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Additional contribution to the study of the freshwater fauna of testate amoebae in southeast Azerbaijan

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Abstract: Investigations of the inland water bodies of southeast Azerbaijan (mainly near the city of Lenkoran and its suburbs) yielded 11 additional species of freshwater testate amoebae. Among these, 7 species (*Oopyxis lenkoranica* sp.n., *Pentagonia azerbaijanica* sp.n., *Diffugia lenkoranica* sp.n., *D.talyshica* sp.n., *D.sapnakeranica* sp.n., *D.pressula* sp.n., and *D.girkanica* sp.n.) are new to science. Descriptions of all 11 species are given.

Key words: Freshwater testate amoebae, fauna, Azerbaijan

Introduction

The fauna of testate amoebae of Azerbaijan has been poorly studied. Prior to our investigations aquatic testate amoebae of southeast Azerbaijan were investigated by Alizade (1934) and Veisig (1940). We recently published a list of testate amoebae found in southeast Azerbaijan, including 75 species. Herein we present 11 additional species for the region.

Materials and methods

We studied the fauna of testate amoebae in several inland freshwater bodies of southeast Azerbaijan near the city of Lenkoran (Figure 1) and its suburbs between 2006 and 2008. More than 50 additional samples of plankton, periphyton, and benthos were collected and processed. Testate amoebae specimens were caught in microcapillary tubes and identified. All descriptions and measurements were made based on at least 10 specimens of each species. The testate

amoebae were studied both in vivo and by means of the glycerin-gelatin technique, which is briefly described as follows:

1. Testate amoebae from natural samples were washed in a watch-glass with distilled water.
2. A small drop of concentrated specimens was placed on a slide.
3. An equally sized drop of glycerin-gelatin was added and mixed.
4. Then slides were mounted in synthetic neutral mounting medium along the slide's margins.

An original technique based on the Chatton-Lwoff wet technique (Aleksperov et al., 1994, 1996) was also used, as follows:

1. If possible, testate amoebae from natural samples were concentrated in a watch-glass.
2. Concentrated specimens were washed with distilled water.

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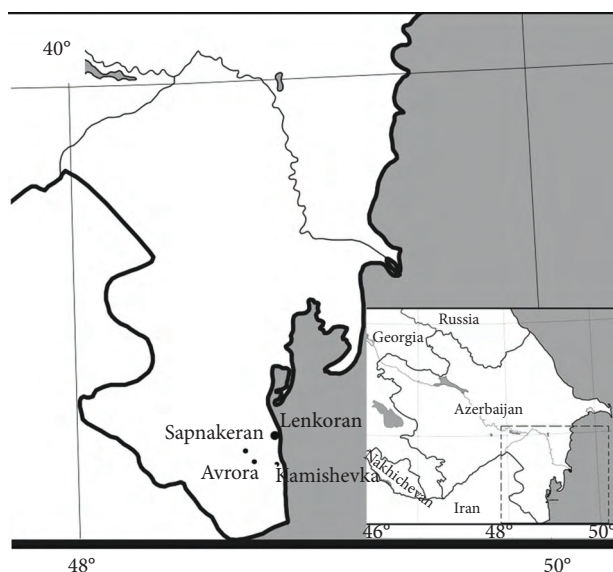


Figure 1. Sampling locations.

3. A small drop of concentrated specimens was placed on a slide.
4. An equally sized drop of molten 5% gelatin (60° C) was added quickly and mixed in.
5. The slide with a thin gelatin layer was immediately transferred into cold and left for up to 5 min, until the gelatin hardened.
6. Then the slide was transferred to cold 3%-5% silver nitrate solution for 25-30 min.
7. The slide was then thoroughly washed with cold distilled water for 1-3 min.
8. The slide was submerged in 1-4 cm of cold distilled water in a white-bottomed dish, and irradiated for 20 min under sunlight or an ultraviolet source, until the gelatin turned golden brown.
9. Each slide was transferred to 70°-96° and 100° alcohol for 5 min.
10. Then the slide was cleaned with xylene for 10 min and mounted in synthetic neutral mounting medium or Canada balsam.

The type material was deposited in the collection of the Protistology Laboratory of the Institute of Zoology of the National Academy of Sciences of Azerbaijan, Baku City. Statistical analysis was performed using the SigmaStat v.2.0 program ($\bar{X}$:

arithmetic mean; M: median; SD: standard deviation; SE: standard error, CV: coefficient of variation (%), Max: maximum; Min: minimum, n: number of specimens).

Results and discussion

Fam. Centropyxidae Jung, 1942

Oopyxis lenkoranica sp.n. (Figures 2-5; Tables 1 and 2)

Diagnosis

Mid-sized shell, oval. Subterminal spherical aperture invaginated. The ratio of the aperture to anterior and aperture to aboral ends is 1:4. The aperture is surrounded by small polygonal sand plates. Morphological and morphometrical characteristics of *O. lenkoranica* sp.n. specimens are given in Figures 2-5, and Tables 1 and 2.

Type specimens

One holotype as a slide L-5.

Type location

Sediments in small forest ponds near the Avrora settlement.

Description

Shell length 100-125 μm , width 70-80 μm (Table 1). The shell is oval, rounded on the anterior and aboral ends. Spherical aperture (20-25 μm) subterminal and located on the 1/3 anterior part. The ratio of the aperture to anterior and aperture to aboral ends is 1:4. The entire shell surface is covered by flat polygonal sand plates. The sand plates surrounding the aperture are smaller than in related species. Endoplasm is light-yellow and granular; 1-3 short lobopodia. There are 3-5 contractile vacuoles.

Comparison with related species

Prior to our investigation the genus *Oopyxis* included 5 species: type species *O. cophostoma* Jung, 1942, *O. cyclostoma* Thomas, 1958, *O. danubialis* Godeanu, 1972, *O. sella* Decloitre, 1970, and *O. islandica* (Decloitre, 1966) (Table 2).

