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A COMPARATIVE ANALYSIS OF FRESHWATER TESTATE AMOEBAE SPECIES COMPOSITION BETWEEN THE SOUTH-EASTERN PART OF AZERBAIJAN AND OTHER REGIONS OF AZERBAIJAN

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Abstract. A study of freshwater testate amoebae fauna of the Lankaran natural area of Azerbaijan was conducted from 2013 to 2018, revealing 126 testacean species belonging to 11 families. Long-term research in south-eastern regions of Azerbaijan demonstrated that the genus *Difflugia* dominated in all investigated freshwater reservoirs with high species diversity. Our study aimed to identify and analyze the degree of similarity in species composition of testate amoebae fauna in various investigated regions of Lankaran natural area, as well as between Lankaran and other regions of Azerbaijan. The cluster analysis and the Czekanowski index were used to compare species composition, yielding consistent results. Our analysis indicated the highest similarity between the species composition of the Lankaran region and Northern Azerbaijan. The Czekanowski index for these regions was also high (35.96 %). The analysis showed that there are 3 clusters of similarity of testate amoebae communities. One of them encompasses 2 regions (56.17 %) of Azerbaijan (south-eastern and north-eastern parts), the second combines these two points with the Absheron peninsula (52.98 %). And the third cluster covers the western region and the remaining 3 points (42.9 %).

Keywords: south-eastern Azerbaijan, testate amoebae, cluster analysis, freshwater.

СРАВНИТЕЛЬНЫЙ АНАЛИЗ ВИДОВОГО СОСТАВА ПРЕСНОВОДНЫХ РАКОВИННЫХ АМЕБ ЮГО-ВОСТОЧНОЙ ЧАСТИ АЗЕРБАЙДЖАНА С ДРУГИМИ РЕГИОНАМИ СТРАНЫ

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Аннотация. В 2013–2018 гг. было проведено исследование фауны пресноводных раковинных амеб Ленкоранской природной области Азербайджана. В результате исследований выявлено 126 видов раковинных амеб, относящихся к 11 семействам. В ходе многолетних исследований, проведенных в юго-восточном Азербайджане, было отмечено, что представители *Difflugia* доминировали с высоким видовым разнообразием во всех исследованных пресных водоемах. Нашей целью было выявить и проанализировать степень сходства видового состава фауны раковинных амеб различных исследованных районов Ленкоранской природной области, а также с другими регионами Азербайджана. Кластерный анализ и индекс Чекановского — Сёренсена были использованы для сравнения видового состава. Результаты обоих анализов совпадают. По результатам анализа наибольшее сходство отмечено между видовым составом Ленкоранского района и Северного Азербайджана. Индекс Чекановского — Сёренсена также был высоким для перечисленных регионов (35,96 %). Анализ показал, что существует 3 кластера сходства сообществ раковинных амеб. Один из них объединяет 2 региона (56,17 %) Азербайджана (юго-восточные и северо-восточные части), второй объединяет эти два пункта с Апшеронским полуостровом (52,98 %). А третий кластер охватывает Западный регион и 3 остальных пункта (42,9 %).

Ключевые слова: юго-восточный Азербайджан, раковинные амебы, кластерный анализ, пресная вода.

INTRODUCTION

The first stage in the investigation of the structure of the fauna is usually associated with its study. It is not enough to study the structure of a single fauna unit to understand its characteristics or achieve further insight into its genesis. It is only after a detailed comparison of the fauna structures of different regions that their differences and particular qualities become apparent. For such comparisons, specific groups of organisms in neighboring regions are usually targeted. To obtain reliable results, the amount of data available for each group of organisms should be approximately the same. However, this condition is often not feasible, due to poor data availability or quality in regards to many animal groups.

A comparative fauna analysis usually begins with a study of the lists of species of local fauna, focusing on qualitative differences, i.e. on taxons (species, genera, families, etc.) that are only present in one of the compared faunas. The number of species (genera, families, etc.) that are characteristic for only one local fauna is usually an indicator of its uniqueness.

The presence or absence of specific taxa and their total number in a given fauna is most often graphically depicted using histograms showing the percentage ratio of the number of species in certain taxa. In a comparative analysis, it is highly important to establish the degree to which the faunas of two specific regions are similar or different. This can be represented more clearly using several well-proven quantitative methods (Bray, Curtis 1957). Several formulas have been proposed for the mathematical expression of the degree of similarity of faunas of two different regions. The Czekanowski coefficient can also be used (Czekanowski 1913).

MATERIAL AND METHODS

Samples of plankton, periphyton and benthos were collected in 2013–2018 from different freshwater basins of 6 districts of Lankaran natural area in Azerbaijan (Fig. 1). Figure 1 also shows some studied regions of Azerbaijan. However, we also compared our results with fauna data from other regions of Azerbaijan. Plastic bottles were used to collect benthic samples. Plankton samples were collected using a plankton mesh. The samples of periphyton were collected by scraping biofilm and pick up water in places of aquatic plant thickets (Alekperov, Asadullaeva, Zaidov 1997). A quantitative account of testate amoebae was conducted in a FlowCam densitometer in 5 ml of water. Specimens were caught in microcapillary tubes and studied in vivo and through the glycerol preparations. For scanning electron microscopy (SEM) the cells were transferred to cover glass with micro-capillary tubes, dried and then coated with gold. The shell morphology of testate amoebae was examined using a scanning electron microscope JEOL JCM-6000 operating at 5-15 kV.

