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Food relationships ciliates with ctenophore of mnemiopsis leidyi in the planktonic communities of the Azerbaijan sector of the Caspian Sea

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Abstract
Presented the results of the research during the 2011 - 2014 period, of planktonic community of the Azerbaijani sector of the Caspian Sea. Revealed the main dominant species of planktonic groups (ciliates - 41, rotifers - 20, cladoceras - 11 and copepods - 13). In nature and in the experimental conditions have been studied food spectrum of species ctenophore *Mnemiopsis leidyi* A. Agassiz, 1865. Revealed the major role of simplest in the nutrition of ctenophore and the dependence of eating different of food objects on their density in the water.

Keywords: plankton, food relationships, ciliates, ctenophore Mnemiopsis leidyi, Caspian Sea

1. Introduction
Back in early eighties of the twentieth century, the exotic invader ctenophore Mnemiopsis leidyi A. Agassiz, 1865 was registered for the first time in the Black Sea. Already in 10 years, this species has been found also in the Azov Sea. Finally in 1999 appeared publications, where was first announced about the findings of Mnemiopsis leidyi in the Caspian Sea (). There are already information about the invasion of this species in the Baltic Sea at present time (private communication). The main way of penetration this species of ctenophore in each of the four seas - it is the ballast water of vessels since the carried investigations have shown that in the ballast tanks of vessels filled into them with the water are present eggs, cysts and even living specimens of many species of hydrobionts (9).
It is known that the homeland of Mnemiopsis leidyi it is desalinated bays of the Atlantic coast of the United States of America, which allowed this species to adapt to existence in the seas with a weak salinity. On the other hand, Mnemiopsis leidyi possesses enormous reproductive capabilities, and is able to produce over 10 thousands of eggs (5). In addition, it has a highly developed ability to regenerate, thus the ability to rapid asexual reproduction. Considering the above it becomes clear that danger of planktonic communities of the Caspian Sea, which emerged after the invasion to the Caspian plankton of the ctenophore.

2. Material and methods
The collection of samples from stationary collection points of littoral zone of the Azerbaijan sector of Caspian Sea for the various groups of zooplankton was carried out in 2011- 2014 (fig. 1). It were collected in coastal area from the boat with the help of the bathometer and the plankton net and processed by hydrobiological standard methods (8, 4). For counting free ciliates used the method of calculation living specimens in the Bogorov's chamber from 3 to 10 times, for taxonomic identification of ciliates used methods of kinetoma silver impregnation (7). For fixation other groups (Rotatoria, Cladocera, Copepoda) used 4% formol solution, and sometimes corrosive sublimate. For painting hydrobionts in the fixing fluid a small amount of dye «Bengal Rose». For species determinantion mainly used books an "Atlas of Invertebrates of the Caspian Sea" [2] and "Atlas free-living ciliates" [1, 6] as well as a number of other publications.
In an experiment has been studied consumption dyed with neutral red ciliate genus Paramecium by young individuals of Mnemiopsis leidyi. Viewing the young ctenophore carried out in a watch glasses and in the petri dishes at certain intervals. The vital staining of ciliates allows accurately enough trace their consumption in food ctenophore even under medium magnification of the microscope (X400). In addition, we carried out the observations on the dependence of consumption ciliates into food from their numbers in the water. To clarify the food spectrum of Mnemiopsis leidyi we put 3 series of 25 experiments in the laboratory conditions. To study the proportion of ciliates in the nutrition of young ctenophore used staining cells with vital dye.

3. Results and discussion
According to recent data (3) in the Azerbaijani sector of the Caspian Sea in the planktonic communities, where marked total 140 species dominates only the 45 species of free-living ciliates. The following number of species it is dominant group of rotifers, which account for a total of 20 species, of crustaceans in plankton communities were marked 13 species of Copepoda and 11 species of Cladocera. The species distribution of the collection of dominant species of main planktonic groups in the Caspian Sea points presented in table 1.
Thus, the representatives of these four main groups constitute currently the backbone of zooplankton community in the Caspian Sea.
As shown by previous research [5] the quantitative development of planktonic ciliates by season revealed two peaks of development - in spring and autumn. Spring maximum of ciliates plankton in the Middle Caspian depend on the development of species such as Mesodinium apsheronicum, M.pulex, Strombidium sulcatum Novistrombidium apsheronicum, with a total number at this time 8 -12 thousand

specimen/L. During the summer, the total number of planktonic ciliates sharply decreases to 2-2, 5 thousand specimen /L.

