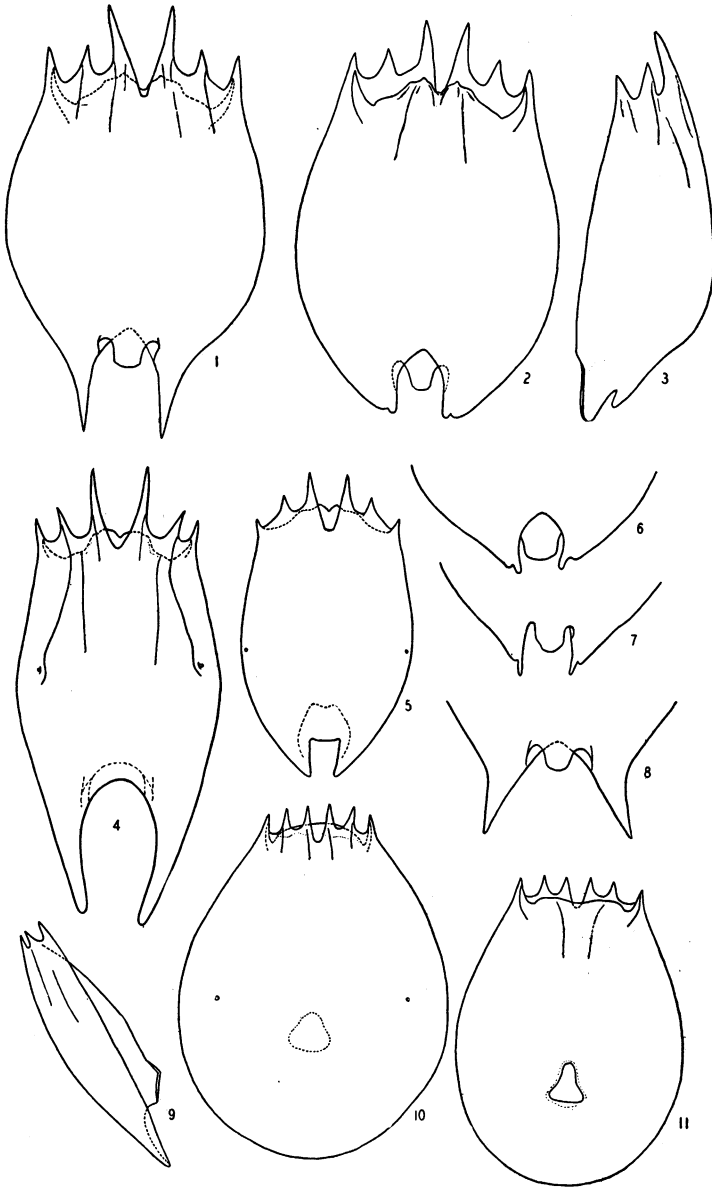




Figs. 1 and 2. *Brachionus bidentata*: 1, dorsal view, from Koorn Spruit, West Bloemfontein, South Africa; 2, ventral view, from Buckeye Lake, Ohio.

Fig. 3. *Brachionus quadridentatus*: lateral view, from near Elfers, Fla.

Figs. 4 to 9. *Brachionus bidentata*: 4, dorsal view, from lagoon, Catawba, Ohio; 5, ventral view, from near New Orleans, La.; 6, lateral view, from Oklahoma City water reservoir; 7, dorsal view, lagoon, Catawba, Ohio; 8, ventral view, from Springar, northern India; 9, dorsal view, from roadside ditch, Palmdale, Fla.

