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Seasonal Changes in Total Quantity and Biomass of Soil Ciliates of Samur-Yalama National Park

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Abstract
The seasonal changes in the quantitative development of ciliates pedobionts in forest and cultivated soils of Samur-Yalama National Park have been investigated. Long-term observation of the quantitative development of the free-living ciliates of soil communities in different areas of the Samur-Yalama National Park showed that, occasionally two distinct maximum number of development and biomass of ciliates pedobionts attributable to the spring and autumn seasons are observed at fixed points located at a distance from settlements. It was found that species diversity of soil ciliates considerably had reduced in the places of strong anthropogenic influence and the main development accounts for a small number of species eurybionts, occasionally developing a large number.

Keywords: Azerbaijan, soil ciliates, abundance, biomass, seasonal changes

Introduction
At present there is no doubt about a great role of ciliates pedobionts in a wide variety of biological processes occurring in the soil. As in most bacteriophages large quantities of ciliates consume found in the soils of different bacteria, including pathogenic than contribute biopurification and production of organic matter, and ultimately increase soil fertility. Long duration of soil ciliates is not taken into account in the investigation of soil fauna, but now studies by several authors [1, 2, 3, 5, 6] have found that the mass development of the biomass of soil ciliates can be tens kilograms per hectare of soil, which is comparable with the biomass of many multicellular representatives of soil fauna.
The purpose of our research were the seasonal adjustments to the quantitative indicators of soil ciliates as well as influence on them of human impact.

Materials and methods
- In the period of 2012-2015s 870 soil samples have been collected and processed at 9 fixed collecting points (Figure 1) located in the areas of the Samur-Yalama National Park with various degrees of human activity impact. In addition to evaluating the impact of human activities on soil fauna - on the pattern of communities of ciliates pedobionts, we collected and processed 120 soil samples with gardens, orchards and forest soils in the vicinity of settlements.

We used a universal method of direct counting of non-concentrated samples in order to quantify the number of soil ciliates [2]. Although this method requires certain skills and experience, it has received more reliable results recently. For the taxonomic identification we widely used methods of impregnation nitrate [4] and silver protein [1], at present it has become mandatory in the investigation of free-living ciliates.

Results and Discussion
Altogether during our research in the period of 2012-2015s 180 species of free-living ciliates were observed in soils of Samur-Yalama National Park. We have specified 58 species of all number for the first time for the fauna of the Caucasus (Table 1).

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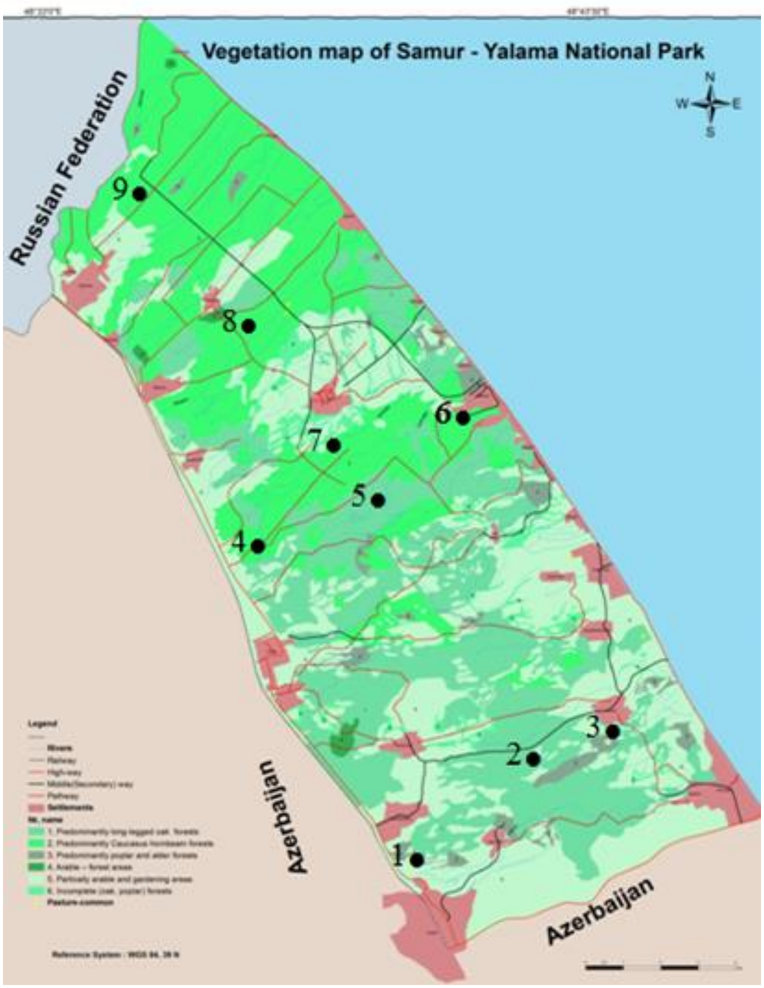

