Cyclopyxis acmodonta n. sp. and *Arcella formosa* n. sp.: Two New Species of Testate Rhizopods (Arcellinida, Protozoa) from Remnant Wetlands in Ontario, Canada

KENNETH H. NICHOLLS

S-15 Concession 1, RR # 1 Sunderland, Ontario L0C 1H0 Canada; e-mail: khnicholls@interhop.net

Nicholls, Kenneth H. 2005. *Cyclopyxis acmodonta* n. sp. and *Arcella formosa* n. sp.: two new species of testate rhizopods (Arcellinida, Protozoa) from remnant wetlands in Ontario, Canada. Canadian Field-Naturalist 119(3): 403-411.

Species of the testate rhizopod genera *Arcella* and *Cyclopyxis* are found predominantly in the benthos of shallow ponds, forest pools, marshes and other freshwater habitats. Their taxonomy is based on the morphology of their tests — the shell-like structure that houses the living single-celled amoeboid protoplast. This paper describes a new species of *Cyclopyxis* discovered in two coniferous forest bogs, and a new species of *Arcella* from a *Typha*-dominated marsh on the north shore of Lake Ontario, Canada. *Cyclopyxis acmodonta* Nicholls n. sp. differs from its closest relative *C. stellata* (Wailes) Deflandre 1929 in its much smaller size and its irregularly shaped pseudostomal aperture, which is embellished with numerous, tiny, sharp-pointed tooth-like quartz granules around the interior margin. Although the saucer-like indentations over the dorsal surface of the test of *A. formosa* Nicholls, Meisterfeld & Török n. sp. resemble similar structures found in several other *Arcella* species, the large size of *A. formosa* (165-235 µm in diameter) and its low profile (low height-to-diameter ratio) are the main features distinguishing this new species from other *Arcella* species.

Key Words: *Arcella*, Arcellaceans, Arcellidae, amoebae, *Cyclopyxis,* Testacealobosia, Rhizopoda, Trigonopyxidae.

The species-level taxonomy of most testate rhizopods has been based on the size and shape of their shells or tests – the structure that "houses" the amoeboid protoplast. Species of the testate amoebae genera *Arcella* and *Cyclopyxis* occupy similar habitats (generally shallow benthic freshwaters, bogs, forest pools and damp mosses) and possess certain superficial similarities in their test structure relating to the usual dome-shaped radial symmetry, including a centrally located pseudostomal aperture. Test composition in these two genera is, however, very different and this fact has been the basis for their separate placement in two distinct families. Tests of *Arcella* (family Arcellidae) are of a rigid and transparent organic material, while those of *Cyclopyxis* (family Trigonopyxidae) are composed of mineral particles embedded in an organic cement (Meisterfeld 2002). There are presently about 120 and 80 species and subspecies of *Arcella* and *Cyclopyxis*, respectively.

Deflandre (1928) provided a monographic treatment of the genus *Arcella* that was followed by a similar compilation for the genus *Centropyxis* (Deflandre 1929). In his treatment of the genus *Centropyxis*, Deflandre (1929) erected the subgenus *Cyclopyxis* to include those *Centropyxis*-like tests with radial symmetry (*Centropyxis* tests are bilaterally symmetric). Virtually all authors since then have considered *Cyclopyxis* an autonomous genus quite distinct from *Centropyxis*. *Arcella* and *Cyclopyxis* taxonomy has been summarily updated by Decloitre (1976, 1977, 1979, 1982 and 1986). Unfortunately, many taxa, especially at the subspecies level, were originally poorly described on the basis of very few specimens, so little is known of the range of form variation and how this relates to the morphology of similar but differently named taxa. Based on a detailed study of form variation of tests, Foissner and Korganova (1995) suggested that nine species and subspecies of *Cyclopyxis* might be reduced to two valid species. Since Decloitre's latest taxonomic update (Decloitre 1986), descriptions of new taxa of *Arcella* and *Cyclopyxis* have been few (e.g., Chardez et al. 1987; Torres and Jebram 1993; Balík 1995).

The purpose of this paper is to describe one new species in each of the genera *Arcella* and *Cyclopyxis* discovered recently in wetlands in Ontario, Canada. Features of test morphology of both species are highly distinctive and not easily confused with previously known taxa. Detailed statistics on test dimensions, as well as light microscopic digital images and drawings, are included.

Methods

Sampling locations and collection methods

Cranberry Marsh (43°50'38"N; 78°57'0"W) is a 16-ha cattail (*Typha*)-dominated wetland within the Town of Whitby, Ontario (Figure 1). There are no permanent surface inflows or outflow from the marsh, although some water exchange with Lake Ontario is possible during storm surges across a low berm separating the marsh from the gravel/cobble beach of Lake Ontario. Cranberry Marsh is a provincially significant wetland managed by the Central Lake Ontario Conservation Authority and is an important nesting/feeding/resting area for resident and migrating songbirds, waterfowl

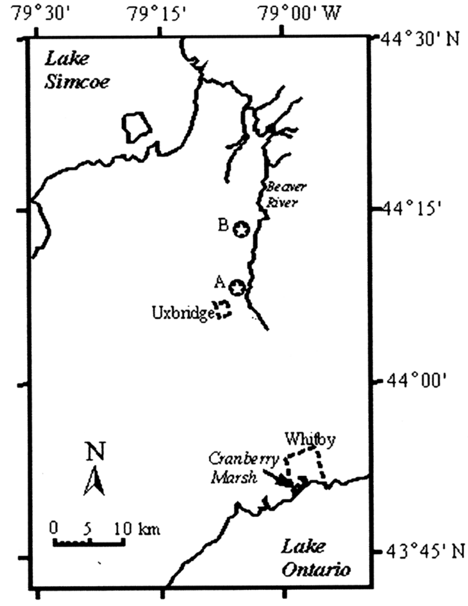

FIGURE 1. Map showing three testate rhizopod collection locations between Lake Ontario and Lake Simcoe in southern Ontario. Latitude and Longitude for Cranberry Marsh, and Sites A and B are as follows: 43°50'38"N, 78°57'30"W; 44°08'27"N, 79°05'12"W; 44°12'33"N, 79°04'40"W, respectively.

and shorebirds. Samples of water and bottom sediment were collected 7 August 2004 by submerging a wide-mouthed 500 mL bottle at the south end of Cranberry Marsh where water depth was about 0.5 m.

