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ZOOPLANKTON, ZOOBENTHOS, AND ZOOPERYPHYTON

Freshwater Testate Amoebae in the Belaya River Basin (Northwestern Caucasus)

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Abstract—Fifty-two species and intraspecific taxa of testate amoebae have been detected in 24 different habitats in the Belaya River basin (Northwestern Caucasus). Four types of communities are distinguished which differ in the composition of the complex of dominating species: freshwater species from bottom sediments in water bodies and water courses, soil-dwelling species from inundated parts of floodplains, a mixture of soil-dwelling and freshwater species in different littoral biotopes, and eurybiontic species in moss hummocks along the banks.

Keywords: testate amoebae, types of communities, Northwestern Caucasus, Belaya River, Kuban River basin

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INTRODUCTION

Testate amoebae are a widespread group of protists which occurs in freshwater, swampy, and soil habitats [3]. Despite the long history of their studies in fresh waters [4, 5] it is still unclear how the communities of testate amoebae, which are typical of bottom sediments in fresh waterbodies, are transformed into such communities in terrestrial habitats. One possible answer to this question was provided when the pattern of communities along the river–land transects [5] in the Medveditsa River (the Don River basin) was analyzed.

We used a different approach for the comparison of different biotopes in the Belaya River basin (the Kuban River basin, Northwestern Caucasus). Earlier testate amoebae were not studied in water courses and littoral floodplain biotopes in the region.

MATERIALS AND METHODS

In October 2015, different types of biotopes were studied in the Belaya River basin along the elevation gradient at an altitude from 800 m (Caucasian State Nature Reserve) to 20 m (Krasnodar Reservoir).

The Belaya River is a typical watercourse for the northwestern part of the Caucasus. Its length is >260 and the total fall is 2283 m; the gradient is 840 cm per km. In the upper reaches the river flows through deep and narrow ravines; in the lower reaches the river runs through the valley and its mountain character changes into quiet plain one. When passing through the stanitsa of Abadzekhskaya, village of Tulsky, and cities of Maikop and Belorechensk, waters of the Belaya River enter the Krasnodar Reservoir [6]. A total of 72 samples from 24 biotopes, three samples from each biotope, were analyzed (table). The volume of each sample was 5 sm^3. Immediately after collection, samples were fixed in 4% formaldehyde.

Samples for microscopy analysis were prepared following a modified common method based on the filtration and concentration of water suspensions [2]. Each sample was soaked in water and stirred intensively to extract testate amoebae. The suspension was filtered through a sieve with a mesh size of 1 mm to remove the coarse particles which can mask testate amoebae during their examination under microscope. The filtrate was settled to deposit shells. The supernatant fluid was poured out, and the remaining amount of filtrate was left to settle down. Then the supernatant was carefully pipetted to a volume of 10 mL. For identification and counting the abundance of testate amoebae, the suspension was placed in a Petri dish where live cells and empty shells were counted. The samples were examined at a magnification of ×160 using an Axoistar plus microscope (Carl Zeiss).

The pattern of variability of the community of testate amoebae was determined using the detrended cor-