O. lenkoranica sp.n., described above, is morphologically similar to *O. cyclostoma* Thomas, 1958 and *O. sella* Decloitre, 1970. Unfortunately, there are no biometric characteristics for *O. cyclostoma* in the original description, but the difference in shape

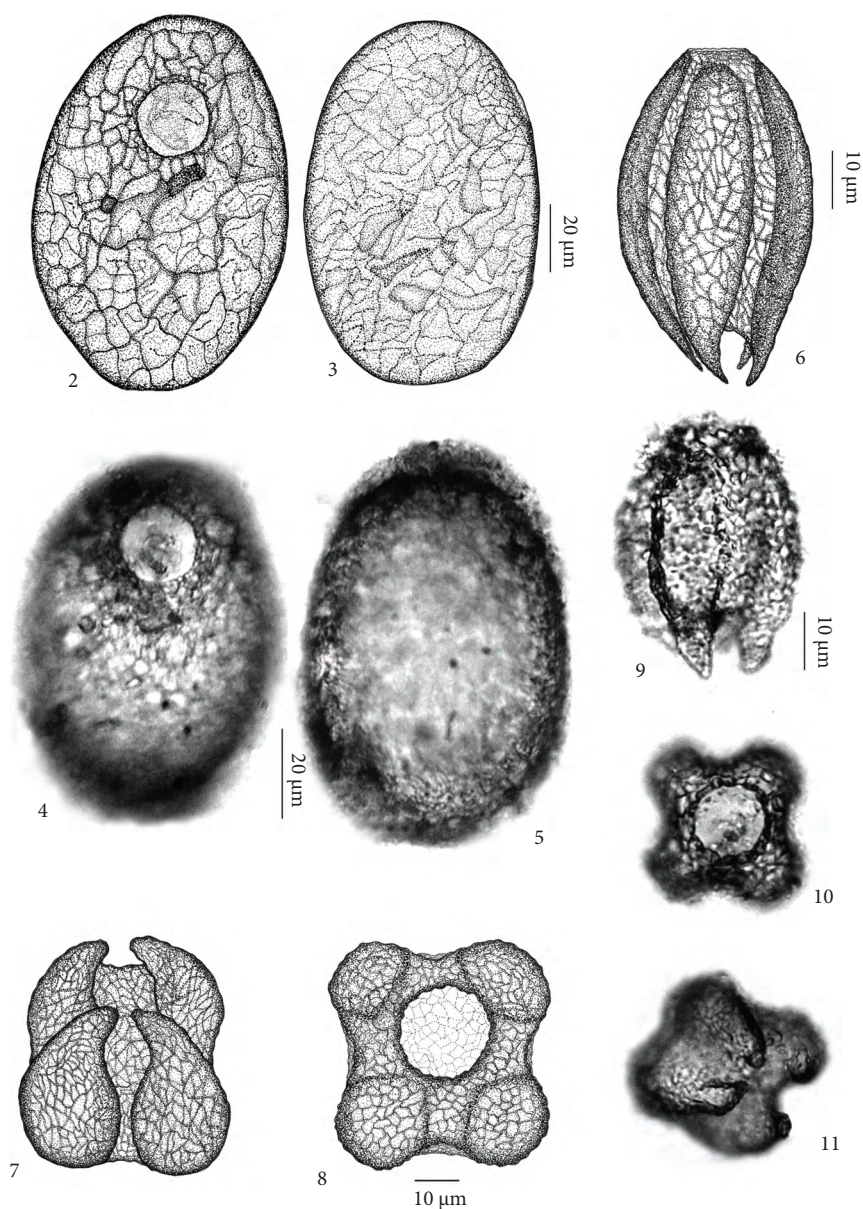


Figure 2. 2: *Oopyxis lenkoranica* sp.n., apertural view; 3: *O. lenkoranica* sp.n., lateral view; 4: *O. lenkoranica* sp.n., apertural view; 5: *O. lenkoranica* sp.n., lateral view; 6: *Pentagonia azerbaijanica* sp.n., general view; 7: *P. azerbaijanica* sp.n., aboral view; 8: *P. azerbaijanica* sp.n., apertural view; 9: *P. azerbaijanica* sp.n., general view; 10: *P. azerbaijanica* sp.n., apertural view; 11: *P. azerbaijanica* sp.n., aboral view.

(*O. cyclostoma* has a drop-like shape with a narrower anterior end, whereas *O. lenkoranica* has an oval shell rounded both on the anterior and aboral ends), larger size of our specimens (100-125 µm versus 80-82 µm), and the difference in the location of the aperture, which is lower than in *O. lenkoranica*, are sufficient characters for taxonomical separation. *O. lenkoranica*

clearly differs from *O. sella* by the lower location and arrangement of the aperture and shell shape—our specimens have an oval shell, but *O. sella* has characteristic dorsoventral flattening. *O. lenkoranica* sp.n. is also easily distinguished from the other species of the genus *Oopyxis* by shell shape, size, and arrangement of the aperture (Table 2).

Table 1. Biometric characteristics of *Oopyxis lenkoranica* sp.n.

Character	$\bar{X}$	M	SD	SE	CV	Min	Max	n
Length of shell	115.0	117.500	9.718	3.073	0.085	100.0	125.0	10
Breadth of shell	75.0	75.0	4.714	1.491	0.063	70.0	80.0	10
Diameter of aperture	23.100	24.0	2.283	0.722	0.099	20.0	25.0	10

Table 2. Comparison of *Oopyxis lenkoranica* sp.n. and related species.