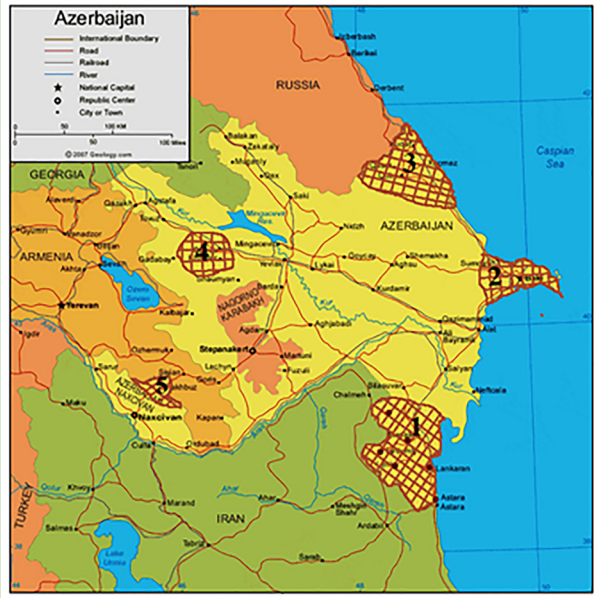

Fig. 1. Location of sampling points: *1* — south-eastern part of Azerbaijan (Lankaran natural area); *2* — Absheron peninsula; *3* — north-eastern part of Azerbaijan (Khachmaz district); *4* — western part of Azerbaijan (Goygol); *5* — Nakhichevan Autonomous Republic

Рис. 1. Расположение точек сбора: *1* — юго-восточная часть Азербайджана (Ленкоранская природная область); *2* — Апшеронский полуостров; *3* — северо-восточная часть Азербайджана (Хачмазский район); *4* — западная часть Азербайджана (Гейгел); *5* — Нахичеванская Автономная Республика

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Bray-Curtis cluster analysis was used to compare the degree of similarity in species diversity of different investigated regions of Azerbaijan (Bray, Curtis 1957). The Czekanowski index was used to identify the similarity of species composition of testate amoebae fauna of various investigated regions, according to the formula (Czekanowski 1913):

$$Ksc = 2c / (a + b),$$

where: a — the number of species in one community, b — number of species in the second community, c — the number of species which are common to both communities. All data were calculated by the "Biodiversity Professional 2" PC Software program.

RESULTS AND DISCUSSION

In total, 126 species of testate amoebae were found in freshwater reservoirs of Lankaran natural area (Table 1). Representatives of the genus *Difflugia* (63 species) were dominant in all studied water bodies of Lankaran natural area. They are followed by representatives of the genera *Centropyxis* and *Arcella*, which recorded 18 and 17 species, respectively (Tahirova 2018).

The aim of this work is to study the fauna of the testate amoebae of the Lankaran natural area of Azerbaijan and to identify its features and specific traits. we conducted a comparative analysis of the commonality between the faunas of testate amoebae from different regions of Azerbaijan. As compared areas, we took the most studied areas of Azerbaijan: North-Eastern Azerbaijan, Western Azerbaijan and the Absheron peninsula. A testate amoebae fauna survey of these regions has been carried out by N. Snegovaya and I. Alekperov (Alekperov, Snegovaya 2000; Snegovaya, Alekperov 2005; 2009; Snegovaya, Tahirova 2015). According to the available data, the number of species of testate amoebae in North-Eastern Azerbaijan is 60, in Western Azerbaijan — 72 species and the Absheron peninsula — 110 species. In total, 218 species of testate amoebae were registered in all compared regions of Azerbaijan. Of course, these do not represent a complete list of testate amoebae, as the study of testate amoebae fauna in all regions is ongoing. We also conducted short-term studies in the Nakhchivan Autonomous Republic (Snegovaya, Tahirova 2018). As a result of investigations carried

Table 1

Freshwater testate amoebae species composition and distribution in the investigated regions of Azerbaijan

Таблица 1

Видовой состав и распространение пресноводных раковинных амеб в исследованных районах Азербайджана

№	Species	1	2	3	4
	Phylum Amoebozoa Lühe, 1913, emend. Cavalier-Smith, 1998				
	Subphylum Lobosa Carpenter, 1861				
	Class Tubulinea Smirnov et al., 2005				
	Order Arcellinida Saville, Kent, 1880				
	Family Arcellidae Ehrenberg, 1830				
1.	*Amphizonella violacea* Greeff, 1886				+
2.	*Arcella arenaria* Greeff, 1866	+		+	+
3.	*A. polypora* Penard, 1902	+	+		+
4.	*A. conica* Playfair	+			+
5.	*A. vulgaris* Defflandre, 1928	+	+	+	+
6.	*A. vulgaris v. undulata* Deflandre, 1928				+
7.	*A. gibbosa* Penard, 1890	+	+		+
8.	*A. gibbosa laevis* Deflandre, 1928	+			
9.	*A. artocrea* Leidy, 1876	+	+		+
10.	*A. megastoma* Penard, 1926	+	+	+	