Fig 1: Points of collecting soil samples in the Samur-Yalama National Park

Table 1: The soil ciliates species new for Caucasus fauna from Samur -Yalama National Park

Ciliates species	Sample points								
	1	2	3	4	5	6	7	8	9
Fam. Amphisiellidae Jank., 1979									
1. *Amphisiella acuta* Foissner, Agata, Berger, 1982		+			+		+	+	+
2. *A. magnigranulosa* Foissner, 1988		+			+		+	+	
3. *Hemiamphisiella granulifera* Foissner,1987		+			+		+	+	+
4. *H. terricola* Foissner,1988					+	+	+		+
5. *Periholosticha lanceolata* Hemberger, 1982		+			+		+	+	
Fam. Oxytrichidae Ehrenberg, 1838									
6. *Oxytricha elegans* Foissner, 1999		+		+			+	+	+
7. *O. longa* Gelei et Szabados, 1950					+		+	+	+
8. *O. longigranulosa* Berger et Foissner, 1989		+		+	+		+	+	
9. *Wallaskia bujorani* Lepsi,1951	+	+	+	+	+	+	+	+	+
10. *Australocirrus oscitans* Blatterer et Foissner, 1982					+		+		+
11. *A. zechmeisterae* Foissner,Berger,Xu and Zechmeister-Boltestern, 2005					+		+	+	+
Fam. Gonostomatidae Small and Lynn,1985									
12. *Gonostomum singhii* Kamran, Kumar, Sapra, 2008					+		+	+	
13. *Paragonostomum simplex* Foissner, Berger Xu and Zechmeister-Boltestern, 2005		+		+	+	+			
Fam. Urostylidae Bütschli, 1889									
14. *Holostycha australis* Blatterer et Foissner, 1988	+				+	+	+		+
15. *H. pullaster* Müller, 1773					+		+	+	
16. *Paraurostyla caudata* (Stokes), 1886	+	+			+			+	+
17. *Birojimia terricola* Berger and Foissner, 1989		+		+	+		+		+
Fam. Spathidiidae Kahl, 1929									
18. *Epispathidium ascendes* (Wenzel), 1965	+			+			+		+
19. *E. polynucleatum* Foissner, Agatha et Berger, 2002		+				+			+
20. *E. terricola* Foissner, 1986	+			+		+	+		+
21. *Latispathidium truncatum* Foissner, Berger, Xu Zechmeister-Boltenstern, 2005	+				+			+	+
Fam. Tracheliidae Ehrenberg, 1838									
22. *Dileptus costaricanus* Foissner,1995				+			+	+	+
23. *D. visscheri* Dragesco, 1963	+			+			+	+	+