Species	Shell length (µm)	Shell width (µm)	Size and shape of aperture	Shape of shell and its composition	Data source
<i>O. cophostoma</i> Jung, 1942	61-91	35-74	11-12 µm, small subterminal, irregular, invaginated.	Ovoid, spherical in transverse section; composed of flat quartz particles.	Jung, 1942; Mazei, Tsyganov, 2006; Godeanu, 1971
<i>O. cyclostoma</i> Thomas, 1958	50-80	40-50	20-25 µm, subterminal, spherical.	Elongated, spherical in transverse section; composed of polygonal plates.	Thomas, 1958
<i>O. danubialis</i> Godeanu, 1972	170-185	75-82	22-26 µm, spherical or oval, subterminal, invaginated.	Drop-like with narrow anterior end, spherical in transverse section; composed of mineral plates varying in size.	Godeanu, 1972
<i>O. islandica</i> (Decloitre, 1966)	68-70	40	16 µm, oval, subterminal	Drop-like, with narrow anterior end, spherical in transverse section; composed of diatoms frustules.	Decloitre, 1966
<i>O. sella</i> Decloitre, 1970	110	75	? oval subterminal.	Oval, rounded on anterior and aboral ends, spherical in transverse section; composed of differently shaped plates.	Decloitre, 1970
<i>O. lenkoranica</i> sp.n.	100-125	70-80	20-25 µm, spherical, subterminal, located on the ¼ of the anterior part.	Oval rounded on anterior and aboral ends; composed of polygonal flat sand plates.	Original

Etymology

The species name refers to the region in which the species was found.

Fam. Diffugiidae Wallich, 1864

***Pentagonia azerbaijanica* sp.n. (Figures 6-11; Tables 3 and 4)**

Diagnosis

The shell is transparent, and elongate, triangular, or quadrangular in transverse section. Apical aperture has no neck. There are 3 or at most 4 rounded

longitudinal ribs that begin below the aperture and terminate like aboral curved horns. Morphological and morphometrical characteristics of our *P. azerbaijanica* sp.n. specimens are given in Figures 6-11, and Tables 3 and 4.

Type specimens

One holotype as a slide L-8 and syntype L-9; 10 has been deposited.

Type location

Sediments in the small forest pond near the Avrova settlement (Lenkoran district).

Table 3. Biometric characteristics of *Pentagonia azerbaijanica* sp.n.

Character	$\bar{X}$	M	SD	SE	CV	Min	Max	n
Shell length	47.6	48.0	2.366	0.748	0.050	45.0	50.0	10
Shell width	39.8	40.0	1.476	0.467	0.037	38.0	42.0	10
Diameter of aperture	19.7	20.0	2.058	0.651	0.104	17.0	22.0	10

Table 4. Biometric characteristics of the *Pentagonia* representatives.

Species	Length (L) (μm)	Width (W) (μm)	Diameter of aperture (DA) (μm)	Length of collar (LC) (μm)	W/L	n (number of specimens measured)
<i>P. maroccana</i> Gauthier-Lièvre et Thomas, 1958	65-95	30-45	12-14	5-8	0.67	–
<i>P. shablensis</i> Todorov and Golemansky, 1998	81-100	52-65	20-28	3-4	0.47	23
<i>P. azerbaijanica</i> sp.n.	45-50	38-42	17-22	–	0.84	10

The measurements for *P. maroccana* are taken from Gauthier-Lièvre and Thomas (1958); measurements for *P. shablensis* are from Todorov and Golemansky (1998).

Description

Shell length is 45-50 μm , width 38-42 μm (Table 3). The width:length ratio is 0.84. The shell is elongate, triangular in transverse section. The neck is absent. There are 3 or at most 4 rounded longitudinal ribs that begin below the apical aperture and terminate like clearly pronounced aboral curved horns. The apical aperture is circular and surrounded by small quartz plates. The shell surface is covered by small to medium flat quartz plates.

Comparison with related species

Prior to our investigation only 2 species of the genus *Pentagonia* were known: the type species *P. maroccana* (Gauthier-Lièvre et Thomas, 1958) and *P. shablensis* from Lake Shabla in northeastern Bulgaria (Todorov and Golemansky, 1998). The specimens of *Pentagonia azerbaijanica* sp.n. clearly differ from *P. maroccana* by smaller shell size and the absence of an aperture neck (Table 4). The width:length ratio of *P. azerbaijanica* (0.84) is larger than that of *P. maroccana* (0.46) and *P. shablensis* (0.67). Furthermore, *P. azerbaijanica* is clearly distinct from *P. maroccana* and *P. shablensis* by the absence of an aperture neck.

Etymology

The species is named after the region in which it was found (Azerbaijan).

Diffflugia lenkoranica sp.n. (Figures 12-15; Table 5)

Diagnosis

Bean-like shape with a characteristic curved anterior part and round aboral ends. Circular apical aperture is surrounded by sand particles that are smaller than those covering the shell surface. Morphological and morphometrical characteristics of our *D. lenkoranica* sp.n. specimens are given in Figures 12-15 and Table 5.

Type specimens

One holotype as a slide L-4 and syntype L-7 has been deposited.

Type location

Aquatic plants in the small Kamishevka River near Kamishevka village (Lenkoran district).