Characteristic of sampling sites

Biotope		Geographic coordinate, N, E	Altitude above sea level, m	Characteristic of substrate
Number	Name			
1	Krasnodar Reservoir, bottom sediments	45°05′74.9″, 39°32′17.6″	19.8	Loamy sand, tussocks of cereals, well-developed aquatic vegetation
2	Giaga River, Bottom sediments	45°03′12.3″, 39°53′80.0″	51.6	Sand, very slow current, well-developed aquatic vegetation
3	Pond in the village of Velikovechnoe, Belorechenskii raion	44°55′76.6″, 39°46′77.9″	67.0	Sand, pebble, very slow current
4	Gryaznukha River	44°58′90.1″, 40°05′02.0″	73.4	Silt, flooded soil (many plant roots), slow current, well-developed aquatic vegetation, water surface of the river is covered with duckweed
5	Temporal waterbody in Shovgenovskii raion	44°58′90.1″, 40°05′02.0″	73.4	A flooded part of hydrophyte meadow, soil
6	Waterbody in Belorechenskii raion near the destroyed plant	44°50′59.9″, 39°49′42.1″	92.4	Green surface moss near the bank
7	Belaya River	44°35′92.5″, 40°06′04.0″	196.6	Stony bottom with sand, stones are incrusted with green algae, strong current
8	Waterbody within the city of Maikop Zelenstroy raion)	44°35′72.3″, 40°04′07.6″	206.3	Sand with a small amount of silt deposits
9	The same	44°35′72.3″, 40°04′07.6″	206.3	Silt, aquatic vegetation
10	Pond in the city of Maikop (Mikhailovo raion)	44°34′54.7″, 40°08′15.6″	230.2	Sand with pebbles, silt deposit, aquatic vegetation
11	Spring in the city of Maikop (Mikhailovo raion)	44°34′54.7″, 40°08′15.6″	230.2	Green moss submersed in water
12	Arboretum of the Adyghe State University, bend of the Kurdzhips River in the vicinity of the village of Krasny Most	44°36′00″, 40°06′00″	238.0	
13	Pond in the city of Maikop (near the infectious diseases hospital)	44°35′68.7″, 40°08′52.8″	244.6	Encrusting filamentous algae on stones
14	Pond in the village of Udobny	44°33′24.5″, 40°09′76.2″	245.4	Sand with pebbles, aquatic vegetation, water surface of the pond is covered with duckweed
15	Temporary waterbody near Sane plant	44°33′45.1″, 40°08′84.6″	247.0	A flooded part of hydrophyte meadow, filamentous algae, soil
16	Temporary waterbody upstream the stanitsa of Dakhovskaya	44°12′59.7″, 40°12′11.1″	580.0	Flooded soil, silt, filamentous algae
17	Khamyshinka River	44°05′58.5″, 40°07′32.6″	600.0	Stony bottom of a small mountain river, encrustations of filamentous algae on stones
18	Lipovaya River	44°05′19.3″, 40°08′35.4″	600.0	Stony silty bottom of a small mountain river
19	The same	44°05′19.3″, 40°08′35.4″	600.0	Green moss on stone
20	Granitny canyon, Divny Sad spring	44°09′58.2″, 40°08′47.0″	620.0	Green moss near the butt of a near-shore tree (with an upper layer of litter)
21	The same	44°09′58.2″, 40°08′47.0″	620.0	Green moss on stone
22	Molchepa River	43°59′45.6″, 40°08′16.3″	800.0	Stony bottom with coarse sand of a rapid mountain river
23	Brook in the ravine	43°59′45.6″, 40°08′16.3″	800.0	Green moss on stone
24	Balka no. 2 (a small waterbody, a tributary of the Molchepa River)	43°59′45.6″, 40°08′16.3″	800.0	Green moss on soil. Water is transparent, leaf litter, rather strong current

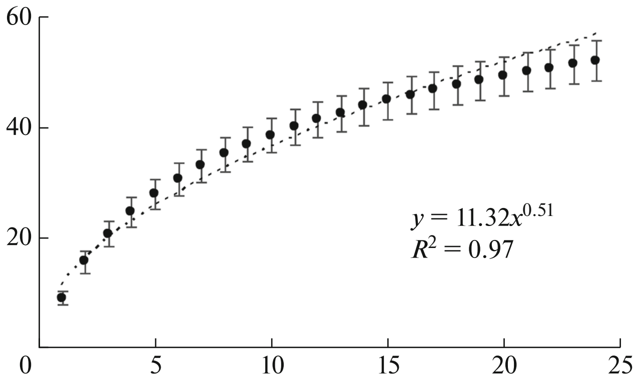

Fig. 1. Changes in the number of found species (ordinate axis) depending on the number of studied habitats (abscissa axis). The curve of the approximate power function is indicated by a dotted line. Error bars show error of the mean.

respondence analysis on the basis of the data on the relative abundances of dominant (>8% of the total abundance, at least in one of the biotopes) species of testate amoebae. All calculations were performed using PAST 2.17b statistical software package.