The Beaver River originates in a forest bog and marsh complex approximately 5 km southeast of the town of Uxbridge, Ontario (Figure 1). With a total length of approximately 50 km, a watershed area of 3.2×10^8 m^2 and a total annual discharge that averaged 8.3×10^7 m^3 $year^{-1}$ for the 1990s (Scott et al. 2001*), the Beaver River is one of the largest rivers flowing into Lake Simcoe. Sampling for testate rhizopods was in moss pools near the upper Beaver River (Sites A and B in Figure 1) in areas of forest bog dominated by White Spruce (*Picea glauca* (Moench) Vos, Northern White Cedar (*Thuja occidentalis* L., Tamarack (*Larix laricina* (Du Roi) Koch), *Sphagnum* spp, *Hylocomium splendens*, and other forest mosses. Samples containing testate rhizopods consisted of approximately 10 cc of wet moss and 500 mL of water mixed with bottom sediment from small forest pools of 20 cm maximum depth.

Laboratory methods

Samples were examined shortly after collection in their living state with an inverted microscope. Other portions of the samples, comprising about 1 cc of sediment and 20 cc of water, were fixed with formalin to achieve a final concentration of about 4% formaldehyde. Testate rhizopods of interest for measuring, image capture or isolation for transfer to a separate permanent preparation were isolated from surrounding debris by manipulation at low power (10× objective) with a single hair brush. A single specimen of each of the two new species described here was selected to serve as the type specimen for museum archival and were transferred with a micro-pipette to a Number 1 cover glass for drying and subsequent mounting on a slide with Canada Balsam. All measurements were made at a magnification of 600× (40× objective, 1.5× microscope head, 10× eyepiece). Optimal orientation for measurement was achieved by manual manipulation of isolated specimens with a single hair brush. Descriptive statistics on measurements were run in CoStat (CoHort Software 1995*). Images were captured with a 3.4 megapixel digital camera and assembled onto plates for publication using Adobe Photoshop 5.0.

Results

Cyclopyxis acmodonta n. sp.

Phylum Rhizopoda Class, Lobosea; Order Arcellinida; Family Trigonopyxidae Loeblich and Tappan, 1964.

Diagnosis: Test constructed of agglutinated microscopic quartz granules and in side view with a flattened ventral surface and domed dorsal surface. Ventral surface with a centrally located and irregularly-shaped oral aperture (pseudostome) about ½ the test diameter and composed of from three to seven lobes or indentations. Margin of the pseudostome ornamented with many sharp-pointed tooth-like granules. Test diameter, 188-298 µm; test height, 150-217 µm; widest opening in pseudostome (between distal lobes), 75-143 µm. Pseudostome only slightly invaginated relative to the surrounding ventral surface of the test.

Etymology: The specific epithet ("acmodonta") refers to the small sharp-pointed "teeth" that embellish the interior margin of the pseudostome [acmodonta (Latin, fem. adj.) = sharp-toothed].

Type specimen: The type specimen was mounted in Canada Balsam on a glass slide and was deposited with the Invertebrate Zoology Division, Canadian Museum of Nature, Catalogue Number CMNI 2005-0004.

Holotype material: A formalin-preserved aqueous sample has been retained by the author under sample No. V-1892, collected 4 January 2004.

Type locality: Forest bog (*Sphagnum* moss dominated small pool) near the upper Beaver River, Ontario Canada (44°08'27"N, 79°05'12"W). Specimens were also collected on 16 October 2001 from a moss pool in a similar forest habitat (Site B in Figure 1; 44°12'33"N, 79°04'40"W), approximately 8 km N of the type locality.

TABLE 1. Sizes of test variables in *Arcella formosa* and *Cyclopyxis acmodonta*. n = 14 for all *A. formosa* variables; n = 18 for *C. acmodonta* except n = 14 for ap and D/ap. Definitions of D, H and ap are as depicted in Figures 2a, 2b and 4b, respectively. The pseudostomal "ap" metric for *C. acmodonta* was represented by the longest straight line joining the most remote lobes of the aperture. For those *A. formosa* specimens for which the aperture was slightly elliptical rather than circular, the longest distance through the centre was measured.

Arcella formosa		diameter (D)	height (H)	aperture (ap)	D/H	D/ap
	median	192	85	58.5	2.3	3.2
	minimum	165	56	46	1.9	2.5
	maximum	235	100	85	3.2	3.6
	mean	199.1	84.9	64.6	2.4	3.2
	SD	27.3	12.4	15.6	0.4	0.4
	coef. var. (%)	13.9	14.9	24.5	16.2	11.4
Cyclopyxis acmodonta		diameter (D)	height (H)	aperture (ap)	D/H	D/ap
	median	260	195	118	1.4	2.2
	minimum	188	150	75	1.2	1.9
	maximum	298	217	143	1.5	2.5
	mean	249.9	185.7	116.1	1.3	2.2
	SD	32.7	21.1	17.7	0.1	0.2
	coef. var. (%)	13.9	14.9	24.5	16.2	11.4