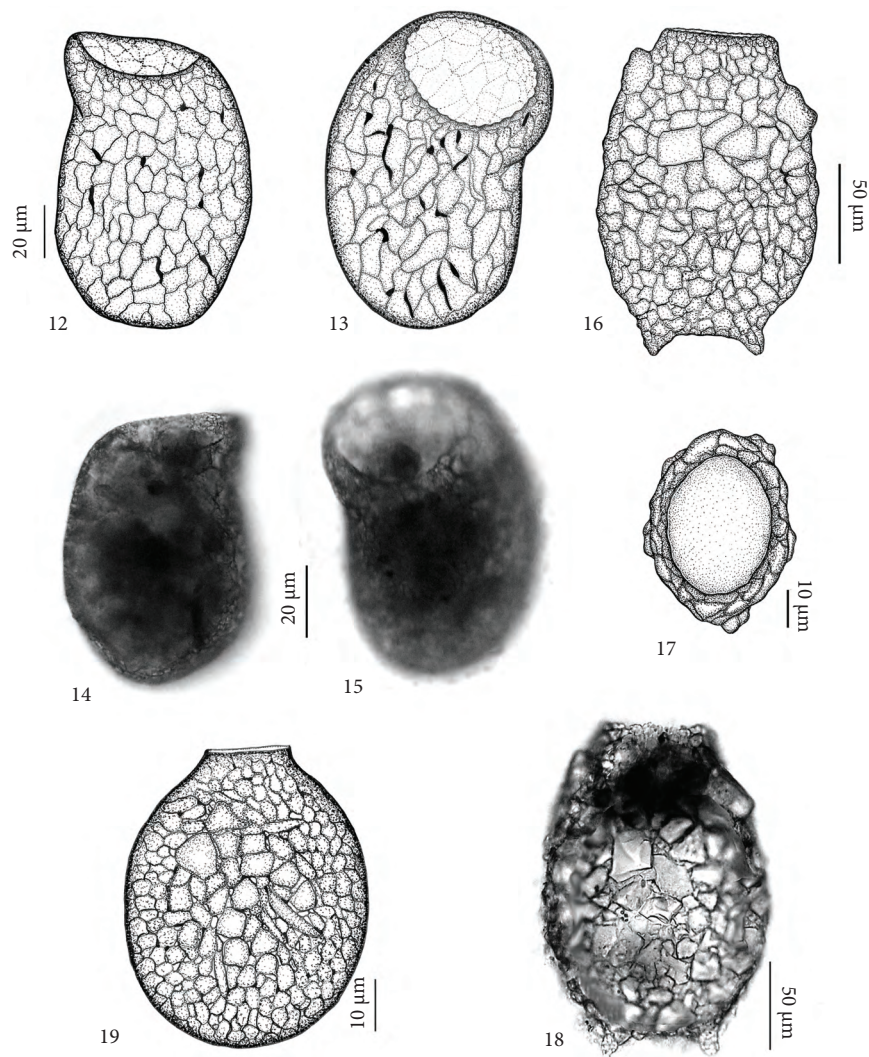


Figure 3. 12: *Diffflugia lenkoranica* sp.n., general view; 13: *D. lenkoranica* sp.n., apertural view; 14: *D. lenkoranica* sp.n., general view; 15: *D. lenkoranica* sp.n., apertural view; 16: *Diffflugia hanaki* Štěpánek, 1967, general view; 17: *D. hanaki* Štěpánek, 1967, apertural view; 18: *D. hanaki* Štěpánek, 1967, general view; 19: *Diffflugia brevicola* Cash and Hopkinson, 1909, general view.

Description

Shell length 100-125 µm, width 70-80 µm (Table 5). The shell is dark brown, bean-like in shape, with a characteristically curved anterior part. The aperture is circular (50-55 µm) and bordered by small sand particles, the inner margin of which is crenulated to form a tooth-like shape. The entire shell surface is covered with sand grains that vary in size. Endoplasm colorless, without inclusions. Two or 3 short lobose pseudopodia. Several (usually 3-4) contractile vacuoles.

Comparison with related species

D. lenkoranica sp.n., described above, distinctly differs from other *Diffflugia* representatives by its shell shape, especially its characteristically curved anterior part. Only *D. ogdeni* Snegovaya and Alekperov, 2005 has a more or less similar shell shape, but it differs from *D. lenkoranica* sp.n. by having a broad, well-pronounced collar.

Etymology

The species name refers to the region in which it was found.

Table 5. Biometric characteristics of *Diffflugia lenkoranica* sp.n.

Character	$\bar{X}$	M	SD	SE	CV	Min	Max	n
Shell length	113.0	115.0	10.328	3.266	0.091	100.0	125.0	10
Shell width	75.0	75.0	4.714	1.491	0.063	70.0	80.0	10
Diameter of aperture	52.5	52.5	2.635	0.833	0.050	50.0	55.0	10

***Diffflugia hanaki* Štěpánek, 1967 (Figures 16-18; Table 6)**

To the best of our knowledge this species has not been observed in other regions since its original description (Štěpánek, 1967). We found *D. hanaki* on the sediments and periphyton of the shallow bays of the Kamishevka River near Kamishevka village (Lenkoran district). Morphological and morphometrical characteristics of our specimens are given in Figures 16-18 and Table 6.

Shell length 155-180 μm , width 100-120 μm . Shell elongate, flattened laterally with 2 spines on the aboral part. The ellipsoidal apical aperture (30-40 $\times$ 40-47 μm) has a small invaginated margin. The entire shell surface is covered with flat polygonal sand plates, which are smaller near the aperture than on the rest of the shell. Endoplasm light gray, 2-5 short lobopodia are rarely observed. There are 1-3 contractile vacuoles.

Our specimens of *Diffflugia hanaki* Štěpánek, 1967 differ from the original description by a smaller shell size (190 μm versus 155-180 μm) and by a 2-fold smaller aperture size (80 $\times$ 50 μm versus 30-40 $\times$ 40-47). This is the first record of this species for the fauna of the Caucasus.

***Diffflugia brevicola* Cash and Hopkinson, 1909 (Figure 19; Table 7)**

Shell length 60-80 μm , width 50-60 μm . Morphological and morphometrical characteristics of

our specimens are given in Figure 19 and Table 7. The shell is drop-like with a narrow anterior end. The circular or oval anterior aperture (17-22 μm) is surrounded by an array of small sand particles that sometimes vary in size. Below the aperture is a short neck. The entire shell surface is covered with polygonal sand plates. Endoplasm colorless, light-brown, without inclusions. There are 1-3 short lobose pseudopodia and 2-6 contractile vacuoles.

Our specimens differ from *D. brevicola* described from Africa (Gauthier-Liévre and Thomas, 1958) by a smaller shell (66-100 μm versus 60-80 μm) and aperture (22-42 μm versus 17-22 μm). This is a common species found in most freshwaters reservoirs of the Lencoran region. It was most dense in the sediments of the shallows of the Lencoranchay River and also on aquatic plants in the small forest pond near the Avrova settlement. Prior to our investigation this species was known in the Caucasus (Arnoldi and Malevitch, 1934), but not in Azerbaijan.

***Diffflugia talyshica* sp.n. (Figures 20-23; Table 8)**

Diagnosis

Small shell, elongated with narrow equatorial area. The apical aperture is surrounded by a shallow undulating lip. The aperture has a 3-4-blade shape. Morphological and morphometrical characteristics of our *D. talyshica* sp.n. specimens are given in Figures 20-23 and Table 8.