RESULTS AND DISCUSSION

A total of 52 species and forms of testate amoebae were found. The species richness varied from one (biotope 7) to 15–16 taxa (biotopes 18 and 6, respectively). The number of taxa in a biotope averaged nine. The species richness increased gradually with the number of analyzed biotopes (Fig. 1). The cumulative curve did not reach the plateau, which is confirmed by the low power of the approximation function. This indicates that the study of new biotopes in the region should result in findings of new species of testate amoebae.

The abundance of shells in different biotopes differed by two orders of magnitude and varied from 100 ind./10 mL (biotope 7) up to 10000 ind./10 mL (biotope 14). On the whole, the abundance depends neither on the altitude above sea level nor the type of the biotope (Fig. 2).

Four community types were distinguished in respect to the species structure (Fig. 3). The community of type I was formed in sandy–silty bottom sediments of water courses and waterbodies at different heights. Typical freshwater species of testate amoebae such as *Difflugia oblonga* Ehrenberg, 1838; *D. bryophila* Jung, 1942; *D. gramen* Penard, 1902; *D. pyriformis* Perty, 1849; *Centropyxis ecornis* Leidy 1879; *C. aculeata* Stein, 1857; and *Arcella rotundata* Playfair, 1918 prevailed in these communities (biotopes 1–3, 8, 9, 14, 17, 18). In contrast to the community of type I, the community of type II was formed in periodically flooded soils. The species composition typical for such soils (biotopes 5, 12, and 16) included *Plagiopyxis labiata* Penard, 1910; *Centropyxis aeropila* Deflandre, 1929; *C. orbicularis* Deflandre, 1929; and *Cyclopyxis kahli* Deflandre, 1929. The communities of type III, which were intermediate in the structure, were represented by a mixture of soil-dwelling (*Plagiopyxis minuta*

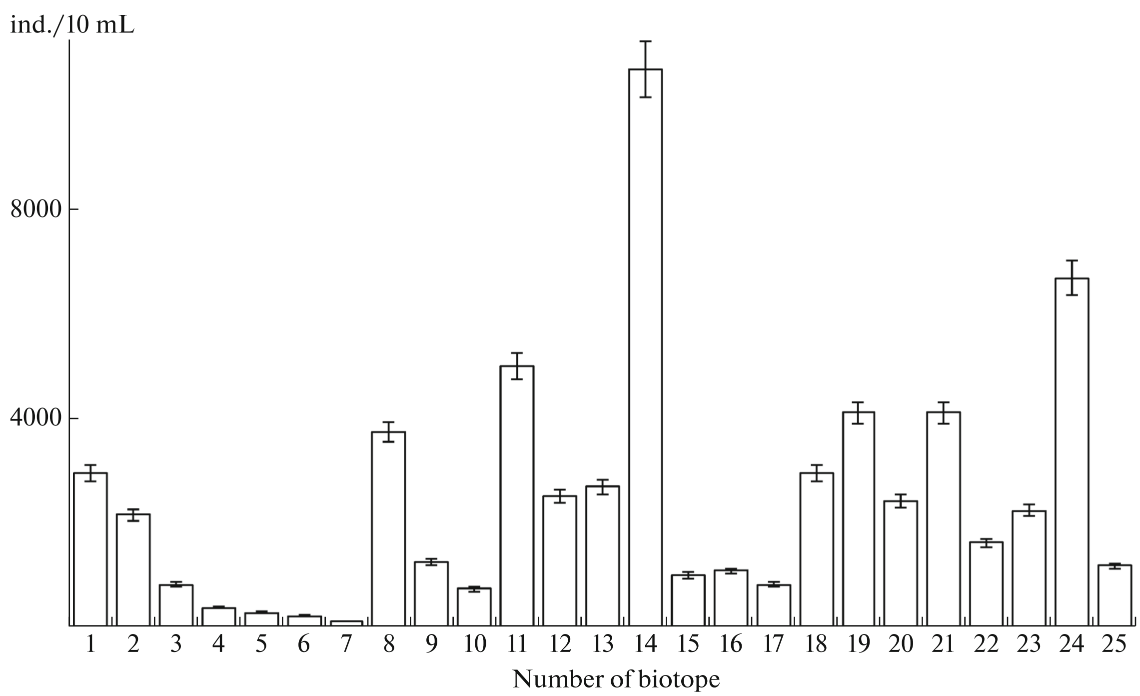

Fig. 2. Abundance (ordinate axis) of testate amoebae in different habitats (abscissa axis). Error bars show error of the mean.