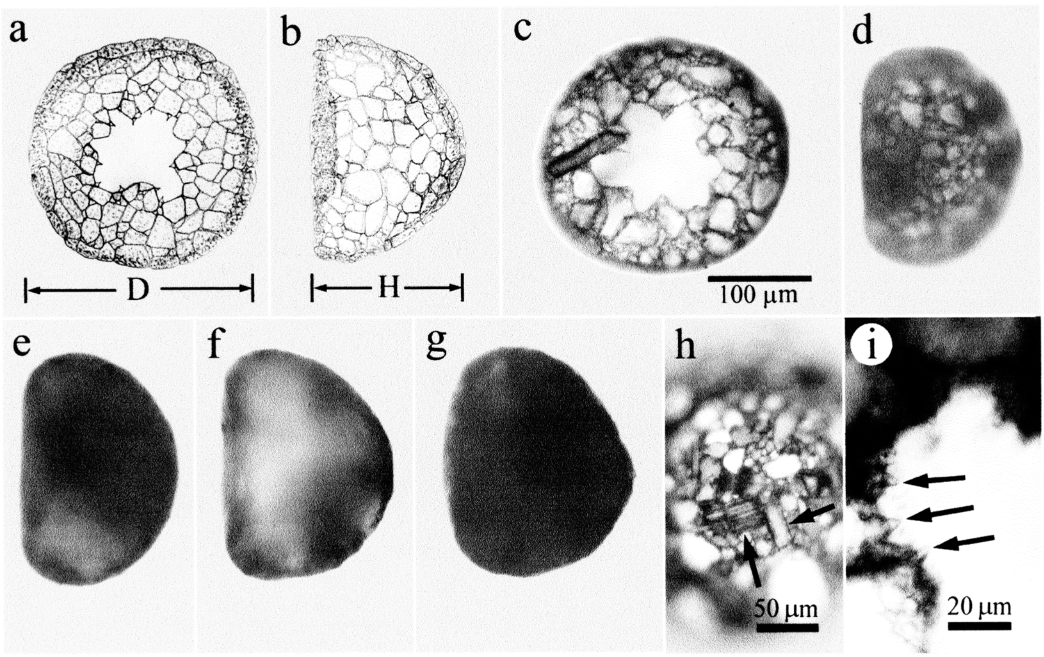

FIGURE 2. *Cyclopyxis acmodonta* tests. **a.** Drawing of the ventral view showing the irregularly lobed and centrally located pseudostomal aperture (D = test diameter). **b.** Drawing of the lateral view; the flat side is the ventral surface (H = test height). **c.** Image of the type specimen archived with the Canadian Museum of Nature (Catalogue Number CMNI 2005-0004). The scale bar in Figure 2c applies to Figures a-g. **d.** Lateral view showing agglutinated quartz granules on the test surface. **e-g.** Three different specimens in lateral view showing variation in profile shape. **h.** Details of test surface showing incorporated diatom frustules (arrows). **i.** interior margin of one lobe of a pseudostomal aperture showing three tooth- like granules (arrows).

In lateral view, the shape of the test of *Cyclopyxis acmodonta* was quite distinctive, although there was some variation in the shape of the domed dorsal surface, ranging from those with a smooth rounded form to those with a slightly more conical shape (Figures 2b,d-g). Certainly, the term hemispherical, which has been applied to several other species of *Cyclopyxis*, cannot be applied here because of *C. acmodonta*'s more exclusive shape. In a hemisphere, the diameter-to-height ratio is 2; in *C. acmodonta*, the test diameter-to-height ratio ranged from 1.2 to 1.5 with a median of 1.4 (Table 1).

The most distinctive feature of this species is the pseudostome with its highly variable and irregularly lobed margin (Figures 2a,c, 3a-i). Higher magnification revealed the many tiny sharp-pointed angular quartz grains attached to the inner margin of the pseudostome rim (Figure 2i), but these were also apparent in some specimens at lower magnification (e.g. Figures 3e,h). The number of apertural lobes ranged from three to seven (nine, if smaller subdivisions of lobes were included). The pseudostome was only slightly invaginated (<1/5 test height) relative to the surrounding ventral surface of the test.

In some specimens there was appeared to be a thin membrane-like cover over the aperture in which were embedded a few thin quartz particles and diatoms (Figure 3g). This structure may be an early component of cyst formation, whereby the aperture becomes more densely plugged at later stages of encystment. Many specimens were observed with the apertural rim only faintly visible owing to the large accumulation of test-like material over the pseudostome. Presumably, these represented a later stage of encystment. In these specimens too, the internal protoplast was dense and darkly coloured.

All tests examined were completely covered in highly refractive microscopic quartzite particles. There did not appear to be any distributional patterns in the sizes of these particles, suggesting that during test construction, the organism does not discriminate among particle sizes for specific regions of the test. Larger particles appeared to be randomly dispersed and interspersed with smaller particles over the whole of the test. Rarely were particles larger than 50 µm diameter found in tests of this species. Intact and broken diatom frustules were sometimes encountered (Figure 2h), again, with no apparent preference for either dorsal, lateral or ventral surfaces of the test.

Arcella formosa **Nicholls, Meisterfeld & Török n. sp.**[1]

Phylum Rhizopoda; Class Lobosea; Order Arcellinida; Family Arcellidae Ehrenberg, 1830 emend. Deflandre, 1953.

Diagnosis: Test nearly colourless to dark rusty-brown in colour, constructed of circular-to-elliptical areoles, 3.0-4.5 × 2.5-3.5 µm. In ventral and dorsal views the test is generally circular in outline but with a wavy or "lumpy" margin 165-235 µm in diameter. The pseudostomal aperture consists of a thickened rim, 46-85 µm in diameter. The pseudostome is invaginated relative to the surrounding ventral surface of the test by a distance of about ¼ the test height. The internal rim of the pseudostome is recurved forming a short (3-4 µm) buccal tube. In lateral view, the test consists of a low, dome-shaped structure with multiple depressions that impart a wavy-edged appearance to the margin of the test. Test height is 56-100 µm.