Fam. Litonotidae Kent, 1882									
24. *Litonotus triqueter* Penard, 1922	+				+			+	
25. *L. muscorum* (Kahl, 1931)			+		+			+	
Fam. Chilodonellidae Deroux, 1970									
26. *Trithigmostoma bavariensis* (Kahl, 1931)		+		+	+		+		
27. *Alinostoma multivacuolata* Alekperov, 1993	+		+						
28. *A. polyvacuolatum* (Foissner et Didier, 1981)	+					+	+		+
Fam. Nassulidae Fromentel, 1874									
29. *Nassula terricola* Foissner, 1989			+	+				+	+
30. *N. exigua* Kahl, 1931		+			+				
Fam. Pseudomicrothoracidae Jankowski, 1967									
31. *Pseudomicrothorax agilis* Mermod, 1914		+				+	+	+	+
Fam. Microthoracidae Wrzesniowski, 1870									
32. *Microthorax glaber* Kahl, 1926						+	+		+
33. *M. elegans* Kahl, 1931	+			+					
34. *Stammeridium kahli* Wenzel, 1969		+			+		+	+	
35. *Drepanomonas sphagni* Kahl, 1931	+	+	+	+	+	+	+	+	+
36. *D. pauciciliata* Foissner, 1986	+	+	+	+	+	+	+	+	+
Fam. Colpodidae Bory de St. Vincent, 1838									
37. *Colpoda ecaudata* (Liebmann,1936)	+	+		+		+	+		+
38. *C. lucida* Greeff, 1888		+			+		+	+	+
39. *C. orientalis* Foissner, 1993		+			+		+	+	+
40. *C. variabilis* Foissner, 1980	+			+			+	+	
Fam. Hausmanniellidae Foissner, 1987									
41. *Hausmanniella patella* (Kahl,1931)					+		+		
42. *H. discoidea* (Gellert, 1956)				+			+		
Fam. Cyrtolophosididae Stokes, 1888									
43. *Cyrtolophosis acuta* Kahl, 1926		+				+		+	+
Fam. Grossglockneriidae Foissner, 1980									
44. *Grossglockneria acuta* Foissner, 1980				+	+		+		
45. *G. hyalina* Foissner, 1985		+						+	+
Fam. Plagiocampidae Kahl, 1926									
46. *Plagiocampa incisa* Kahl, 1933		+			+			+	+
47. *P. multiseta* Kahl, 1930	+	+	+	+	+	+	+	+	+
Fam. Urotrichidae Small et Lynn, 1985									
48. *Urotricha striata* Penard, 1922				+			+		+
Fam. Frontoniidae Kahl, 1926									
49. *Frontonia disciformis* Alekperov, Obolkina, Wilbert, 2012	+	+	+	+	+	+	+	+	+
50. *F. solea* Foissner, 1986		+		+	+				+
Fam. Turaniellidae Didier, 1971									
51. *Colpidium singular* Vuxanovici, 1962		+			+		+		+
Fam. Tetrahymenidae Corliss, 1952									
52. *Tetrahymena edaphoni* Foissner, 1986	+		+	+				+	
Fam. Spirozonidae Kahl, 1926									
53. *Stegochilum smalli* Alekperov, 1993	+			+			+		+
Fam. Cinetochilidae Perty, 1852									
54. *Sathrophilus agitates* Stokes, 1887	+	+	+	+	+	+	+	+	+
55. *S. mobilis* Kahl, 1926		+	+	+			+	+	+
Fam. Cyclidiidae Ehrenberg, 1838									
56. *Cyclidium heptatrichum* Schewiakoff, 1893	+	+				+		+	
Fam. Uronematidae Thompson, 1964									
57. *Uronemella filicium* (Kahl, 1931)		+			+				+
58. *Cristigera pleuronemoides* Roux, 1899		+			+				+

According to our long-term observations of the changes in the total number and density of certain ciliates populations in nature and in the laboratory, it can be concluded that the balance and the regulation of the number of ciliates pedobionts regulated as random abiotic factors, especially climatic and biotic factors associated with the density population. According to our observations the determining role of various factors first of all depends on the specific conditions of the environment, as well as the properties of the organisms. Under natural conditions in a changing environment the leading role belongs to abiotic, climatic factors, regulation of biotic factors usually dominates on the stable environment abiotically.

It should be noted that the variety of biological mechanisms of density population regulation of ciliates principally is determined by interspecies regulation – i.e. reaction to the density and population status of the species, and the species regulation, i.e. reacting the effect of density and the status of other species populations.

Long-term observation of the quantitative development of the free-living ciliates of soil communities in different areas of the Samur-Yalama National Park showed that, occasionally two distinct maximum number of development and biomass of ciliates pedobionts attributable to the spring and autumn seasons are observed at fixed points located at a distance from settlements (Figure.2A and B).

As it is seen from Fig. 2A, a maximum total number of soil ciliates is observed in spring. In Fig. 2A, the data shows that the total number of ciliates was 325 specimen/dm^2 in 2012 in the spring, in 2013 it was -350 specimen/dm^2, and in 2014 and 2015, characterized by low rainfall in the spring season, the total number of ciliates was considerably lower and equaled 270specimen/dm^2 in 2014.and 250 in 2015.