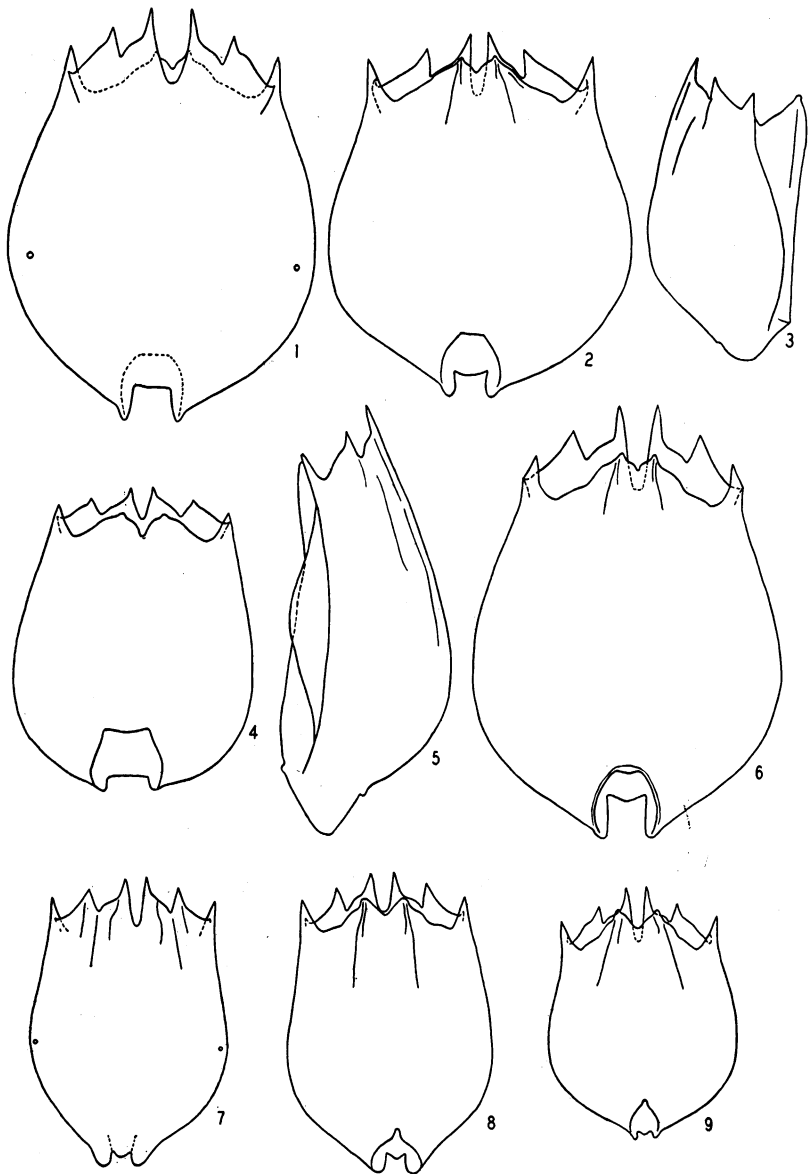


Figs. 1 to 3. *Brachionus variabilis*: 1, dorsal view, from near Los Angeles, Calif.; 2, ventral view 3, lateral view, from Oklahoma City water reservoir.

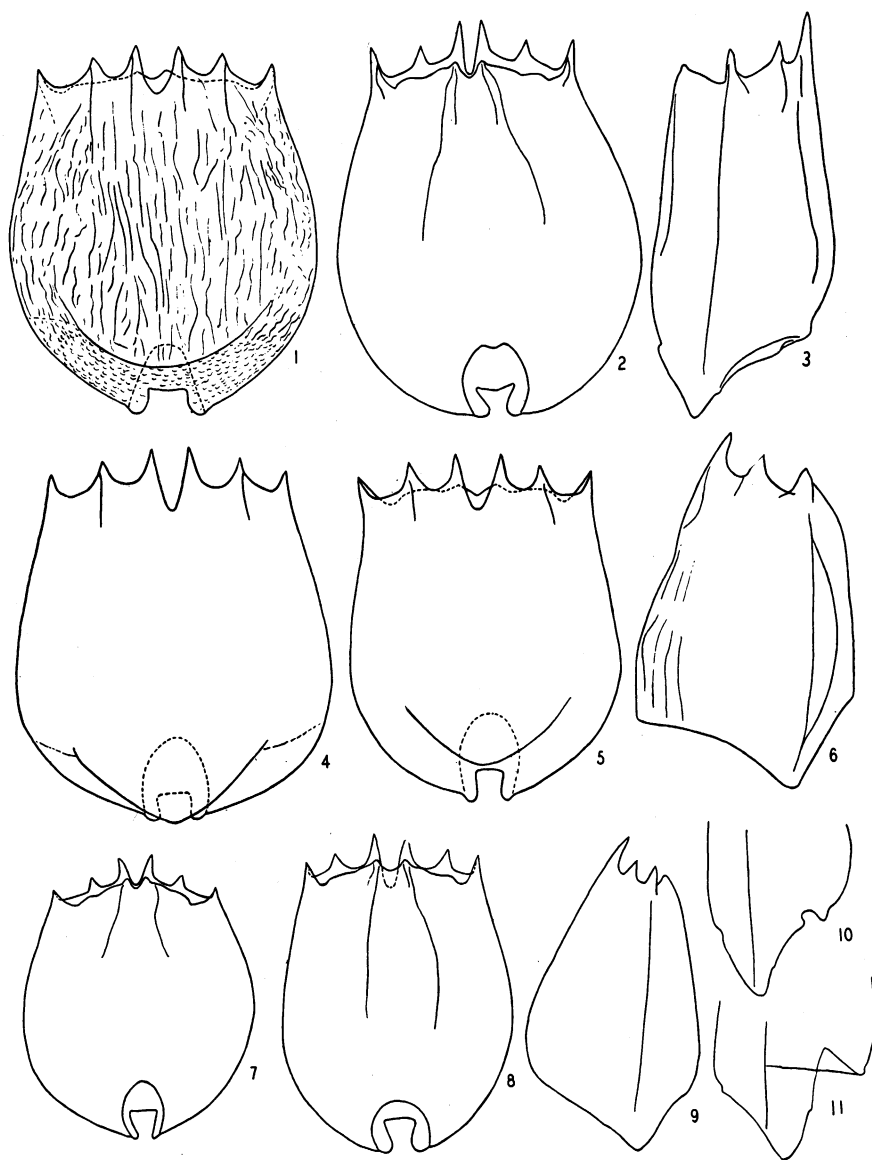
Figs. 4 and 5. *Brachionus novae-zelandiae*: dorsal view, from Oamaru, New Zealand (type locality); 5, ventral view, from Eilandspan, South Africa.