Table 1. Continued
Таблица 1. Продолжение

№	Species	1	2	3	4
11.	*A. megastoma arcuata* Deflandre, 1928	+			
12.	*A. dentata* Ehrenberg, 1832	+			+
13.	*A. excavata* Cunningham, 1919	+			+
14.	*A. discoides* Ehrenberg, 1872	+	+		+
15.	*A. discoides ssp.scutelliformis* Playfair, 1918**	+			
16.	*A. rotundata* Playfair, 1918				+
17.	*A. brasiliensis* Cunha, 1913				+
18.	*A. mitrata* Leidy, 1876				+
19.	*A. hemispherica* Perty, 1852	+	+	+	+
20.	*A. bathystoma* Deflandre, 1928	+			
21.	*A. atava* Collin 1914		+		
22.	*A. catinus* Penard, 1890	+			+
23.	*A. crenulata* Deflandre, 1928	+			+
	Family Trigonopyxidae Loeblich et Tappan, 1964				
24.	*Cyclopyxis arcelloides* Penard, 1902				+
25.	*C. kahli* Deflandre, 1929	+	+	+	+
26.	*C. intermedia* Kufferath, 1932	+			
27.	*C. euristoma* Deflandre, 1929	+	+	+	+
28.	*C. penardi* Deflandre, 1929	+			+
29.	*C. ambigua* Bonnet et Thomas, 1960	+			
30.	*Trigonopyxis arcula* (Leidy, 1879)	+	+		+
	Family Centropyxidae Deflandre, 1953				
31.	*Centropyxis aculeata* Ehrenberg, 1838	+	+	+	+
32.	*C. aculeata v. oblonga* Deflandre, 1929				+
33.	*C. spinosa* Cash, 1905	+	+	+	+
34.	*C. aerophila* Deflandre, 1929	+	+	+	+
35.	*C. gibba* Deflandre, 1929				+
36.	*C. pileformis* Snegovaya et Alekperov, 2009			+	
37.	*C. trigonostoma* Snegovaya et Alekperov, 2009			+	
38.	*C. pectinata* Snegovaya et Alekperov, 2009			+	
39.	*C. plagiostoma* Bonnet et Thomas, 1956	+			+
40.	*C. elongata* (Penard, 1890)	+	+	+	+
41.	*C. ecornis* Ehrenberg, 1838	+	+	+	+
42.	*C. platystoma* Penard, 1890	+		+	+
43.	*C. percolabiensis* Dekhtyar 1994		+		
44.	*C. hirsuta* Deflandre, 1929	+	+	+	+
45.	*C. discoides* (Penard, 1890)	+	+	+	+
46.	*C. kurakchayensis* Snegovaya et Alekperov, 2005	+	+		
47.	*C. marsupiformis* (Wall, 1864)	+		+	+
48.	*C. cassis* (Wallich, 1864)	+	+		
49.	*C. constricta* (Ehrenberg,1838) Deflandre, 1929	+			+
50.	*C. hemisphaerica* (Bernard, 1879)	+		+	+
51.	*C. mirabilis* Bartoš, 1940		+		
52.	*C. minuta* Deflandre, 1929	+			+
53.	*C. silvatica* (Deflandre, 1929)	+			+
54.	*C. compressa* van Oye, 1948		+		
55.	*C. laevigata* Penard, 1890				+
56.	*Ellipsopyxis lamottei* Bonnet, 1974	+			

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Table 1. Continued
Таблица 1. Продолжение

№	Species	1	2	3	4
57.	*Oopyxis lenkoranica* Snegovaya et Alekperov, 2010	+			
58.	*Hoogenraadia cryptostoma* Gauthier-Lièvre et Thomas,1958				+
	Family Plagiopyxidae Bonnet et Thomas, 1960				
59.	*Plagiopyxis minuta phanerostoma* Bonnet, 1959	+			
60.	*P. declivis* Thomas, 1958	+			
	Family Difflugiidae Awerintzev, 1906				
61.	*Difflugia acuminata* Ehrenberg, 1838	+		+	+
62.	*D.acuminata v.curvata* Cash, 1909	+			+
63.	*D. acuminata v.inflata* Penard 1899		+		+
64.	*D. acuminata v. magna* Deflandre, 1926				+
65.	*D. ampullula* Playfair, 1918	+			
66.	*D. claviformis* Penard, 1899	+		+	+
67.	*D. microclaviformis* Ogden, 1983*	+			
68.	*D. corona* Wallich, 1864	+	+	+	+
69.	*D. corona ssp. ecornis* Gauthier-Lièvre et Thomas, 1958	+	+	+	
70.	*D. corona ssp. tuberculata* Vuchetich, 1973**	+			
71.	*D. difficilis* Thomas, 1972	+	+	+	+
72.	*D. distenda,* Ogden, 1983	+			
73.	*D. elegans* Penard, 1890	+	+	+	+
74.	*D. elegans teres* Penard, 1899	+	+	+	
75.	*D. capreolata* Penard, 1902	+	+	+	
76.	*D. giganteacuminata* Chardez, 1958	+			
77.	*D. globulosa* Dujardin, 1837	+		+	+
78.	*D. globularis* Wallich, 1864	+	+		+
79.	*D. pressula* Snegovaya et Alekperov, 2010	+			
80.	*D. mamillaris* Penard, 1893	+			
81.	*D. gramen* Penard, 1902	+	+	+	+
82.	*D. tuberculata* Wallich, 1864	+			
83.	*D. scalpellum* Penard, 1899	+		+	
84.	*D. sarissa* Li Sun Tai, 1931	+		+	
85.	*D. limnetica* Penard, 1902	+			
86.	*D. linearis* (Penard, 1890) Gauthier-Lièvre et Thomas, 1958	+			
87.	*D. litophila* Gauthier-Lièvre et	+		+	
88.	*D. myriformis* Gauthier-Lièvre et Thomas, 1958	+	+		
89.	*D. oviformis* Cash, 1909	+			
90.	*D. penardi* Hopkinson, 1909	+		+	+
91.	*D. pyriformis* Perty, 1849	+			
92.	*D. urceolata* Carter, 1864	+		+	
93.	*D. pristis* Penard, 1902	+		+	+
94.	*D. oblonga* Ehrenberg, 1838	+		+	+
95.	*D. oblonga v. parva* Thomas, 1954	+			+
96.	*D. lanceolata* Penard, 1890	+		+	+
97.	*D. lobostoma* Leidy, 1879	+	+	+	+
98.	*D. lobostoma multilobata* Gauthier-Lièvre and Thomas, 1958	+	+		
99.	*D. manicata* Penard, 1902				+
100.	*D. bipartis* Godeanu, 1972				+
101.	*D. decloitrei* Godeanu, 1972				+
102.	*D. bacilifera* Penard, 1890	+			