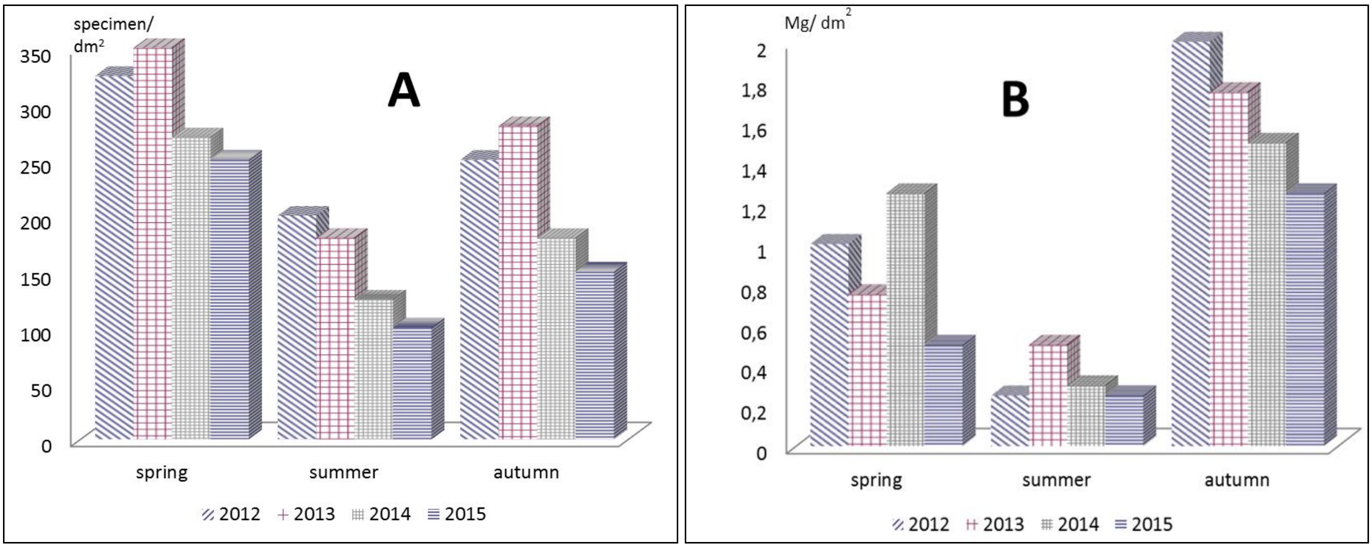

Fig 2: Seasonal changes in the total number (A) and biomass (B) of ciliates pedobionts at the fixed points with minimal human impact (2012-2015).

In summer, the number of ciliates pedobionts greatly reduces primarily due to the low soil moisture at this time. The total number of ciliates pedobionts was 200 specimen/dm^2 in the summer of 2012, in 2013 it was 180 specimen/dm^2, and the minimum total number has been observed in the recent years and has been equal to 125 specimen/ dm^2 in 2014, 100 specimen/dm^2 in 2015.

Besides we have calculated the total biomass of soil ciliates for the mentioned years. It should immediately be noted that, not always the maximum total number of soil ciliates corresponds to their maximum biomass. This is due to strong fluctuations in the individual masses of various species of ciliates. As a result, two or three dozen major species of Hypotrichida are heavier for several times than a few hundred of small Cyclidiidae representatives.