In the summer the basis of the total number of planktonic ciliates are representatives of genera Codonella, Tintinnidium, Favella and Askenasia, which accounted for 85% of the total.

However, a second lesser peak of the quantitative development was observed in autumn. Usually, we have observed with decreasing water temperature to 13- 15ºC and stipulated by the development of representative genera Mesodinium, Halteria, Pelagohalteria, Strombidium.

In winter, the quantitative development of dominant planktonic ciliates are extremely low and species diversity in this time of the year represented only 15 species, belonging to the genera Monodium, Uronema and Cyclidium.

As already noted above, for our research, a special interest is study the invasive of ctenophore-Mnemiopsis leidyi. It is known that Mnemiopsis leidyi is capable of producing as a huge amount of eggs, as well regenerating missing body fragments. These biological features and the virtual absence in the Caspian Sea the natural enemies promote very quickly sharp increase of its total number in the period of mass breeding. To study the potential impact of Mnemiopsis leidyi on the organisms of the communities of Caspian plankton we carried out in the experimental conditions the comparative study of the most actively feeding of its juveniles 0,5-3,0 sm size, both in nature and in the experimental conditions.

The research has shown that young individuals Mnemiopsis leidyi prefer Copepoda, which amounted 44,.5% of the diet, then Cladocera, which accounted up to 38% and Rotifera, which accounted up to 32,1%. Obtained earlier data about ctenophore nutrition were significantly adjusted. It is extremely difficult to control in nature the use of Mnemiopsis in the food diet of protozoa. The data in the experiment with stained vital paint the Paramecium and Frontonia genera of ciliates showed that their share in the food spectrum of small individuals Mnemiopsis leidyi much higher than has hitherto been known and can reach 32%. Furthermore it turned out that during reproduction hydrobionts with pelagic eggs smaller individuals of ctenophore actively absorb the sprat eggs and small fish in the early stages of ontogenesis.