Table 6. Biometric characteristics of *Diffflugia hanaki* Štěpánek, 1967.

Character	$\bar{X}$	M	SD	SE	CV	Min	Max	n
Shell length	170.5	170.0	9.560	3.023	0.056	155.0	180.0	10
Shell width	113.0	115.0	8.233	2.603	0.073	100.0	120.0	10
Shell thickness of	92.5	92.5	2.635	0.833	0.028	90.0	95.0	10
Length of aperture	42.9	42.5	3.143	0.994	0.073	40.0	47.0	10
Breadth of aperture	35.0	35.0	4.714	1.491	0.135	30.0	40.0	10
Length of spines	12.6	12.0	2.221	0.702	0.176	10.0	15.0	10

Table 7. Biometric characteristics of *Diffflugia brevicola* Cash and Hopkinson, 1909.

Character	$\bar{X}$	M	SD	SE	CV	Min	Max	n
Shell length	69.5	70.0	8.960	2.833	0.129	60.0	80.0	10
Shell width	54.5	55.0	4.378	1.384	0.080	50.0	60.0	10
Diameter of aperture	19.7	20.0	2.058	0.651	0.104	17.0	22.0	10

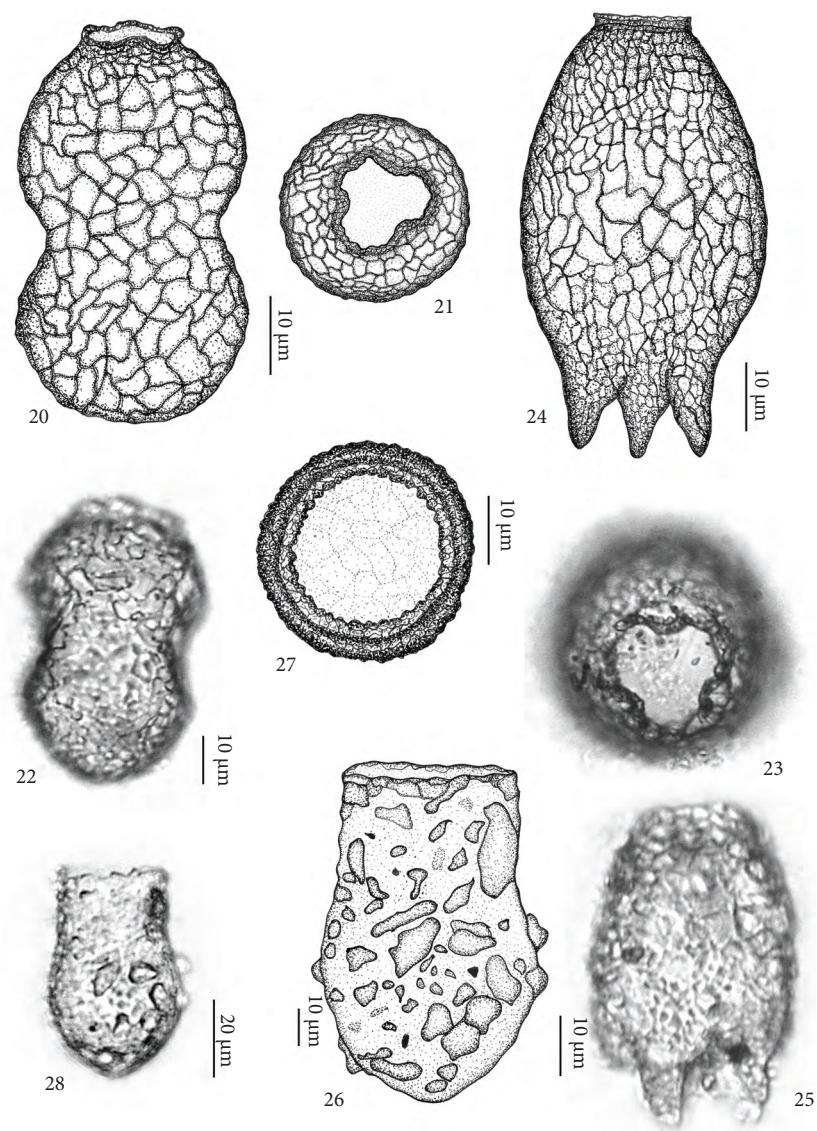


Figure 4. 20: *Diffflugia talyshica* sp.n., general view; 21: *D. talyshica* sp.n., apertural view; 22: *D. talyshica* sp.n., general view; 23: *D. talyshica* sp.n., apertural view; 24: *Diffflugia sapnakeranica* sp.n., general view; 25: *D. sapnakeranica* sp.n., general view; 26: *Diffflugia cratera* Leidy, 1877, general view; 27: *D. cratera*, apertural view; 28: *D. cratera* Leidy, 1877, general view.

Type specimens
One holotype as a slide N L-8, syntype L- 9, and 10 has been deposited.

Type location
Sediments in the small pond of the mountain forest near the Avrora settlement (Lenkoran district).

Table 8. Biometric characteristics of *Diffflugia talyshica* sp.n.

Character	$\bar{X}$	M	SD	SE	CV	Min	Max	n
Shell length	62.6	63.0	2.366	0.748	0.038	60.0	65.0	10
Shell width	45.0	45.0	1.826	0.577	0.041	42.0	47.0	10
Diameter of aperture	22.3	21.5	2.497	0.790	0.112	20.0	25.0	10

Description

Shell length 60-65 μm , width 42-47 μm . The shell is elongated with a narrow equatorial area. The apical aperture (20-25 μm) has a 3-4-blade shape and is surrounded by a shallow undulating lip. The shell is composed of polygonal flat quartz plates. Endoplasm colorless, light-gray without inclusion. There are 1-2 short thick lobopodia and several contractile vacuoles.