Figs. 6 to 8. *Brachionus variabilis*: 6, 7, posterior portion of lorica, from Los Angeles, Calif.; 8, posterior portion of lorica, from Oklahoma City water reservoir.

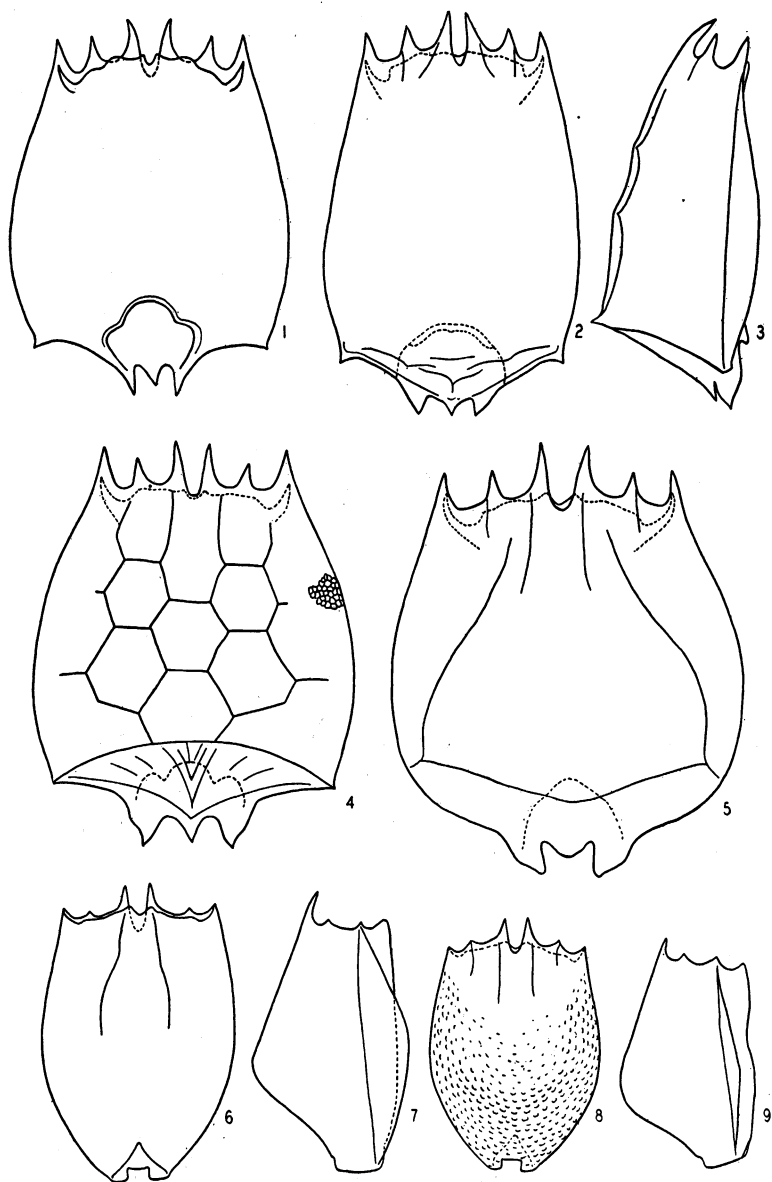
Figs. 9 to 11. *Brachionus pterodinoides*: 9, lateral view, from Cordoba, Mexico; 10, ventral view, from Devils Lake, N. D. (type locality); 11, dorsal view, from Cordoba, Mexico.