Table 1. Continued
Таблица 1. Продолжение

№	Species	1	2	3	4
103.	*D. sapnakeranica* Snegovaya et Alekperov, 2010	+			
104.	*D. cratera* Leidy, 1877	+			
105.	*D. alekperovi* Snegovaya et Tahirova, 2015*	+			
106.	*D. brevicola* Cash et Hopkinson, 1909	+		+	
107.	*D. amphoralis* Hopkinson, 1909	+			+
108.	*D. amphoralis cornuta* Gauthier-Lièvre et Thomas, 1958	+			
109.	*D. lucida* Penard, 1890	+			+
110.	*D. bicornis* Penard, 1902	+	+	+	
111.	*D. bryophila* (Penard, 1902)	+		+	
112.	*D. acutissima* Deflandre, 1931	+		+	
113.	*D. acutisimella* Chardez, 1985	+	+	+	
114.	*D. smilion* Thomas, 1953	+			
115.	*D. longicollis* (Gassowsky, 1936)	+		+	+
116.	*D. decloitrei* Godeanu, 1972	+			+
117.	*D. baculosa* Schonborn, 1966	+			
118.	*D. pseudoclaviformis* Snegovaya et Alekperov, 2010	+			
119.	*D. rubescens* Penard, 1902				+
120.	*D. oblonga v. angusticollis* Stepanek, 1952				+
121.	*D. pysciformis* Snegovaya et Alekperov, 2010	+			
122.	*D. ventricosa* Deflandre, 1926	+			+
123.	*D. labiosa* Wailes, 1919	+		+	+
124.	*D. pulex* Penard, 1902	+			+
125.	*D. varians* Penard, 1902	+			+
126.	*D. biconcava* Ertl, 1964*	+	+		
127.	*D. armatostoma* Snegovaya et Alekperov, 2005		+		
128.	*D. rotiferoformis* Snegovaya et Alekperov, 2005		+		
129.	*D. caucasica* Snegovaya et Alekperov, 2005		+		
130.	*D. vermiformis* Snegovaya et Alekperov, 2005		+		
131.	*D. bifurcata* Snegovaya et Alekperov, 2005		+		
132.	*D. azerbaijanica* Snegovaya et Alekperov, 2005		+		
133.	*D. petricola* Cash, 1909*	+			
134.	*D. elongata* Penard, 1905				+
135.	*D. avellana* Penard, 1890				+
136.	*D. lenkoranica* Snegovaya et Alekperov, 2010	+			
137.	*D. crucistoma* Snegovaya et Alekperov, 2009			+	
138.	*D. immemorata* Snegovaya et Alekperov, 2009			+	
139.	*D. khachmazica* Snegovaya et Alekperov, 2009			+	
140.	*D. talyshica* Snegovaya et Alekperov, 2010	+			
141.	*D. girkanica* Snegovaya et Alekperov, 2010	+			
142.	*D. oblonga v. nodosa* Leidy, 1879				+
143.	*D. guttula* S. Godeanu, 1972		+		+
144.	*D. ogdenii* Snegovaya et Alekperov, 2005		+		
145.	*D. echinulata* Penard, 1911		+		
146.	*D. hanaki* Štěpánek, 1967	+			
147.	*Pentagonia azerbaijanica* Snegovaya et Alekperov, 2010	+			
148.	*Pontigulasia compressoidea* Jung, 1942	+			
149.	*P. compressa* (Carter, 1864)		+	+	+
150.	*P. breviottis* Snegovaya et Alekperov, 2005		+		

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Table 1. Continued
Таблица 1. Продолжение