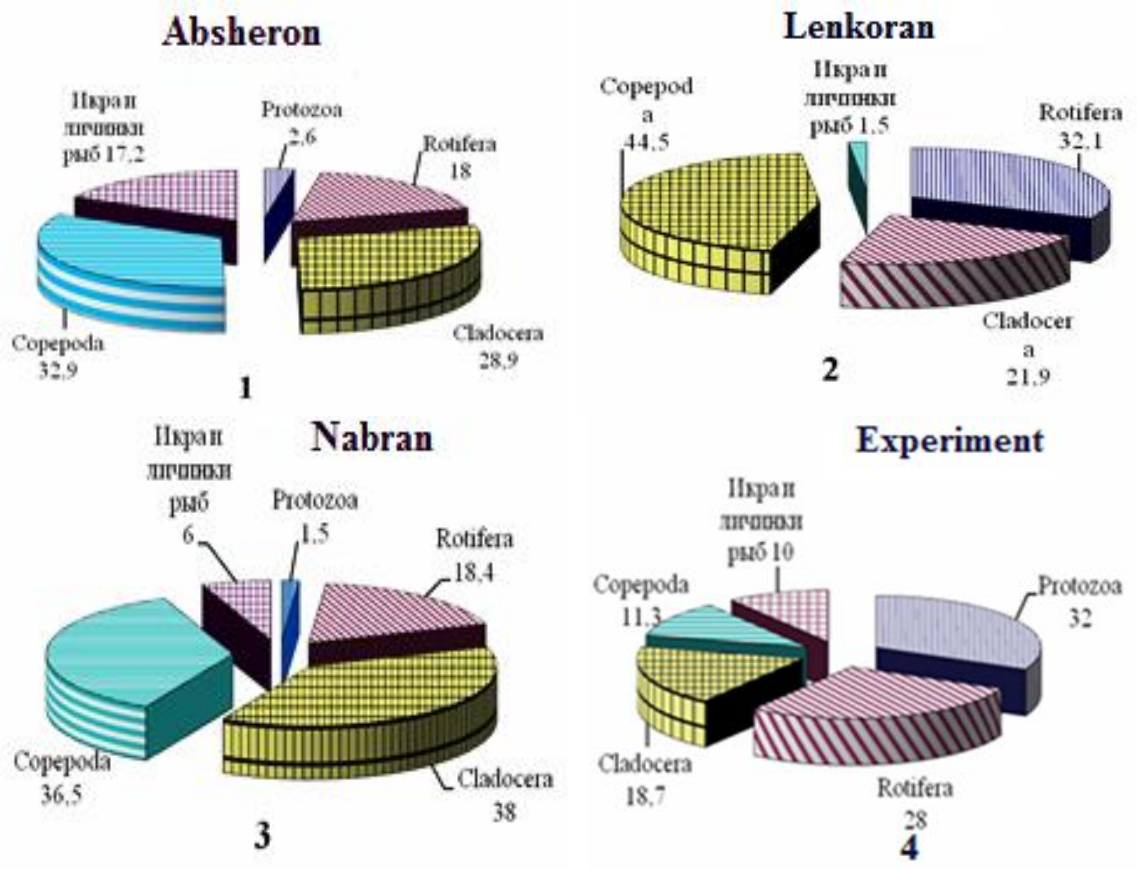

Fig 1: Changes (percentage) the food spectrum of Mnemiopsis leidyi in natural communities of various collection points (1-3) and in the experimental conditions (4).

Below in Figure 2, we present comparative results of the food spectrum of Mnemiopsis leidyi, obtained by visual examination under binocular microscope individuals from the natural communities of coastal zone of the Caspian Sea and in experimental conditions at different points of the collection (1-3).

As seen from Fig.1 data, of the food spectrum of the most actively feeding juvenile Mnemiopsis leidyi in natural plankton communities in various points of the collection is markedly different. For instance, in Nabran area where the salinity of about 10‰ the total number of ctenophore generally much smaller than the more southerly collection points with a high salinity (about 12-13‰). In settlement Nabran in the food spectrum of ctenophore dominated crustaceans - (Cladocera-38%, Copepoda - 36,5%).The proportion of rotifer in nutrition of ctenophore is 18.4%, the consumption of eggs and larvae of

fish (6%), and the lowest share in the food spectrum accounted for the protozoa (1.5).

As shown in fig.1, near the coast of Absheron in the food spectrum of Mnemiopsis leidyi leading role crustacean food organisms is maintained, accounting for Copepoda – 32,9% and for Cladocera – 28,9%, but the proportion of free-living protozoa are slightly higher, amounting to 2,6%. The most interesting record-high percentage in the food spectrum of ctenophore it is fish eggs and larvae, which reaches here -17, 2%. However, such a high consumption in food fish eggs and larvae, at this point of collection is partly explained the specifics of this area, representing the small bay with a high density of fish larvae that congregate here.

It should be noted that earlier research have shown that consumption of that or other food object depends on its density in the surrounding water (Alekperov, 2011). For example, it was revealed that rotifers actively consumed in the food of Mnemiopsis leidyi when their numbers in water over 80 specimens./L and the fish larvae at a concentration of not less than 90 specimens./L. Probably here is played the role and speed of the movement of food object in the water. Since Mnemiopsis leidyi in principle by the method of nutrition can be attributed to passive filter feeders, the occurrence of ctenophore with food object should correlate with the speed of movement of the latter.

As seen from table 2, the food spectrum of Mnemiopsis leidyi on the most southern point collection in Lankaran, different from the others in the first place the highest consumption of Copepoda – 44.5% and rotifers – 32.1%. It should be noted at this point of collection the maximum development of ctenophore juveniles, whose individuals almost immediately slaughtered all plankton net. Probably here is played role as a highest salinity in the Caspian Sea (about 13%), and as well sufficiently high density of many plankton communities. Consumption of Cladocera amounted 21.9%, and the eggs and larvae of fish were 1.5%. To note the ctenophore consumption of protozoa on this collection point failed, due to the extremely low density of the latter.