Comparison with related species

Described above, *Diffflugia talyshica* sp.n. is morphologically close to *D. biconcava* Ertl, 1964 and *D. baculosa* Schönborn, 1965. Our species clearly differs from *D. biconcava* by having different shell and aperture shapes. Our specimens of *D. talyshica* sp.n.

differ from the second species by having a narrow equatorial spot and smaller size (90-95 μm versus 60-65 μm).

Etymology

The species name refers to the region in which the species was discovered.

***Diffflugia sapnakeranica* sp.n. (Figures 24 and 25; Tables 9 and 10)**

Diagnosis

Shell elongate, with truncated apical end and 3 thick horns on the aboral end. Apical spherical aperture has a small lip. Morphological and morphometrical characteristics of our *D.*

Table 9. Biometric characteristics of *Diffflugia sapnakeranica* sp.n.

Character	$\bar{X}$	M	SD	SE	CV	Min	Max	n
Shell length	65.9	68.5	2.331	0.737	0.035	65.0	70.0	10
Shell width	41.8	40.0	2.394	0.757	0.057	40.0	45.0	10
Diameter of aperture	25.0	25.0	1.333	0.422	0.053	23.0	27.0	10
Length of spines	16.6	17.0	1.430	0.452	0.086	15.0	18.0	10

Table 10. Comparison of *Diffflugia sapnakeranica* sp.n. with related species.

Species	Shell length (μm)	Shell width (μm)	Size (μm) and shape of aperture	Shape of shell and its composition	Data source
<i>D. bicuris</i> Gauthier-Liévre et Thomas, 1958	158-207	77-115	Ø 33-58 rounded.	Elongated, lateral sides are nearly parallel, 2 aboral spines, collar absent; small surface composed of large and mid-sized polygonal plates.	Gauthier-Liévre and Thomas, 1958
<i>D. tricornis</i> (Jung, 1936)	110-130	65-82	Ø 40, rounded.	Shell pear-like, narrowed to anterior end; 3 sharp aboral spines, collar absent; shell surface composed mainly of large sand pieces.	Jung, 1936; Ogden, 1983; Mazei, Tsyganov, 2006
<i>D. foissneri</i> Chardez, 1987	210-230	170-180	Ø 86-90, ovoid.	Shell trapezoid-like, flattened laterally and narrowed to the aboral part; 3 sharp aboral spines; collar absent.	Chardez, 1987; Mazei, Tsyganov, 2006
<i>D. sapnakeranica</i> sp.n.	65-70	40-45	Ø 23-27, rounded.	Elongate, with truncated apical end and 3 aboral blunt horns; small collar; covered by variously shaped sand pieces.	Original

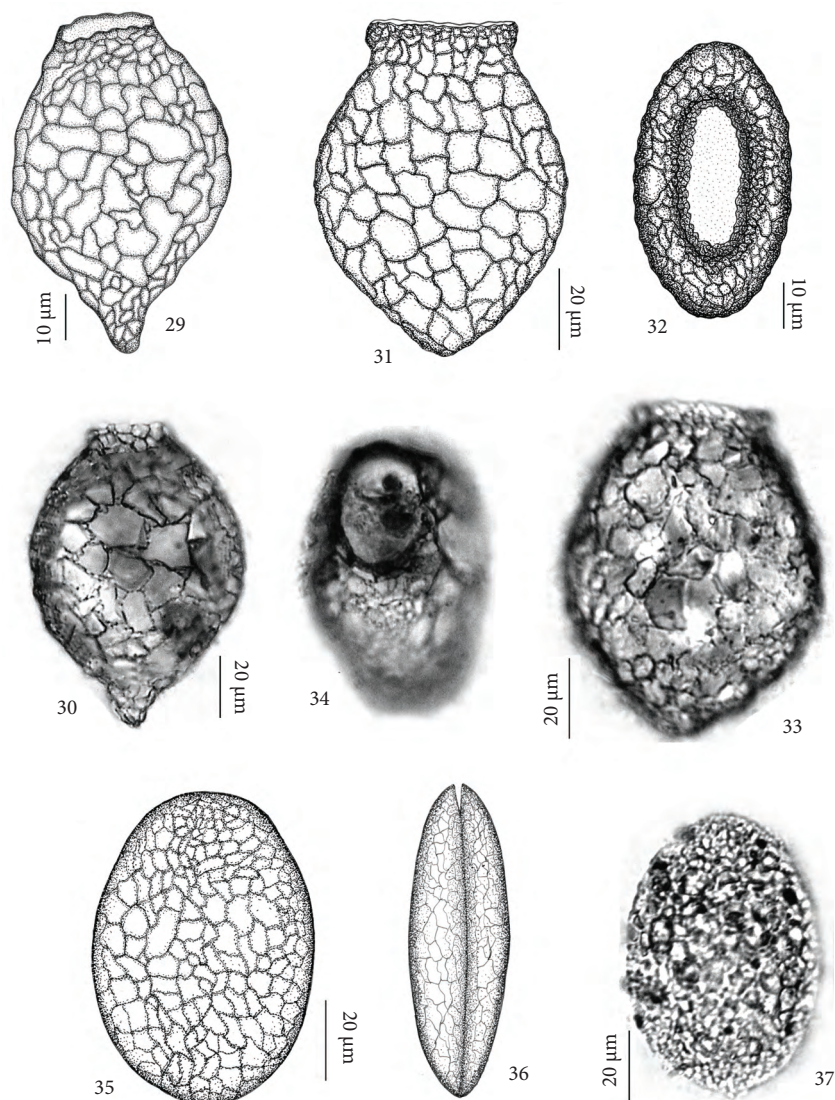


Figure 5. 29: *Diffflugia pressula* sp.n., general view; 30: *D. pressula* sp.n., general view; 31: *Diffflugia girkanica* sp.n., general view; 32: *D. girkanica* sp.n., apertural view; 33: *D. girkanica* sp.n., general view; 34: *D. girkanica* sp.n., apertural view; 35: *Heleopera petricola* Leidy, 1879, general view; 36: *H. petricola*, lateral view; 37: *H. petricola* Leidy, 1879, general view.

sapnakeranica sp.n. specimens are given in Figures 24 and 25 and Tables 9 and 10.