№	Species	1	2	3	4
151.	*P. bryophila* Penard, 1902	+	+	+	+
152.	*P. bigibbosa* Penard, 1902	+	+	+	+
153.	*P. spectabilis* Penard, 1902				+
154.	*P. elisa* (Penard, 1893)				+
155.	*Protocucurbitella danubialis* Živkovic, 1976	+			
156.	*Cucurbitella mespiliformis v. africana* Gauthier-Lièvre et Thomas, 1960		+		
157.	*Schwabia sphaerica* Snegovaya et Alekperov, 2005		+		
158.	*Pelecyamoeba stenostom*a Snegovaya et Alekperov, 2005		+		
159.	*Zivkovicia compressa* (Carter, 1864) Ogden, 1987	+			
160.	*Armatodifflugia ceratophora* Snegovaya, Alekperov, 2005		+		
161.	*A.cuneata* Snegovaya et Alekperov, 2005		+		
	Family Lesquereusidae Jung, 1942				
162.	*Lesquereusia spiralis* Schlumberger, 1849	+		+	
163.	*L. modesta* Rhumbler, 1895	+	+	+	+
164.	*L. gibbosa* Thomas et Gauthier-Lièvre 1959		+		
165.	*L. nabranica* Snegovaya et Alekperov, 2009			+	
166.	*L. contorta* Snegovaya et Alekperov, 2009			+	
167.	*L. azerbaijanica* Snegovaya et Alekperov, 2009			+	
168.	*L. macrolabiata* Snegovaya et Alekperov, 2009			+	
169.	*L. epistomium* Penard, 1902				+
170.	*Quadrulella symmetrica* (Wallich, 1863)				+
171.	*Fabalesquereusia graniformis* Snegovaya et Alekperov, 2005		+		
172.	*F. compressa* Snegovaya et Alekperov, 2005		+		
173.	*F. linearis* Snegovaya et Alekperov, 2005		+		
	Family Cryptodifflugiidae Jung, 1942				
174.	*Difflugiella apiculata* Cash, 1904				+
175.	*Cryptodifflugia compressa* Penard, 1902				+
176.	*C. oviformis* Penard, 1890	+			+
	Family Heleoperidae Jung, 1942				
177.	*Heleopera petricola* Leidy, 1879	+			
178.	*Nebela collaris* (Ehrenberg, 1848)				+
179.	*N. penardiana* Deflandre, 1936				+
180.	*N. militaris* Penard, 1890				+
181.	*N. galeata* Penard, 1890				+
182.	*N. barbata* Leidy, 1874				+
183.	*Awerintzewia minuta* Snegovaya et Tahirova, 2018*		+		
	Family Euglyphidae Wallich, 1864				
184.	*Euglypha acanthophora* (Ehrenberg, 1841)	+			+
185.	*E. tuberculata* Dujardin, 1841	+			+
186.	*E. compressa* Carter, 1864	+			
187.	*E. aspera* Penard, 1899				+
188.	*E. laevis* (Ehrenberg, 1832)				+
189.	*E. rotunda* Wailes, 1911				+
190.	*Assulina muscorum* Greeff, 1888				+
191.	*A. scandinavica* Penard, 1890				+
192.	*Placocista spinosa* (Carter, 1865)				+
193.	*Tracheleuglypha dentata* (Moniez, 1888)				+

Table 1. Completion
Таблица 1. Окончание

№	Species	1	2	3	4
	Family Trinematidae Hoogenraad et Groot, 1940				
194.	*Trinema enchelys* (Ehrenberg, 1838)		+		+
195.	*T. penardi* Thomas et Chardez, 1958				+
196.	*T. verrucosum* France, 1914				+
197.	*T. complanatum* Penard, 1890				+
198.	*Corythion dubium* Taranek, 1881				+
	Family Cyphoderiidae de Saedeleer, 1934				
199.	*Cyphoderia ampula* (Ehrenberg, 1840)	+	+	+	+
200.	*C. ampula papillata* Wailes et Penard, 1911	+			
201.	*C. ventricosa* Chardez, 1991	+			
202.	*C. trochus v. amphoralis* Penard 1899		+		
203.	*C. laevis* Penard, 1902				+
	Family Shamkiriidae Snegovaya et Alekperov, 2005				
204.	*Shamkiriella convoluta* Snegovaya et Alekperov, 2005		+		
205.	*S. reticulata* Snegovaya et Alekperov, 2005		+		
206.	*S. phimatophora* Snegovaya et Alekperov, 2005		+		
207.	*S. turanica* Snegovaya et Alekperov, 2009			+	
208.	*Nabranella brevis* Snegovaya et Alekperov, 2009			+	
209.	*Bipseudostomatella bifurcata* Snegovaya et Alekperov, 2005		+		
210.	*B. gracilis* Snegovaya et Alekperov, 2005		+		
211.	*B. cornuta* Snegovaya et Alekperov, 2005		+		
212.	*Gomocollariella ranaformis* Snegovaya et Alekperov, 2005		+		
	Family Phryganellidae Jung, 1942				
213.	*Phryganella nidulus* Penard, 1902				+
214.	*Ph.acropodia* (Hertwig et Lesser, 1874)				+
	Family Pseudodifflugiidae De Saedeleer, 1934				
215.	*Pseudodifflugia gracilis* Schlumberger, 1849	+			+
216.	*P. magna* Snegovaya et Alekperov, 2010	+			
217.	*Lenkorania microstoma* (Playfair, 1918)	+			
	Family Gromiidae Claparede et Lachmann, 1861				
218.	*Gromia fluviatilis* Dujardin, 1855				+
	Total	126	72	60	110

Notes: 1 — south-eastern part of Azerbaijan, 2 — western regions of Azerbaijan, 3 — north-eastern of Azerbaijan, 4 — Absheron peninsula
* — new species for the Caucasus, ** — new species for the fauna of Azerbaijan (recorded in the Lankaran natural area)

out in the south-eastern regions of Azerbaijan, new testate amoebae species and subspecies have been recorded for the Caucasus and Azerbaijan fauna (Snegovaya, Tahirova 2015; Tahirova 2018) (Fig. 4).

To assess the similarities and differences between the fauna of testate amoebae of compared regions we used cluster analysis of Bray-Curtis similarity (Fig. 2).