Etymology: The specific epithet ("*formosa*") refers to the attractive smooth curves created by the depressions in the dorsal surface of the test [formosa (Latin, fem. adj.) = beautiful].

Type specimen: The type specimen was mounted in Canada Balsam on a glass slide and was deposited with the Invertebrate Zoology Division, Canadian Museum of Nature, Catalogue Number CMNI 2005-0003.

Holotype material: A formalin-preserved aqueous sample has been retained by the author under sample Number V-1924, collected 7 August 2004.

Type locality: South end of Cranberry Marsh, Town of Whitby, Ontario, Canada (43°50'38"N, 78°57'30"W).

The large size (median test diameter of 192 µm; Table 1) and the "lumpy" appearance of the test margins, in both ventral and lateral views (Figures 4a, b), are distinctive features of this species. There was considerable variation in the colour and degree of development of the depressions on the dorsal surface of this species. In the lighter coloured specimens (pale yellowish-grey), the dorsal depressions were less well developed (Figures 4c-f) than in the darker (brownish orange) coloured specimens, where the depressions and the thickened rims delineating their boundaries were very well defined (Figures 4g-l). The pseudostomal aperture was invaginated about ¼ of the test height and its structure included a well-developed buccal tube (Figures 4b, f). Of all measurements made on tests of

[1]After submission of this paper by K. Nicholls to *The Canadian Field-Naturalist* in February, 2005, one of the referees selected by the editor to review it (R. Meisterfeld) informed Nicholls that *A. formosa* had been previously found by him in Germany and by J. Török in Hungary. Although neither discovery had been submitted for publication, a poster presentation by Török had been made in Italy at the 4th European Congress of Protistology under the unofficial name, "*Arcella siemensmai*". The inclusion of Meisterfeld and Török as co-authorities of *A. formosa* in this paper was agreed by all as an acceptable way to acknowledge the original and preemptory submission by Nicholls as well as the independent discoveries of this taxon by Meisterfeld and Török. As a consequence, the names "*A. siemensmai*" and "*A. robusta*" previously used by Török & Meisterfeld and F. Siemensma, respectively, to describe this taxon are rendered invalid.

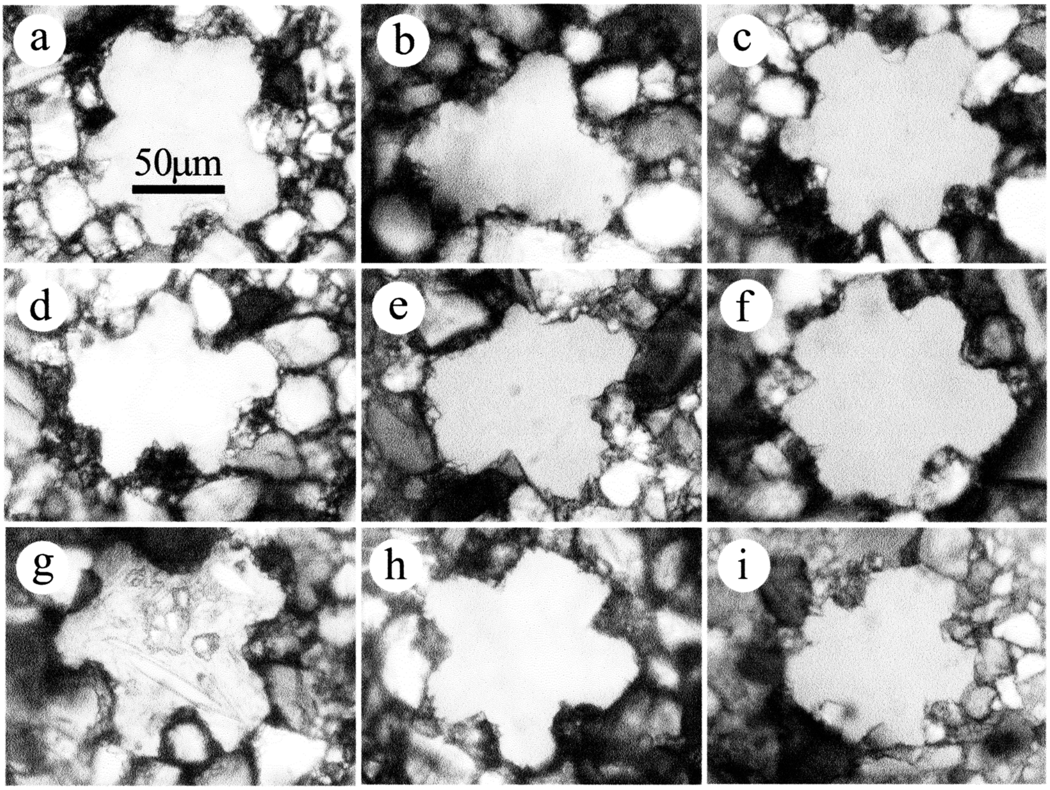

FIGURE 3. Pseudostomal apertures in nine different specimens of *Cyclopyxis acmodonta* illustrating the wide range in shape. The scale bar in Figure 3a applies to all Figures 3a-i.

this species, the greatest variation was found in the aperture diameter (coefficient of variation = 24.5%; Table 1).

The test of *A. formosa* appears to be of two major structural components: an underlying meshwork of irregularly sized and shaped meshes (Figure 5a), and an overlying sheet of elliptical-to-circular disc-like areoles averaging about 3×4 μm. Small, but well-defined pores are located at the junctions of adjacent areoles so that each areole is surrounded by usually 4-5 pores (Figure 5b). This two-layered structure was revealed in the broken test of a specimen that apparently had a large piece of the outer areolar layer stripped off (Figure 5a; but note the small patch containing the surface areolar layer in the lower right of Figure 5a).