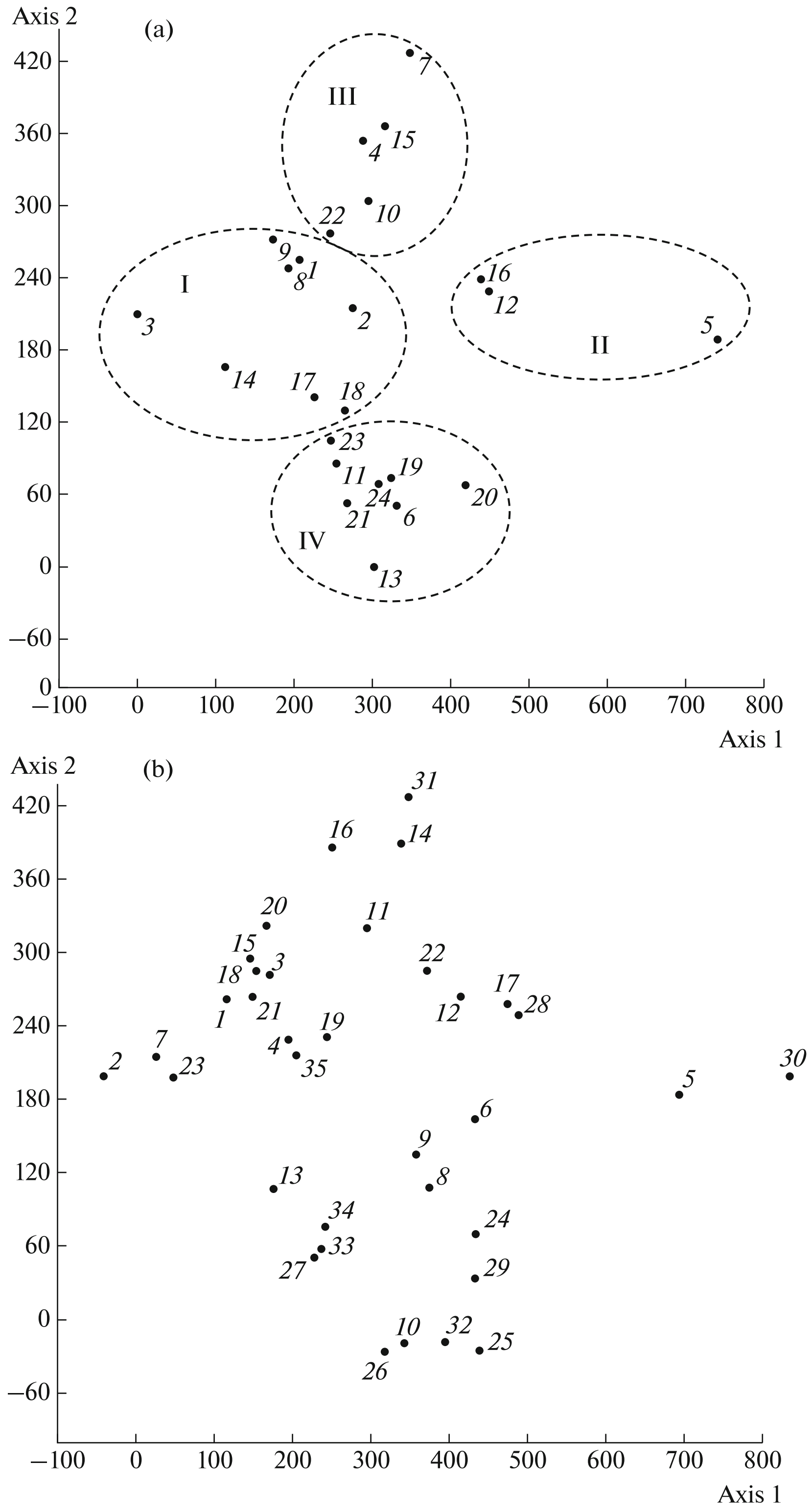

Fig. 3. Results of ordination of communities by detrended correspondence analysis: (a, b) distribution of habitats (a) and species (b) within the space of ordination axes. Species: (*1*) *Arcella arenaria compressa*, (*2*) *A. rotundata*, (*3*) *Centropyxis aculeata*, (*4*) *C. aculeata oblonga*, (*5*) *C. aerophila*, (*6*) *C. aerophila sphagnicola*, (*7*) *C. ecornis*, (*8*) *C. elongata*, (*9*) *C. orbicularis*, (*10*) *C. platystoma*, (*11*) *Cyclopyxis eurystoma*, (*12*) *C. kahlii*, (*13*) *Cyphoderia ampulla crassa*, (*14*) *Difflugia acuminata*, (*15*) *D. bryophila*, (*16*) *D. corona*, (*17*) *D. elegans*, (*18*) *D. gramen*, (*19*) *D. linearis*, (*20*) *D. oblonga*, (*21*) *D. pyriformis*, (*22*) *D. shurmanni*, (*23*) *Euglypha acanthophora*, (*24*) *E. ciliata glabra*, (*25*) *E. laevis*, (*26*) *E. rotunda*, (*27*) *E. tuberculata*, (*28*) *Lagenodifflugia vas*, (*29*) *Plagiopyxis callida*, (*30*) *P. labiata*, (*31*) *P. minuta*, (*32*) *Trinema complanatum*, (*33*) *T. enchelys*, (*34*) *T. lineare*, and (*35*) *Zivkovicia compressa*. (I–IV) Types of communities which differ in the composition of the complex of dominant species. Axes 1 and 2 demonstrate 39.6% of the total dispersion of the species structure.

Penard, 1910, *Cyclopyxis eutystoma* Deflandre, 1929) and aquatic (*Difflugia corona* Wallich, 1864; *D. acuminata* Ehrenberg, 1838; *D. shurmanni* van Oye, 1932; and *D. elegans* Penard, 1890) testate amoebae. Such communities were formed in different biotopes (4, 7, 19, 15, and 22) in sandy–silty sediments of waterbodies and/or in flooded