From the resultant dendrograms it is evident (Fig. 2) that the highest degree of similarity (56.17 %) is identified between the species composition of the Lankaran region and Northern Azerbaijan. When comparing the combined cluster of the species composition of the Lankaran region and north-eastern part of Azerbaijan with the species composition of the Absheron peninsula, the similarity of fauna reaches 52.98 %. The comparison of the testate amoebae species composition similarity between the combined clusters of the of the above-mentioned regions and Western

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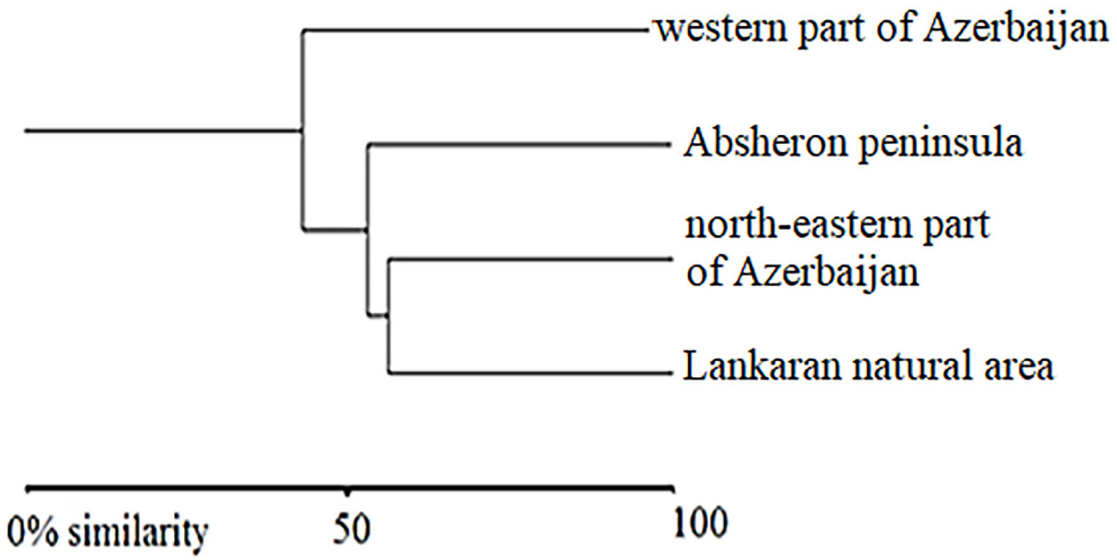

Fig. 2. Cluster analysis of faunistic similarity of testate amoebae of different regions of Azerbaijan (the results of Bray-Curtis analysis)

Рис. 2. Кластерный анализ фаунистического сходства раковинных амеб разных регионов Азербайджана (результаты анализа Брея — Кертиса)

Azerbaijan yields the lowest degree of similarity: 42.9 %.

To obtain more representative data, we compared the similarities between testate amoebae fauna of different regions of Azerbaijan using the Czekanowski index (Table 2). The results of this analysis have been consistent with the results of the cluster analysis.

When using this method, the greatest similarity coefficient value is that of the Lankaran region and Northern Azerbaijan at 35.96 %. Slightly lower (33.82 %) similarity index was obtained when comparing testate amoebae species composition of the Lankaran region and the Absheron peninsula. For the fauna of Northern and Western Azerbaijan, the Czekanowski index was 30.15 %, while the similarity index between the fauna of northern

Table 2

Czekhanowsky similarity index of testate amoebae fauna of different regions of Azerbaijan (%)

Таблица 2

Индекс сходства Чехановского — Сёренсена фауны раковинных амеб различных регионов Азербайджана (%)

	Lankaran natural area	North-eastern part of Azerbaijan (Khachmaz district)	Western part of Azerbaijan (Goygol district)	Absheron peninsula
Lankaran natural area		35.96	15.32	33.82
North-eastern part of Azerbaijan (Khachmaz district)	35.96		30.15	29.72
Western part of Azerbaijan (Goygol district)	15.32	30.15		24.59
Absheron peninsula	33.82	29.72	24.59	

