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Free-living protozoa (ciliates and testate amoebae) in the freshwaters of the Nakhchivan autonomous republic

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Abstract

Between 2017 and 2022, studies on ciliated protozoa and testate amoebae were conducted in the freshwater ecosystems of the Nakhchivan Autonomous Republic. To date, 110 species of ciliates and 65 species of amoebae have been identified in the region's freshwater habitats. It was observed that the species diversity of infusoria in freshwater is nearly twice as high as that in soil, though the differences in species diversity between aquatic and soil amoebae are relatively small. The article highlights the need for standardization in the methods employed by researchers. Further studies of these protozoan groups are essential for drawing more accurate conclusions about their ecological roles, interrelationships, and their significance in various biological processes.

Keywords: Infusoria, testate amoebae, freshwater, soils, Azerbaijan

Introduction

Among other protozoan groups, free-living ciliates and amoebae play a pivotal role in the transformation of organic matter (Foissner, 2008; 2016) ^[8, 9]. These unicellular organisms serve as primary consumers and, in turn, as a food source for many small aquatic organisms; they actively contribute to the production and decomposition of organic matter at the primary trophic levels (Pavlovskaya, 1969; 1973) ^[14, 15]. It has long been established that free-living ciliates exhibit rapid responses to even minor environmental changes, making them valuable tools for bioanalysis at both the cellular and community levels (Railkin, 2011) ^[16]. Despite the recognized importance of studying ciliates and testate amoebae, these two primitive groups-particularly testate amoebae-remain under-researched in Azerbaijan compared to Russia. In contrast, amoebae have been extensively studied by numerous foreign researchers (Geltser *et al.*, 1995; Bobrov, 1999; Korganova, 2004; Zharikov, 2001) ^[10, 6, 11, 19].

The earliest information on these protozoan groups in Azerbaijan can be found in the works of Weisig (1940) and Alizade (1939; 1942). Based on their findings, it was established that prior to the modern era of research, approximately 70 species of ciliates and 28 species of testate amoebae were documented in Azerbaijan's fauna. Currently, the study of ciliates in the region has reached a relatively satisfactory level.

It should be mentioned that according to recent estimates, 757 species of ciliates and 265 species of amoebae have been recorded in the waters and soils of Azerbaijan.

Building on this data, we conducted a comparative study of the species diversity, distribution, and ecological characteristics of these primitive groups of free-living ciliates and amoebae in the freshwaters of the autonomous republic. The classification system for free-living ciliates followed Lynn (2008) ^[12], while the taxonomy of testate amoebae was based on the eukaryotic system proposed by an international team of experts (Adl *et al.*, 2005) ^[1].

Quantitative analysis of both ciliates and testate amoebae was carried out using the 'non-concentrated' live sample counting method. To determine the species composition of ciliates, the kinetome impregnation techniques using nitrate (Chatton & Lwoff, 1930) ^[7] and silver proteinate (Aleksparov, 1992) were widely employed. Identification of testate amoebae was performed using a scanning electron microscope (JCM 6000, JEOL).

The similarity of species diversity between protozoan groups in aquatic biotopes across different regions was evaluated using Bray-Curtis cluster analysis (Sørensen, 1948) ^[17].

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The species' quantitative ratio was calculated as the ratio of individual species counts to the total number of species (N) in the sample. Based on the results, ciliates and testate amoebae were classified into groups according to Tischler's classification (Tischler, 1955) [18]:

1. The group of dominating species - up to n/N 5%.
2. The group of sub-dominating species - up to 2% n/N.
3. The group of presedent species - up to n/N 1% (small).
4. The group of sub-presedent species - less than n/N 1% (random).

All the results were processed through Biodiversity Professional 2 computer.

Results of the study

The studies conducted by us revealed that only 10 species of ciliates and 75 species of testate amoebae were identified in the water bodies of the autonomous republic. The species composition and distribution of these protozoan groups are detailed.

The findings indicate that the species composition of amoebae across the three collection sites varies significantly, ranging from a minimum of 31 species to a maximum of 43 species in freshwater habitats.

Additionally, it should be noted that certain groups of free-living ciliates and testate amoebae show a clear preference for either aquatic or terrestrial biotopes. During the study period, the following ciliate species were consistently observed in all freshwater environments: *Anigsteinia salinara*, *Blepharisma tardum*, *B. hyalinum*, *Condylostoma reichii*, *Spirostomum teres*, *Urostyla grandis*, *U. magna*, *Halteria grandinella*, and *Aspidisca steini*.

Among the testate amoebae identified in water bodies, the following species were recorded: *Cyclopyxis eurystoma*, *C. penardi*, *Trigonopyxis arcuata*, *Centropyxis aculeata* var. *oblonga*, *C. minuta*, *C. elongata*, *Diffflugia difficilis*, *D. oblonga*, *D. labiosa*, *Pentagonia azerbaijanica*, *P. compressa*, and others.

Long-term observations of seasonal changes in freshwater ciliate colonies revealed a predominantly dual pattern in their qualitative and quantitative development. In small, temporary reservoirs that often dry up during summer, the maximum abundance of ciliates was typically observed in the spring. However, in autumn, when rainwater refilled these reservoirs and increased their total volume, no significant growth in species diversity or abundance was noted.

The generalized results of assessing the significance of ciliate species in freshwater ecosystems revealed a distinct group of species that are present in water bodies almost year-round, occasionally disappearing from communities only during the winter season. These species include *Oxytricha tenella*, *Euplotes harpa*, *E. balteatus*, *Lacrymaria olor*, *Coleps cucullus*, *Cilodonella spiralis*, *Paramecium caudatum*, *Cyclidium citrullus*, and *Uronema elegans*. Notably, these background species, despite their consistent presence, are typically found in low numbers as single specimens. Their population tends to increase alongside other species during the warmer months. Regarding the quantitatively dominant species in freshwater communities, it is important to note that the core of dominant and subdominant species often varies significantly between different water bodies. This variation is reflected in the replacement of certain dominant species in one water

body by others, which may be subdominant or even rare in neighboring water bodies. Additionally, species dominance is often restricted to specific seasons. For instance, members of the genera *Euplotes* and *Aspidisca*, along with lower-group ciliates such as *Halteria grandinella*, *Heterostrombidium calkinsi*, and *Strombidium conicoides*, exhibit peak quantitative growth in the spring. Conversely, species such as *Oxytricha tenella*, *Lacrymaria kahli*, *Mesodinium acarus*, *Uronema nigricans*, and *Carchesium aselli* become numerically dominant in the autumn.

For freshwater testate amoebae, similar patterns observed in ciliates also apply. Background species in freshwater communities are primarily represented by the genera *Arcella*, *Cyclopyxis*, *Centropyxis*, and *Diffflugia*. Dominant and subdominant groups in these environments include *Arcella hemispherica*, *A. diskoides*, *Cyclopyxis eurystoma*, *Centropyxis aculeata*, and the particularly abundant genus *Diffflugia*.

To summarize the above, it can be noted that the species diversity of free-living ciliates (110 species) and testate amoebae (65 species) in the water bodies of the autonomous republic was found to be notably high.

Conclusion

The study revealed a high species diversity of free-living ciliates (110 species) and testate amoebae (65 species) in the Nakhchivan Autonomous Republic's freshwater ecosystems. The findings emphasize the ecological significance and seasonal variations of these protozoa, with notable dominance patterns and habitat preferences. Continued research is essential to further understand their roles in ecosystem functioning and biodiversity conservation, as well as to enhance methodological consistency in future studies.

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