Discussion

The genus *Cyclopyxis* contains a few large species with lobed pseudostomal apertures; consequently, the test structure of each had to be reviewed before any conclusions about the autonomy of *C. acmodonta* was established. *Cyclopyxis impressa* (Daday) Deflandre (= *Difflugia lobostoma* var. *impressa* Daday = *Centropyxis impressa* (Daday) Da Cunha) is apparently restricted to a few locations in the Southern Hemisphere (Velho et al. 1996). All reports show a much larger test (300-561 μm in diameter) than that found for *C. acmodonta*; other differences include a very regularly shaped and symmetrical pseudostomal aperture with 5-8 lobes, a much greater diameter-to-height ratio, and a much greater degree of invagination of the pseudostome (to about 50% of the test height). *Cyclopyxis trilobata* var. *maxima* Chardez, 1971, test size (D = 225-235; H = 110-140 μm) is close to *C. acmodonta*. Although Chardez (1971) did not illustrate his new taxon (to which I attribute subspecies status implied by his term "var."), he stated that *C. triblobata* var. *maxima* differed from *C. trilobata* Bartos,1963 only in its much greater size. Like its nominotypical subspecies, *Cyclopyxis trilobata* var. *maxima* has a small, well-defined, three-lobed pseudostome which clearly distinguishes it from *C. acmodonta*.

Bartos (1963) described *Cyclopyxis crucistoma* which is significantly smaller than *C. acmodonta* with a test diameter of 122-124 μm and a height of 50 μm. It also has a well-defined pseudostome in the shape of a cross. *Cyclopyxis grospietschi* (Schönborn 1962) also has a pseudostome in the shape of a cross, but its test diameter and height are only 125 and 80 µm, respectively (significantly smaller than *C. acmodonta*). Decloitre (1954) described *Cyclopyxis lobostoma* with a 7-lobed pseudostome and a test diameter and height of 430 and 280 µm, respectively according to Bartos (1963), or 400 and 300 µm, according to Decloitre (1977). In ventral view, this species resembles *C. impressa*, but its pseudostome is apparently not invaginated. This fact is grounds for questioning its placement in the genus *Cyclopyxis*, so it needs to be rediscovered and evaluated relative to other genera in the Trigonopyxidae (possibly a *Geopyxella* species?).

As regards overall test shape and degree of invagination of the pseudostome, *C. acmodonta*'s closest "relative" would appear to be *C. stellata* (Wailes 1927) Defl. 1929. Important differences between the two species