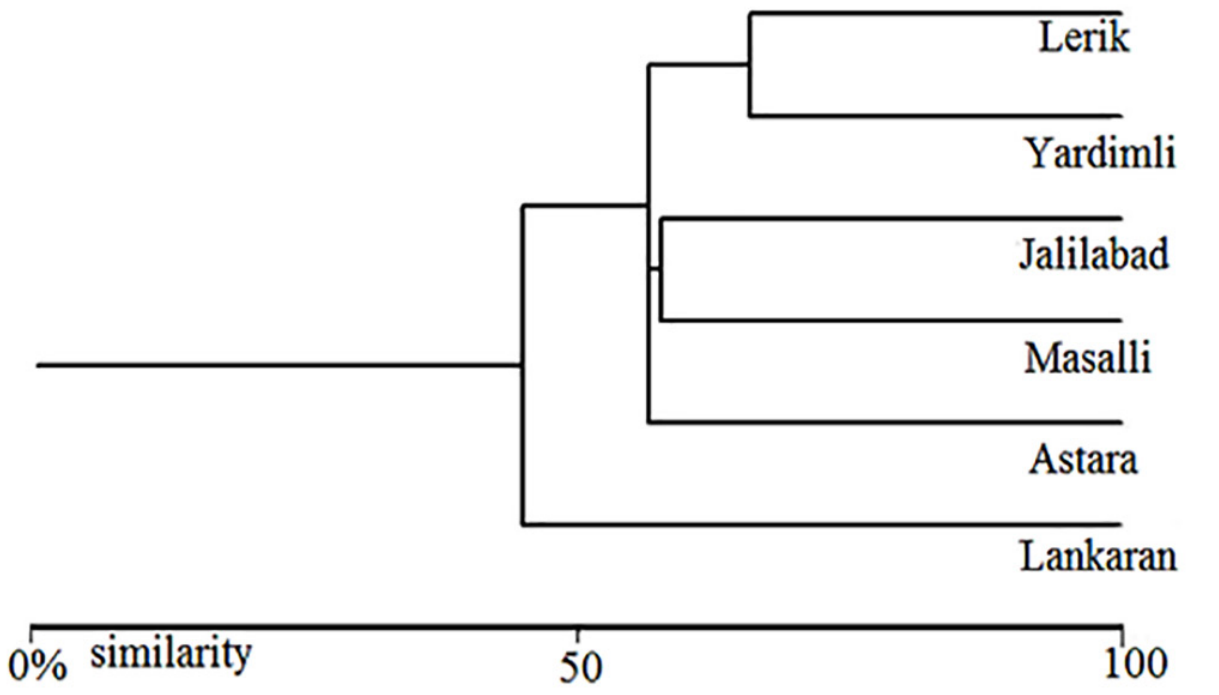

Fig. 3. Cluster analysis of the faunistic similarity of testate amoebae in different parts of South-Eastern Azerbaijan

Рис. 3. Кластерный анализ фаунистического сходства раковинных амеб в разных регионах юго-восточного Азербайджана

Azerbaijan and Absheron was 29.72 %. The testacean fauna of Western Azerbaijan and the Absheron peninsula were 24.59 % similar. The lowest similarity index was recorded between the testate amoebae fauna of the Lankaran region and Western Azerbaijan; it was approximately 15.32 %.

In addition to comparing the fauna of testate amoebae of various investigated regions of Azerbaijan, we compared testate amoebae species composition of the studied areas within the Lankaran natural area. The comparison is shown in figure 3. From the resultant dendrogram it is clear that Lerik and Yardimli districts are the most similar (65,6 %) in the species compositions of testaceans, out of all the studied regions of Lankaran natural area. The similarity between Jalilabad and Masalli districts reached 57.5 %. The similarity between the combined clusters of the above areas and the cluster of the species composition of the Astara region was for 56.3 %. And, finally, the

Table 3

The similarity index of testate amoebae fauna of different investigated regions of Lankaran natural area (South-Eastern Azerbaijan) (%)

Таблица 3

Индекс сходства фауны раковинных амеб различных исследованных районов Ленкоранской природной области (юго-восток Азербайджана) (%)

	Lankaran	Astara	Masalli	Yardimli	Jalilabad	Lerik
Lankaran		29.15	30.1	30.69	29.0	29.15
Astara	29.15		34.78	31.07	36.07	35.71
Masalli	30.1	34.78		33.93	36.22	32.43
Yardimli	30.69	31.07	33.93		36.36	40.34
Jalilabad	29.0	36.07	36.22	36.36		34.0
Lerik	29.15	35.71	32.43	40.34	34.0	

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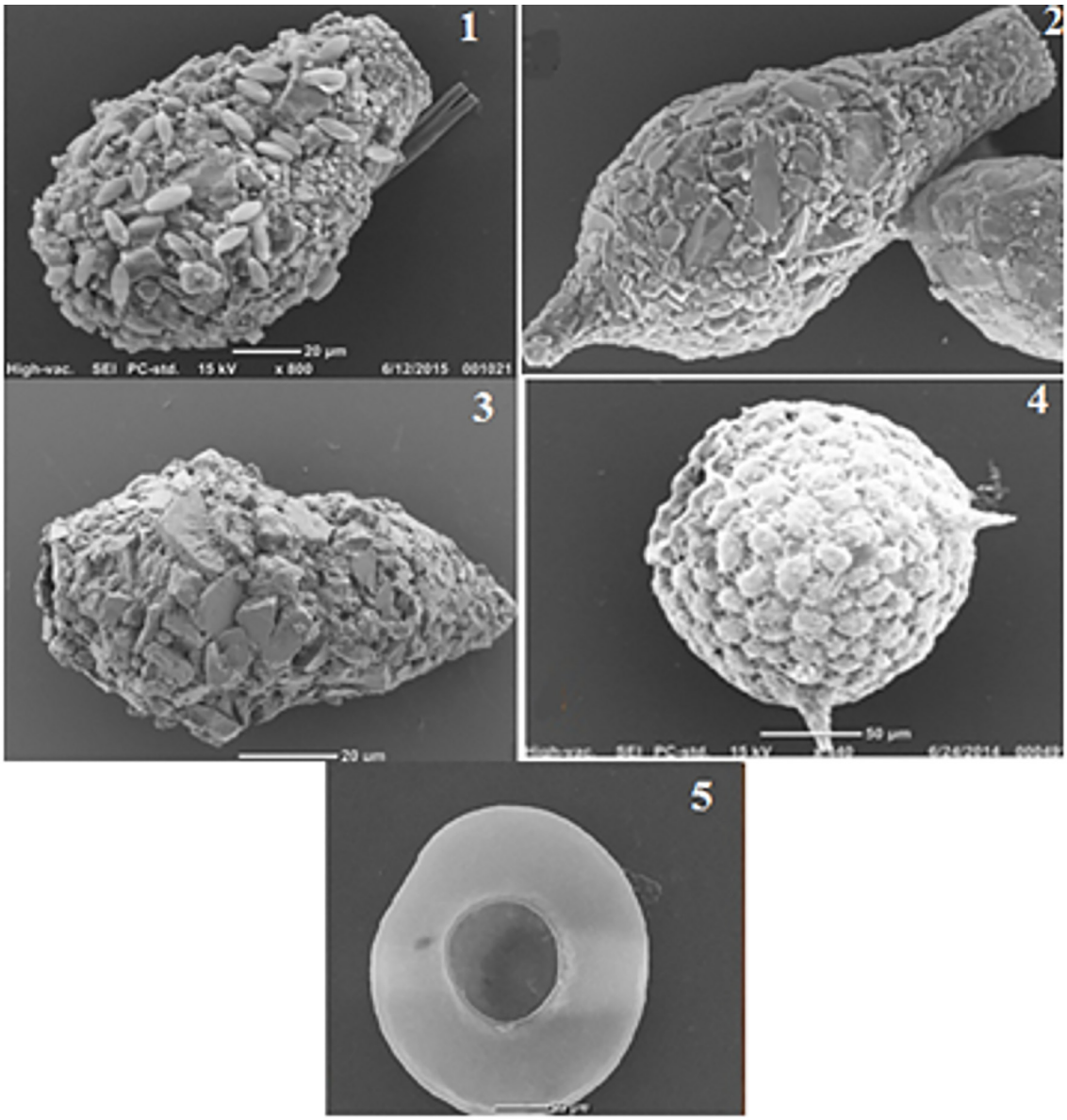