soils. Specific communities (type IV) developed in hummocks of green mosses (biotopes 6, 11, 13, 20, 21, 23, and 24), where eurybiontic amoebae from the group Rhizaria (*Euglypha laevis* Perty, 1849; *E. rotunda* Wailes, 1915; *E. ciliata glabra* Wailes, 1915; *Trinema lineare* Penard, 1890; *T. enchelys* Leidy, 1878; and *T. complanatum* Penard, 1890) and Amoebozoa (*Centropyxis platystoma* Deflandre, 1929 and *Plagiopyxis callida* Penard, 1910) were dominant.

In general, the subdivision of communities into variants corresponds to our data which were obtained earlier [5] and evidence of the rather distinct subdivision of communities which are formed in bottom sediments of water bodies and inundated floodplain soils. It is also confirmed [1, 8, 9] that the communities of testate amoebae on moss hummocks are formed, mainly, by eurybiontic species, which differs them from soil and aquatic associations.

CONCLUSIONS

As a result of the study, 52 species and intraspecific taxa of testate amoebae were recorded in 24 different biotopes in the Belaya River basin (Republic of Adygea, Russia). It is found that the abundance does not depend on the altitude above sea level or type of biotope. Four types of communities are distinguished which differ in the composition of the complex of dominating species: freshwater species from bottom sediments in water bodies and water courses, soil-dwelling species from inundated parts of floodplains, a mixture of soil-dwelling and freshwater species in different littoral biotopes, and eurybiontic species in moss hummocks along the banks.

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