Figs. 1 to 9. *Brachionus rubens*: 1, dorsal view, from Slowmarket, Suffolk, Eng.; 2, dorsal view, from Green Pond, near Farmersville, Pa.; 3, lateral view, from Swan Creek in northwestern Ohio; 4, ventral view, from Philadelphia, Pa. (on *Daphnia*); 5, lateral view, 6, ventral view, from pond, Fleninge, Sweden, epiplanctonic on cladocera; 7, dorsal view, 8, ventral view, Swan Creek in northwestern Ohio; 9, ventral view, from Açude Simão, Parahyba, Brazil.

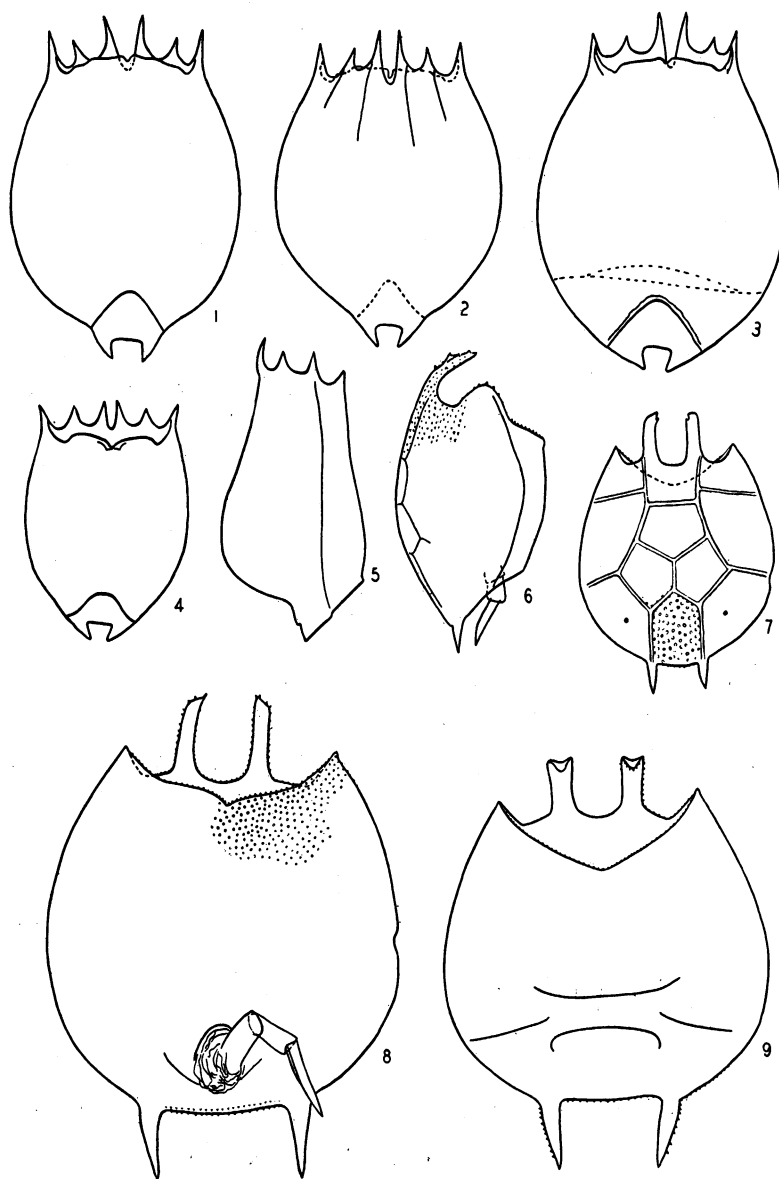


Figs. 1 to 11. *Brachionus urceolaris*: 1, dorsal view, from Luntz, Austria; 2, ventral view, 3, lateral view, from Buckeye Lake, Ohio; 4, dorsal view, from near London, Eng.; 5, dorsal view, 6, lateral view, from near Myakka City, Fla.; 7, ventral view, from Oklahoma City water reservoir; 8, ventral view, from near Tarpon Springs, Fla.; 9, lateral view, from Butler Lake, Fla.; 10, lateral views, from Buckeye Lake, Ohio.



Figs. 1 to 5. *Brachionus rotundulus* (Forsk.): 1, ventral view, from Sohawa, northern India; 2, dorsal view, from Foo Choo, China; 3, lateral view; 4, dorsal view, from pond, Lund, Sweden; 5, dorsal view (rotundus form) from Richmond Park, Surrey, Eng.

Figs. 6 to 9. *Brachionus rotundulus* (Forsk.): 6, ventral view, 7, lateral view, 8, dorsal view, 9, lateral view, from Mud Creek near Port Clinton, Ohio.