Type specimens

One holotype as a slide N L-6.

Type location

Sediments in the small shallow pond near the Sapnakeran settlement (Lenkoran district).

Description

Shell length 65-70 µm, width 40-45 µm. Shell elongate, with truncated apical end and 3 thick horns on the aboral end. Apical spherical aperture (23-27 µm) is surrounded by a small lip. The light-brown shell is covered with variously shaped plates.

Endoplasm colorless and granular. There are 2-5 short lobopodia and 3-5 contractile vacuoles.

Comparison with related species

D. sapnakeranica sp.n., described above, is morphologically close to *D. bicruris* Gauthier-Liévre et Thomas, 1958, *D. tricornis* (Jung, 1936), and *D. foissneri* Chardez, 1987 (Table 10). Our *D. sapnakeranica* sp.n. clearly differs from all related species by a 2-fold smaller shell and aperture diameter, different shell shape, arrangement of aboral horns, and the shape of the collar surrounding the aperture.

Etymology

The species name refers to the Sapnakeran settlement, where the species was found.

Diffflugia cratera Leidy, 1877 (Figures 26-28; Table 11)

Shell length 70-80 μm , width of equatorial body part 30-35 μm . Shell has a goblet-like shape, with a cylindroidal anterior part and spheroidal aboral part. Apical aperture (20-25 μm) circular with rim. Shell surface composed of flat polygonal siliceous plates arranged in an organic matrix. Morphological and morphometrical characteristics of our specimens are given in Figures 26-28 and Table 11. Endoplasm occupies about 2/3 of the inner-shell cavity, and contains a single nucleus and 2-5 contractile vacuoles. There are 3-5 thin lobopodia.

We found *D. cratera* on the sediments of small ponds near the Sapnakeran settlement (Lenkoran district). The species was found in the Caucasus for the first time. Our specimens have morphological

characteristics that correspond to the species described from freshwaters of the USA (Leidy, 1879).

Diffflugia pressula sp.n. (Figures 29 and 30; Tables 12 and 13)

Diagnosis

The shell has a cone-like shape with a truncated apical end and a horn on the aboral end. The shell is flattened laterally. Oval apical aperture is surrounded by a thin collar. Usually there are 1-3 lobopodia. Morphological and morphometrical characteristics of our *D. pressula* sp.n. specimens are given in Figures 29 and 30 and Tables 12 and 13.

Type specimens

One holotype as a slide N L-8, syntype L-9, 10.

Type location

Sediments in the small forest pond near the Avrora settlement.

Description

Shell length 65-75 μm , width 50-60 μm . The shell is cone-like with a truncated apical end and a horn at the aboral end. The shell is flattened laterally (30 μm thick). The oval apical aperture (18-23 μm) has a thin collar composed of small quartz plates. The entire shell surface is composed of irregular sand plates. Endoplasm colorless. Pseudopodia lobose, usually 1-3. There are 3-5 contractile vacuoles.

Table 11. Biometric characteristics of *Diffflugia cratera* Leidy, 1877.

Character	$\bar{X}$	M	SD	SE	CV	Min	Max	n
Shell length	75.5	75.0	4.378	1.384	0.058	70.0	80.0	10
Shell width	33.5	35.0	2.415	0.764	0.072	30.0	35.0	10
Diameter of aperture	21.5	20.0	2.415	0.764	0.112	20.0	25.0	10

Table 12. Biometric characteristics of *Diffflugia pressula* sp.n.

Character	$\bar{X}$	M	SD	SE	CV	Min	Max	n
Shell length	69.0	70.0	3.944	1.247	0.057	65.0	75.0	10
Shell width	54.5	55.0	4.378	1.384	0.080	50.0	60.0	10
Diameter of aperture	20.5	20.0	1.90	0.601	0.093	18.0	23.0	10
Length of horn	11.6	12.0	1.174	0.371	0.101	10.0	13.0	10

Table 13. Comparison of *Diffflugia pressula* sp.n. and related species.

Species	Shell length (µm)	Shell width (µm)	Size and shape of aperture	Shape of shell and its composition	Data source
<i>D. acutissima</i> Deflandre, 1931	178-233	8-110	Ø 40-51 rounded.	Elongate, cone-like, narrowed on aboral end with single sharp horn; the shell surface is smooth, covered with flat sand plates.	Deflandre, 1931; Mazei, Tsyganov, 2006
<i>D. acutissimella</i> Chardez, 1985	100-126	45-58	Ø 22-24 rounded.	Elongate, with one sharp aboral horn; covered by siliceous grains varying in size.	Chardez, 1985
<i>D. brychtae</i> Štěpánek, 1967	81	46	Ø 24 rounded.	Asymmetrical retort-like, with narrowed aboral end and blunt aboral horn; covered by the large sand plates.	Štěpánek, 1967; Mazei, Tsyganov, 2006
<i>D. claviformis</i> Penard, 1899	250-450	100-200	Ø 33-62 rounded.	Elongated pear-like, with neck on the anterior part and small blunt aboral horn; surface covered by large flat sand plates.	Penard, 1899; Mazei, Tsyganov, 2006
<i>D. difficilis</i> Thomas, 1954	81-100	53-63	Ø 18-20 rounded.	Shell colorless, ovate with narrowed aboral end and blunt aboral horn; there is a collar; the shell surface is covered by large and mid-sized flat sand plates.	Thomas, 1954; Gauthier-Liévre and Thomas, 1958
<i>Diffflugia pressula</i> sp.n.	65-75	50-60	Ø 18-23 ovoid.	Cone-like with truncated apical end and 1 horn on the aboral end; thin collar; covered by irregular sand plates.	Original

Table 14. Biometric characteristics of *Diffflugia girkanica* sp.n.