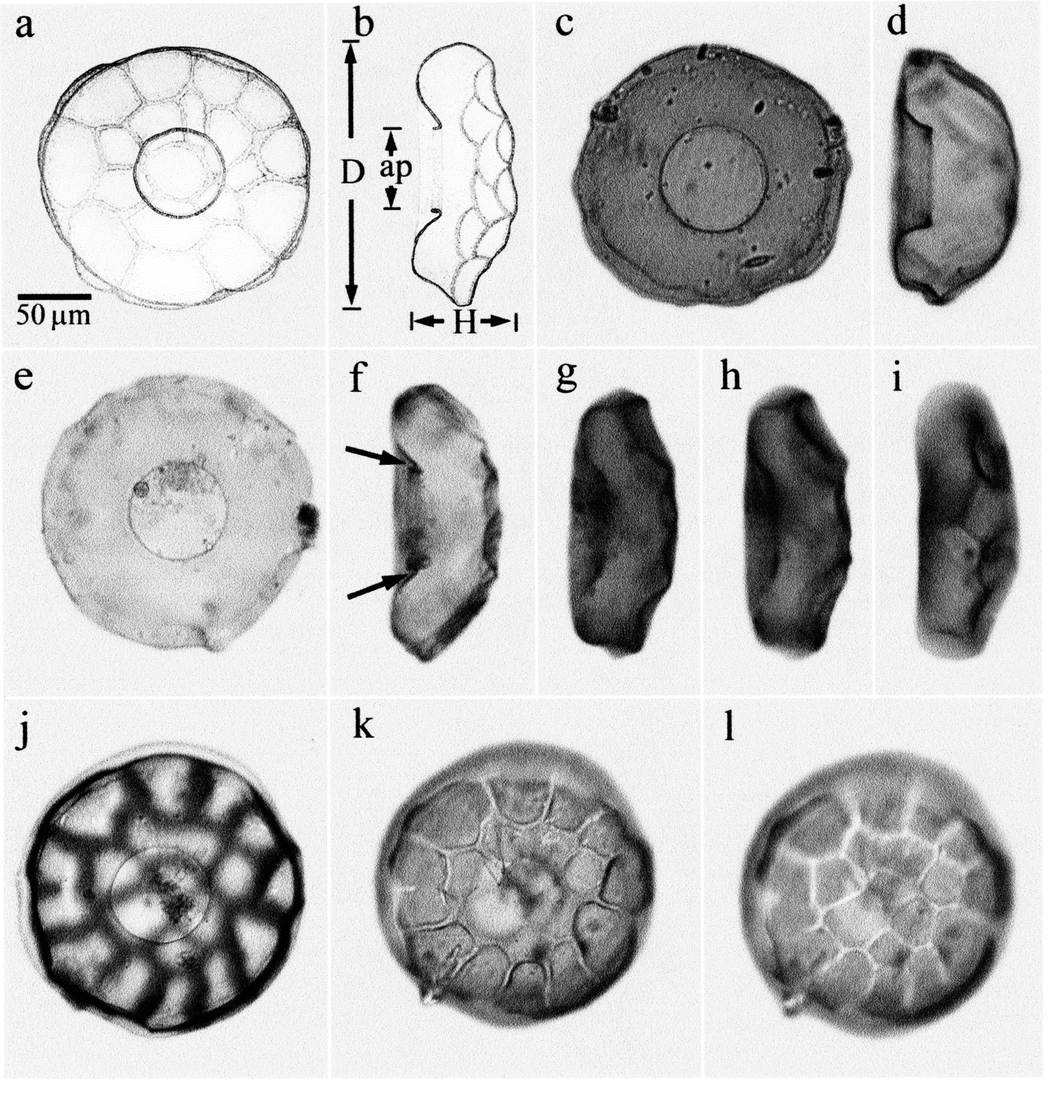

FIGURE 4. *Arcella formosa* tests. **a.** Drawing of the ventral surface (translucency of the test allows the ridges separating the depressions on the dorsal surface to be revealed; see also Figure 4j; scale bar applies to all Figures 4a-l). **b.** Drawing of the lateral view; the pseudostomal aperture (ap) is on the ventral surface; D = test diameter; H = test height. **c.** Image of the ventral view of a test. **d.** Image of the lateral view of the same specimen illustrated in Figure 4c. **e.** Image of the ventral view of a different specimen. **f.** Image of the lateral view of the same specimen illustrated in Figure 4e; arrows indicate the location of the buccal tube. **g-i.** Images of the lateral view of a different specimen at three different levels of microscopic focus. **j-l.** Images of the ventral side (j), sub-dorsal (k), and dorsal (l) surfaces of the same specimen illustrated in Figures 4 g-i.

are as follows: (1) *C. stellata* has a pseudostomal aperture with 3-5 well-defined lobes while *C. acmodonta*'s aperture is irregularly shaped. (2) The distinctive sharp-pointed granules ornamenting the internal margin of the pseudostome in *C. acmodonta* are apparently not present in *C. stellata*. (3) With test diameters and heights of 335-400 and 252-290 µm, respectively, *C. stellata* is significantly larger than *C. acmodonta*; the smallest *C. stellata* tests are larger than the biggest *C. acmodonta* tests. (4) Wailes (1927) described the test of *C. stellata* as being "composed of irregularly shaped siliceous plates, without protuberances". In *C. acmodonta*, although there were some flat plate-like particles seen, the test elements are more aptly described as "irregularly shaped polygonal particles".

In a review of the variability and taxonomy of several smaller species of *Cyclopyxis*, Foissner and Korganova (1995) found a wide range of sizes among some species. They concluded that size criteria may be of limited value in distinguishing among certain species unless the differences are very distinct, and/or the size difference is accompanied by at least one other reliable morphologic character. It is not known how such criteria might apply to the larger *Cyclopyxis* species with lobed pseudostomal apertures, because measurements of large numbers of specimens and the appropriate follow-up statistical analyses have not been published for most. With the literature data available, however, *C. acmodonta*'s test size and other morphometric features (pseudostome shape and degree of invagination) clearly set this species apart from other similar *Cyclopyxis* species.

Unfortunately the nomenclature of the three *Centropyxis* species (*C. stellata* Wailes, *C. arcelloides* Pénard and *C. impressa* (Daday) Da Cunha) transferred to *Cyclopyxis* by Deflandre (1929) is somewhat confused. Undoubtedly this confusion stems from Deflandre's own treatment of *Cyclopyxis* in later years. Since the erection of *Cyclopyxis* in 1929, virtually all students of the Arcellinida have considered *Cyclopyxis* a separate and well defined genus (Decloitre (1977). Deflandre's post-1929 treatment of *Cyclopyxis*, however, remains ambiguous. Deflandre (1953) acknowledged that other authors had treated *Cyclopyxis* and *Centropyxis* as separate and distinct genera, but by this date (1953) Deflandre himself apparently still had not accepted this. He did not list *Cyclopyxis* anywhere in his classification of the Testacealobosa, except noting its existence in a footnote to the genus *Centropyxis*, within which he continued to submerge it. Several years later, in his comprehensive summary and key of freshwater testate rhizopods, Deflandre (1959) did not list any *Cyclopyxis* species but named two *Cyclopyxis* species under *Centropyxis* (*Centropyxis stellata* Wailes and *Centropyxis arcelloides* Penard).

Other sources of confusion include (1) Harnisch (1958), who considered *Cyclopyxis* a subgenus of *Centropyxis*, and, like Deflandre (1959) listed "*Centropyxis stellata* Wailes", and (2) Chardez (1967) who listed "*Cyclopyxis stellata* Wailes" despite the fact that Wailes had described it as a *Centropyxis* species and that it had not previously been formally assigned to *Cyclopyxis* as a new combination. Chardez (1967) listed *Centropyxis* and *Cyclopyxis* as distinct genera in the family Centropyxidae, but listed 12 other genera, 11 of which had not been included in Deflandre's (1953) original concept of the family. Chardez (1967, and later papers) did not formally revise the description of the Centropyxidae to include the broadened range of form implied by inclusion of the 11 additional genera.