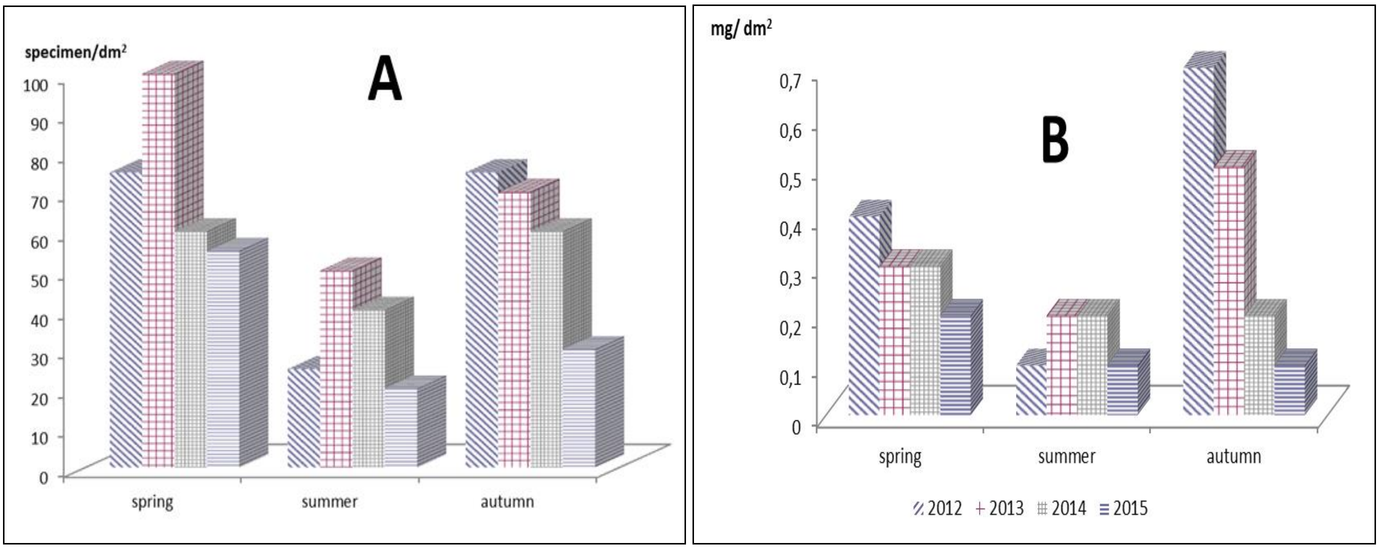

Fig 3: Seasonal changes in the total number (A) and biomass (B) of ciliates pedobionts at fixed point with a strong anthropogenic influence (2012-2015).

Generalized data presented in Fig. 2B on seasonal changes in the total biomass of ciliates pedobionts generally correspond to the data for the total number. It should be noted that the value of the total number of ciliates was significantly higher in the spring than in the autumn during all-time studies. However, in comparison with similar results in terms of biomass, it is obvious that the biomass values of ciliates pedobionts were higher in the spring, despite the lower total number of free-living ciliates in the autumn. As noted above, this is due to the strong difference in the values of the individual masses of different species.

We have carried out similar studies at the fixed points (1.3. 4.6) located near populated centers and inclined to anthropogenic factors. As it is seen from Fig.3A, first of all there is noticeable difference with the previous data on extreme low total number. So, the total number investigated in the spring period changed from 80 specimen/dm^2 in 2012, the maximum was observed in the spring of 2013 and in 2014-2015s the total number relatively equaled to 60 specimen/dm^2 and 55 specimen/dm ^{2}.

We observed the lowest value of the total number in the summer during the investigation. For example, in 2012, it was noted 25 specimen/dm2, in 2013 it was 50 specimen/dm2, in 2014 -40 specimen/dm2, and in 2015 only 20 specimen/dm2. We observed some rises in the total number in the autumn, when the total number of ciliates pedobionts increased to 75 specimen/dm^2 in 2012 in 2013 the total number was 70 specimen/dm^2, in 2014 it decreased to 60 specimen/dm^2, and in 2015 it was only 30 specimen/dm^2. Thus, the data clearly shows that, experiencing the impact of the anthropogenic nearby settlements the total number of ciliates pedobionts almost in an order of magnitude lower than in the rest of the fixed collection point of the Samur-Yalama National Park.

Seasonal changes shown in fig.3B in the biomass of free-living ciliates generally correspond to the above mentioned quantitative data. The minimum biomass was also observed in the summer season. It is noteworthy that in the spring of 2013, the total number of 100 specimen/dm^2 total biomass was only 0.3 mg/dm^2, while total number was 75specimen/dm^2 in the autumn of 2012, the maximum for this fixed point was recorded as 0.7mg/dm^2 of biomass.

Thus, the general laws of the qualitative and quantitative seasonal changes principally are common both for fixed points without human impact and the collection points near populated areas during the research (2012-2015s.). The results showed that the anthropogenic influence appears both in the diversity of species depletion and in a strong reduction of the quantitative characteristics (the total number and biomass) of soil free-living ciliates communities.

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