Character	$\bar{X}$	M	SD	SE	CV	Min	Max	n
Shell length	79.0	80.0	3.944	1.247	0.050	75.0	85.0	10
Shell width	67.0	65.0	2.582	0.816	0.039	65.0	70.0	10
Diameter of aperture	36.9	36.0	2.283	0.722	0.062	35.0	40.0	10
Thickness of shell	41.0	40.0	2.108	0.667	0.051	40.0	45.0	10

Comparison with related species

Diffflugia pressula sp.n., described above, is morphologically close to *D. acutissima* Gauthier-Liévre et Thomas, 1958, *D. acutissimella* Chardez, 1985, *D. brychtae* Štěpánek, 1967, *D. claviformis* Penard, 1899, and *D. difficilis* Thomas, 1954 (Table 13). Nonetheless, our *D. pressula* sp.n. clearly differs from all related species by the lateral pressing of its shell.

Etymology

The species name refers to its shell morphology (Lat. pressus = compressed).

Diffflugia girkanica sp.n. (Figures 31-34; Tables 14 and 15)

Diagnosis

The shell is amphora-like, flattened laterally with truncated apical and narrow aboral ends. Apical elliptic aperture is bordered by small sand pieces. There is a well-defined neck. Morphological and morphometrical characteristics of our *D.girkanica* sp.n. specimens are given in Figures 31-34 and Tables 14 and 15.

Type specimens

One holotype as a slide N L-8, syntype L-9, 10 has been deposited.

Table 15. Comparison of *Diffflugia girkanica* sp.n. and related species.

Species	Shell length (µm)	Shell width (µm)	Thickness of shell (µm)	Size and shape of aperture	Shape of shell and its composition	Data source
<i>D. mammilaris</i> Penard, 1893	93-111	54-72	93-111	Ø 23-31, rounded.	Elongated, asymmetrical laterally with truncated anterior and long blunt aboral horn; below anterior aperture there is a well-defined neck; shell is covered by polygonal flat sand plates.	Penard, 1893; Mazei, Tsyganov, 2006
<i>D. lucida</i> Penard, 1890	40-90	25-55	16-37	Ø 12-29, elliptical.	Elongated, colorless, flattened laterally, with narrow elliptical anterior aperture; neck absent; the shell surface is covered by variously shaped flat sand plates.	Penard, 1890; Mazei, Tsyganov, 2006
<i>D. balcanica</i> Ogden, Živković, 1983	111-114	79-82	50	Ø 31, asymmetrically-round.	Elongated, flattened laterally only in the equatorial part; anterior aperture asymmetrically spheroidal, bordered by small sand grains; there is a blunt aboral horn; the shell surface is covered by variously shaped flat sand plates.	Ogden, Živković, 1983; Mazei, Tsyganov, 2006
<i>D. biconcava</i> Ertl, 1964	100-143	66-96	35-76	Ø 29-32, ovoid.	Ovate, with spicate fundus and very small neck, laterally flattened, covered by grains.	Ertl, 1964; Mazei, Tsyganov, 2006
<i>Diffflugia girkanica</i> sp.n.	75-85	65-70	40-45	Ø 35-40, elliptical.	Amphora-like, flattened laterally with truncated apical and narrow aboral end; elliptical aperture bordered by small sand pieces; well-defined neck; shell covered by the siliceous flat plates.	Original

Table 16. Biometric characteristics of *Heleopera petricola* Leidy, 1879.

Character	$\bar{X}$	M	SD	SE	CV	Min	Max	n
Shell length	80.5	82.5	5.986	1.893	0.074	70.0	85.0	10
Shell width	56.0	57.5	4.595	1.453	0.082	50.0	60.0	10
Depth of shell	17.0	15.0	2.582	0.816	0.152	15.0	20.0	10
Length of aperture	23.3	24.0	2.058	0.651	0.088	20.0	25.0	10

Type location

Sediments in the small shallow forest pond.

Description

Shell length 75-85 µm, width 65-70 µm, lateral thickness 40-45 µm. The shell has an amphora-like shape, flattened laterally with truncated apical and narrow aboral ends. Apical elliptical aperture (35-40 µm) is bordered by small sand pieces. Below the aperture is a well-defined neck. The entire shell surface is covered by siliceous flat plates. Endoplasm light gray, granulated, without inclusion. There are 1-3 lobopodia and usually 2 contractile vacuoles.

Comparison with related species

Described above, *Diffflugia girkanica* sp.n. is morphologically close to *D. mammilaris* Penard, 1893, *D. lucida* Penard, 1890, *D. balcanica* Ogden, Živković, 1983, and *D. biconcava* Ertl, 1964 (Table 15). Only *D. mamillaris* has a small neck, as does our species, but

it clearly differs by its shell shape. *D. balcanica* has a similar laterally flattened shell shape, but differs from our *D. girkanica* sp.n. by its larger size and absence of a neck. The other 2 species—*D. lucida* and *D. biconcava*—clearly differ from our *D. girkanica* sp.n. in shell shape and absence of a neck.

Fam. Heleoperidae Jung, 1942***Heleopera petricola* Leidy, 1879 (Figures 35-37; Table 16)**

Shell length 70-85 µm, width 50-60 µm, depth 15-20 µm (Table 16). The shell is ovoid, laterally flattened, and composed mainly of irregularly arranged siliceous shell plates. The shell outline is smooth, the lateral margin is parallel convex in broad view, the narrow aperture (20-25 µm) is terminal and slightly convex in broad view, and the narrow linear opening is bordered by a thin collar of organic cement. Morphological and morphometrical characteristics of our specimens are given in Figures 35-37 and Table

16. Endoplasm colorless, without inclusion. One nucleus.

Our specimens of *H. petricola* differ from those described by Ogden and Hedley (1980) by their smaller shell size (length 117-128 µm versus 70-85 µm; width 94-107 µm versus 50-60 µm; depth 51-57

µm versus 15-20 µm) and differently shaped siliceous shell plates. Prior to our investigations this species was known in the Caucasus from water reservoirs (Kasymov, 1972) and from soils of west Azerbaijan (Zaidov, 1995). We found it in the shallows of the Kamishevka River.

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