Fig. 4. Electron microphotos of new species and subspecies of testate amoebae for the fauna of Caucasus: *1 — Difflugia petricola* Cash, 1909; *2 — D. microclaviformis* Ogden, 1983; *3 — D. biconcava* Ertl, 1964; *4 — D.corona ssp. tuberculata* Vucetich, 1973; *5 — Arcella discoides ssp. scutelliformis* Playfair, 1918

Рис. 4. Электронные микрофотографии новых для фауны Кавказа видов и подвидов раковинных амеб: *1 — Difflugia petricola* Cash, 1909; *2 — D. microclaviformis* Ogden, 1983; *3 — D. biconcava* Ertl, 1964; *4 — D. corona ssp. tuberculata* Vucetich, 1973; *5 — Arcella discoides ssp. scutelliformis* Playfair, 1918

least similarity by species composition was recorded between the above-mentioned regions and the Lankaran region: 44.8 %.

The results of the comparison of testate amoebae species composition of different regions of Lankaran natural area according to the Czekanowski index are presented in Table 3.

Based on the obtained data, it follows that the highest similarity coefficient was observed for the Lerik and Yardimli regions (40.34 % similarity); the lowest similarity was observed between the testaceans fauna of Jalilabad and Lankaran districts (29.0 % of similarity).

CONCLUSION

A comparison of species diversity of freshwater testate amoebae of South-Eastern Azerbaijan showed that their similarity varies

within 44.8 % and 65.6 %. The high level of similarity between the fauna of testate amoebae of the south-eastern and north-eastern parts of Azerbaijan is related to the similarity in geography and climate of both areas. Although studies on freshwater testate amoebae fauna of different regions of Azerbaijan were conducted, there is a need for additional studies in the future for accurate comparison of testate amoebae fauna similarity.

References

Alekperov, I., Asadullaeva, E., Zaidov, T. (1997) *Metody sbora i izucheniya svobodnozhivushchikh infuzorij i rakovinnykh ameb [Collection methods and study of free-living ciliates and testate amoebae]*. Saint Petersburg: Sajgon Publ., pp. 1–51. (In Russian)

Alekperov, I. Kh., Snegovaya, N. Yu. (2000) The fauna of testate amoebae (Protozoa, Rhizopoda, Testacea) in freshwater basins of Apsheron peninsula. *Protistology*, vol. 1, no. 4, pp. 135–147. (In English)

Bray, R. J., Curtis, J. T. (1957) An ordination of the upland forest communities of Southern Wisconsin. *Ecological Monographs*, vol. 27, no. 4, pp. 325–349. DOI: 10.2307/1942268 (In English)

Czekanowski, J. (1913) *Zarys metod statystycznych: w zastosowaniu do antropologii [Outline of statistical methods in relation to anthropology]*. Warsaw: Nakł. Towarzystwa Naukowego Warszawskiego, IV, 228 p. (Prace Towarzystwa Naukowego Warszawskiego. 3. Wydział Nauk Matematycznych i Przyrodniczych [Works of Warsaw Scientific Society. 3. Department of Mathematical and Natural Sciences]. No. 5). (In Polish)

Snegovaya, N., Alekperov, I. (2005) Fauna of testate amoeba of the western Azerbaijan rivers. *Protistology*, vol. 4, no. 2, pp. 149–183. (In English)

Snegovaya, N. Yu., Alekperov, I. Kh. (2009) New testate amoebae (Protozoa, Testacea) from the northern-east Azerbaijan inland water bodies. *Protistology*, vol. 6, no. 2, pp. 111–125. (In English)

Snegovaya, N. Yu., Tahirova, E. N. (2015) A new species of testate amoebae of the genus *Difflugia* from the freshwaters of Azerbaijan (Rhizopoda, Testacea, Difflugiidae). *Vestnik zoologii*, vol. 49, no. 2, pp. 99–104. DOI: 10.1515/vzoo-2015-0010 (In English)

Snegovaya, N. Yu., Tahirova, E. N. (2018) The new and rare species of the testate amoebae (Amoebozoa: Arcellinida) from mountain lakes of Azerbaijan. *Protistology*, vol. 12, no. 1, pp. 38–46. DOI: 10.21685/1680-0826-2018-12-1-3 (In English)

Tahirova, E. (2018) The fauna of testate amoebae in freshwater basins of Jalilabad and Yardimli districts in the Lankaran natural area (Rhizopoda, Testacea). *Proceedings ANAS Biological and Medical Sciences*, vol. 73, no. 1, pp. 98–103. (In English)

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