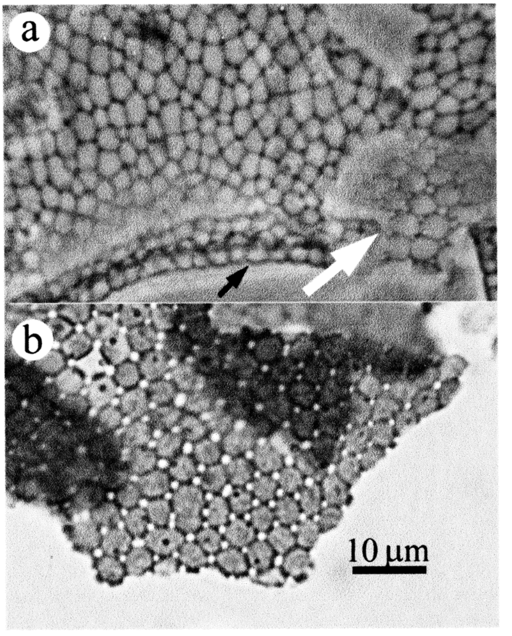

FIGURE 5. Microscopic structure of the test wall of *Arcella formosa*. **a**. Underlying meshwork of test wall showing variation in shape and size of meshes. Small black arrow points to the interior rim of the pseudostomal aperture with its palisade layer of meshes. Larger white arrow points to a small patch of overlying subcircular areoles. **b.** Piece of broken test wall showing the arrangement of circular to elliptical areoles with interspersed pores. Scale bar applies to both Figures 5a and b.

Although Jung (1942) first introduced the family name Centropyxidae, with the result that Jung (1942) is sometimes listed as the authority for this family (e.g., Bovee 1985; Meisterfeld 2002), the correct authority is Deflandre (1953) who first provided a formal circumscription and included four genera. More recently, however, the family Centropyxidae has implicitly become better defined with the recognition that several genera originally on Chardez's (1967) list of Centropyxidae could be more naturally accommodated within the family Trigonopyxidae Loeblich and Tappan, 1964.

In the future, in order to correct some of the problems outlined above, students of the taxonomy of these arcellinid families should list the authority for the Centropyxidae as follows: "Centropyxidae Deflandre, 1953 sensu Meisterfeld 2002", in order to reflect its contemporary generic composition. As well, species transferred from *Centropyxis* to *Cyclopyxis* by Deflandre (1929) should be rendered in accordance with Article 51 of the Interntional Code of Zoological Nomenclature (ICZN) as a combination attributed to Deflandre; e.g., *Cyclopyxis arcelloides* (Penard) Deflandre, as listed in Jung (1942) and Laminger (1972), for example, and not as *Cyclopyxis arcelloides* Penard, as listed in Chardez (1967), Bonnet (1977), and Coûteaux and Chardez (1981). Species of *Cyclopyxis* described after Deflandre (1929) should not pose any nomenclatural or authorship difficulties because no new combinations are required (e.g., *Cyclopyxis crucistoma* Bartos, 1963).

There are virtually no *Arcella* species that can be confused with *A. formosa*. Firstly, its large size is highly unusual among representatives of the genus. Only *A. artocrea* Leidy emend. Deflandre, *A. rota* Daday, *A. megastoma* Penard, *A. leidyana* Deflandre and *A arenaria* var. *grandis* Bunescu & Matis are of comparable size. All of the above-listed species have markedly different test shapes including much greater or lesser test diameter-to-height ratios, much smaller pseudostomal apertures of different structure (e.g., greater degree of invagination on the ventral surface, presence of large pores surrounding the aperture rim).

Many *Arcella* species have dorsal surfaces ornamented with shallow depressions separated in some cases by thickened ridges on the test wall. Some of these include *A. crenata* Playfair, *A. bathystoma* Deflandre, *A. artocrea* Leidy ssp. *pseudocatinus* Deflandre and *A. gibbosa* Penard, among several others. Again, these all have major size and structural differences that clearly set them apart from *A. formosa*. The degree of form variation in *A. formosa* was objectively quantified in 14 randomly encountered specimens and subjectively evaluated in several more specimens so that there can be little doubt that its morphology is distinct and separate from any previously described species.

Species that are very small in size likely have a great potential to be overlooked in investigations of testate rhizopods. When new species of small-sized taxa are discovered, conclusions about geographic distribution may not generally be possible because of the potential for such species to exist in many habitats over large geographic areas, but to have escaped previous detection because of their small size. Because of their large sizes, both *A formosa* and *C. acmodonta*, on the other hand, were readily detected in the Ontario samples. Recognizing that many species of *Arcella* and *Cyclopyxis* (earlier as *Centropyxis*) were known to science nearly a century ago, if *A. formosa* and *C. acmodonta* were widespread in other habitats in other parts of the world, they should have been detected by others long ago (notwithstanding the recent discoveries of *C. acmodonta* in Hungary and Germany: (R. Meisterfeld, personal communication). The logical conclusion is that Cranberry Marsh and the Beaver River coniferous forest bogs afford these species certain environmental tolerances or requirements not widely available elsewhere. This lends support to the widely held view among local naturalists and biologists familiar with the botanical and avian attributes of these habitats that these are areas of unique biological status deserving of special protection and further scientific investigation.

Documents Cited (marked * in text)

CoHort Software. 1995. *CoStat*. Minneapolis, Minnesota U.S.A.

Scott, L. D., J. G. Winter, M. N. Futter, and **R. E. Girard.** 2001. Annual water balances and phosphorus loading for Lake Simcoe (1990-1998). LSEMS Implementation Phase II, Technical Report Number Imp. A.4. Lake Simcoe Region Conservation Authority, Newmarket, Ontario. 62 pages.

Literature Cited

Balík, V. 1995. Testate amoebae (Protozoa: Rhizopoda) from a primary mountain rain forest in the Tam-Dao region (Vietnam). Acta Societatis Zoologica Bohemoslov 59: 1-16.

Bartos, E. 1963. Rhizopoden einiger moosproben aus Java. Acta Universitatis Carolinae- Biologica 1963: 119-190.

Bonnet, L. 1977. Le peuplement thécamoebien des sols du Népal et son intérêt biogéographique. Bulletin de la Société d'Histoire Naturelle de Toulouse 113: 331-348.