Figs. 1 to 5. *Brachionus nilsoni*: 1, 3, ventral views, 2, dorsal view, from Ottawa Creek, near Toledo, Ohio (type locality); 4, ventral view, from Mud Creek, near Port Clinton, Ohio; 5, lateral view, from Ottawa Creek, Ohio.

Figs. 6 to 9. *Platyas quadricornis*: 6, lateral view, 7, dorsal view, small form, 8, ventral view, large form, from near Fort Myers, Fla.; 9, ventral view, from pond, Bass Island region, Ohio.

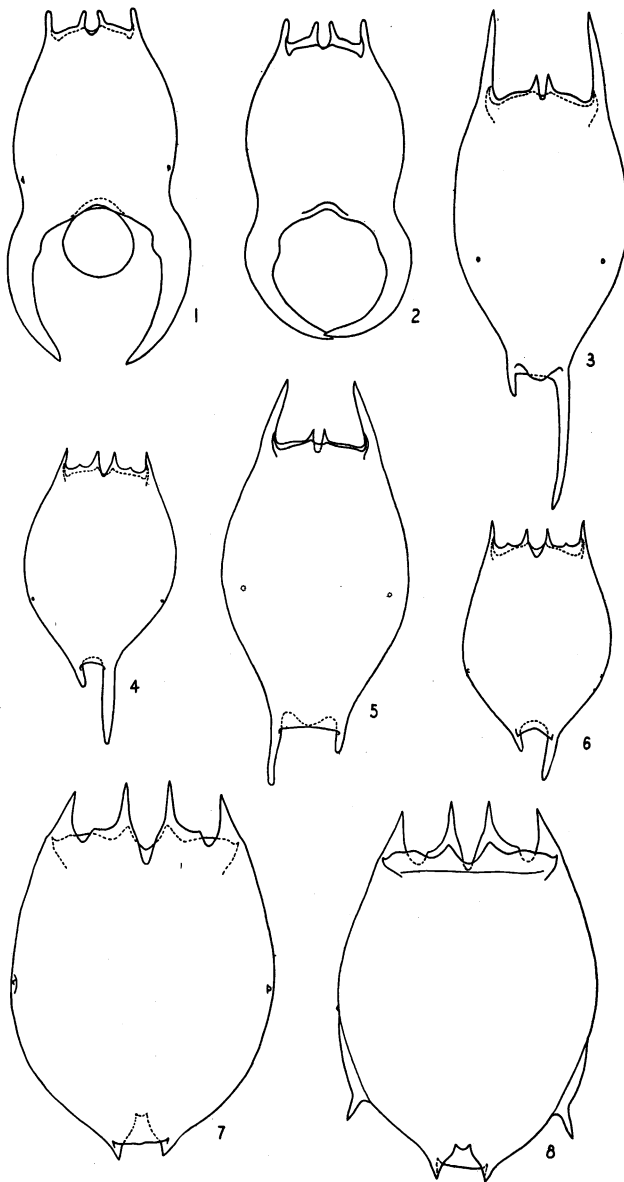


Figs. 1 to 4. *Platytia patulus*: 1, dorsal view, from Mud Creek, near Port Clinton, Ohio; 2, ventral view, 3, lateral view, pond, Bass Island region, Ohio; 4, ventral view, form with long postero-lateral spines, from ditch, Minocqua, Wis.

Fig. 5. *Platytia patulus* var. *macracanthus*: dorsal view, from Guatemala.

Figs. 6 and 7. *Platytia polyacanthus*: 6, dorsal view, reduced form, from near Orlando, Fla.; 7, dorsal view, from railroad ditch, Minocqua, Wis.

Fig. 8. *Platytia patulus* var. *macracanthus*: ventral view, from near Okeechobee, Fla.



Figs. 1 and 2. *Brachionus forficula*: 1, dorsal view, 2, ventral view, pond at Takao, Formosa.  
 Fig. 3. *B. diversicornis*: dorsal view, Liaoyang, Manchoukuo.  
 Fig. 4. *B. havanaensis*: dorsal view, McCarron's Pond, near St. Paul, Minnesota (material on which var. *minnesotensis* Lindeman is based).  
 Fig. 5. *B. diversicornis*: ventral view, pond at Takao, Formosa.  
 Fig. 6. *B. havanaensis*: dorsal view, McCarron's Pond, Minnesota.  
 Figs. 7 and 8. *B. calyciflorus*: 7, dorsal view, pond at Takao, Formosa (form *borgerti* Apstein); 8, ventral view, same locality, specimen with postero-lateral spines developed.