Bovee, E. C. 1985. Class Lobosea Carpenter, 1861. Pages 158-211 *in:* An Illustrated Guide to the Protozoa. *Edited by* J. J. Lee, S. H. Hunter, and E. C. Bovee. Society of Protozoologists, Lawrence, Kansas.

Chardez, D. 1971. *Cyclopyxis trilobata* v. *maxima* var. nov. Revue Verviétoise d'Histoire Naturelle 27(1-3): 6.

Chardez, D. 1967. Histoire Naturelle des Protozoaires Thécamoebiens. Les Naturalistes Belges. Bruxelles. 100 pages.

Chardez, D., L. Beyens, and **P. De Bock.** 1987. *Arcella ovaliformis* sp. nov., a new testate amoeba from Edgeøya, a high Arctic island. Archiv fur Protistenkunde 134: 297-301.

Coûteaux, M-M., and **D. Chardez.** 1981. Thécamoebiens édaphiques et muscicoles de Guyane Française. Revue d'Écologie et Biologie du Sol 18: 193-208.

Decloitre, L. 1954. Mission A. Villiers au Togo et au Dahomey (1950), XXIII Rhizopodes. Bulletin de l'Institut Français d'Afrique Noire 16(1) séries A: 89-125.

Decloitre, L. 1976. Le genre *Arcella*. Compléments à jour au 31 décembre 1974 de la monographie du genre parvue en 1928. Archiv fur Protistenkunde 118: 291-309.

Decloitre, L. 1977. Le genre *Cyclopyxis*. Compléments à jour au 31 décembre 1974 de la monographie du genre parue en 1929. Archiv fur Protistenkunde 119: 31-53.

Decloitre, L. 1979. Mises à jour au 31.12.1978 des mises à jour au 31.12.1974 concernant les genres *Arcella*, *Centropyxis*, *Cyclopyxis*, *Euglypha* et *Nebela*: Archiv fur Protistenkunde 122: 387-397.

Decloitre, L. 1982. Compléments aux publications précédentes Mise à jour au 31.XII.1981 des genres *Arcella*, *Centropyxis*, *Cyclopyxis*, *Euglypha*, *Nebela* et *Trinema*. Archiv fur Protistenkunde 126: 393-407.

Decloitre, L. 1986. Compléments aux publications précédentes Mise à jour au 31.XII.1984 des genres *Arcella*, *Centropyxis*, *Cyclopyxis*, *Euglypha* et *Nebela*. Archiv fur Protistenkunde 132: 131-136.

Deflandre, G. 1928. Le genre *Arcella* Ehrenberg. Morphologie-Biologie. Essai phylogénétique et systématiqe. Archiv fur Protistenkunde 64: 152-287.

Deflandre, G. 1929. Le genre *Centropyxis* Stein. Archiv fur Protistenkunde 67: 322-375.
Deflandre, G. 1953. Ordres des Testacealobosa (De Saedeleer, 1934), Testaceafilosa (De Saedeleer, 1934), Thalamia (Haeckel, 1862) ou Thécamoebiens (Auct.) (Rhizopoda Testacea). Pages 97-149 *in* Traité de Zoologie – Anatomie, Systématique, Biologie. Tome I, Fasc. II. *Edited by* P. P. Grassé. Masson et C[ie], Paris.
Deflandre, G. 1959. Rhizopoda and Actinopoda. Pages 232-264 *in* Freshwater Biology, 2[nd] Edition. *Edited by* W. T. Edmondson. John Wiley & Sons, Inc. New York.
Foissner, W., and **G. A. Korganova.** 1995. Redescription of three testate amoebae (Protozoa, Rhizopoda) from a Caucasian soil: *Centropyxis plagiostoma* Bonnet & Thomas, *Cyclopyxis kahli* (Deflandre) and *C. intermedia* Kufferath. Archiv fur Protistenkunde. 146: 13-28.
Harnisch, O. 1958. II. Klasse: Wurzelfüßler, Rhizopoda. Pages 1-75 + 26 plates *in* Die Tierwelt Mitteleuropas, Band 1. *Edited by* P. Brohmer, P. Ehrmann, and G. Ulmer. Quelle and Meyer, Leipzig.
Jung, W. 1942. Südchilenische Thekamöben (Aus dem südchilenische Küstengebiet, Beitrag 10). Archiv fur Protistenkunde 95: 253-356.
Laminger, H. 1972. Die profundale Testaceenfauna (Protozoa, Rhizopoda) älterer und jüngerer Bodensee-Sedimente. Archiv fur Hydrobiologie 70: 108-129.
Meisterfeld, R. 2002. Order Arcellinida Kent, 1880. Pages 827-860 *in* An Illustrated Guide to the Protozoa. Second Edition. Volume II. *Edited by* J. J. Lee, G. F. Leedale, and P. Bradbury. Society of Protozoologists, Lawrence, Kansas.
Schönborn, W. 1962. Neue Testaceen aus dem Großen Stechlinsee und dessen Umgebung. Limnologica (Berlin) 1: 83-91.
Torres, V. S., and **D. H. A. Jebram.** 1993. *Arcella gibbosa microsoma* var. n. (Protozoa: Sarcodina, Arcellinida): descrição e observações feitas em seu cultivo. Biotemas 7: 65-78.
Velho, L. F. M., F. A. Lansac-Toha, and **M. Serafim, Jr.** 1996. Testate amoebae (Rhizopodea-Sarcodina) from zooplankton of the high Parana River floodplain, state of Mato Grosso do Sul, Brazil: 1. Families Arcellidae and Centropyxidae. Studies on Neotropical Fauna and Environment 31: 35-50.
Wailes, G. H. 1927. Rhizopoda and Heliozoa from British Columbia. Annals and Magazine of Natural History 20: 153-156.

Received 11 February 2005
Accepted 15 August 2005