For reception of more proper results under the experimental conditions in aquariums were carried out works on clarify the food spectrum of juvenile Mnemiopsis leidyi. As seen from the Fig.2.4, the food spectrum of ctenophore under experimental conditions different from the data of natural communities is the first place dominated among food objects free-living protozoa, especially ciliates which constituting 32%. We attribute this to the following circumstances. Intravital staining under experimental conditions ciliates allows you to clearly follow their food consumption ctenophore transparent, even under low magnification microscope (Alekperov, 2011). In natural conditions correctly identify the consumption degree of ctenophore protozoa extremely difficult and probably the obtained findings are low. Moreover, it should be noted that in the experiments the number of ciliates in the water was 150 ind./L, rotifers 100 ind./L, Copepoda and Cladocera 50 copies./L and the density of caviar and larvae was 40 ind./L. The obtained data for the study of the ctenophore food spectrum under the experimental conditions showed that the second highest place for consumption is a group of rotifers (28%), than cladocerans (18.7%) and copepods (11.3%). Caviar and larvae of fish amounted 10% in the food spectrum, although in our previous experimental studies, their consumption does not observed. We explain this fact that in previous experiments, the density of these food items were only 15 copies./L, which influenced to the obtained result.

4. Conclusions

1. The invasion Mnemiopsis leidyi A. Agassiz, 1865 in the plankton communities of the Caspian Sea has brought very serious damage in the first place plankton species of fish.
2. Investigations have shown that the food spectrum ctenophore include major groups of zooplankton, which are the basis of the food items for juveniles and larvae of many valuable commercial fish. In addition, the comb jelly causes direct damage to eating the caviar and larvae of commercial fish.
3. Experimental data allowed correcting the obtained results in nature and revealing the great value in the food spectrum of Mnemiopsis leidyi free- living protozoa in the first place ciliates, and the correlation between the density of different food organisms in the environment and their percentage in the ctenophore food spectrum.

Table 1: Distribution the dominant species of main planktonic groups of hydrobionts in the Azerbaijan Sector of the Caspian Sea

Genus, types	Lenkoran	Neftchala	Apsheron	Shabran	Nabran
Ciliata					
1. *Holophrya pelagica* Lohman. 1920	+	+	+	---	---
2. *H.saginata* Penard, 1922	+	+	+	---	+
3. *Mesodinium pulex* Claparede et .et Lachman	+	+	+	+	+
4. *M.apsheronicum* Alekperov and Asadullayeva.	+	---	+	---	---
5. *Cyclotrichium ovatum* Fauré- Fremiet, 1997	---	---	+	---	+
6. *C.cyclocaryon* Munier, 1907	+	---	---	---	---
7. *C.inflatum* Alekperov, 1984	+	---	+	+	+
8. *Askenasia elegans* (Fauré-Fremiet, 1924)	+	+	+	+	+
9. *A.stellaris* (Leegaard, 1920)	+	+	+	+	+
10. *Monodinium balbianii* Fabre- Domerque, 1988	+	+	+	+	+
11. *Didinium nasutum* Müller, 1773	+	+	+	+	+
12. *Zosterodasys agamalievi* Deroux, 1978	---	---	+	---	---
13. *Z.caspica* Fern-Leb. et Alekperov, 1996	+	---	+	+	---
14. *Z.cantabrica* Fern.-Leb. *et al* ekperov, 1996	---	---	+	+	+
15. *Nassula marina* Alekperov and Asadullayeva, 1977	+	---	+	+	+
16. *Chlamydodon Mnemosyne* Ehrbenbery, 1857	---	---	+	---	+
17. *Ch.rectus* Ozaki and Yagiu, 1857	+	---	+	---	---
18. *Frontonia marina* Fabre.- Domerque, 1891	+	+	+	+	+
19. *F.salmastra* Dragesco et Dragesco- Kerneis, 1896	+	---	+	---	---
20. *Uronema nigricans* (Müller, 1786)	+	+	+	+	+
21. *U. marinum* Dujardin, 1841	+	+	+	+	+
22. *Uronemella filificium* (Kahl, 1931) Song and Wilbert, 2002	+	+	+	+	+
23. *Pleuronema marinum* Dujardin, 1836	+	+	+	+	+
24. Blepharisma hyalinum Pert 1849	---	---	+	---	+
25. *Pelagohalteria caspica* (Alekperov and Asadullayeva, 1997)	+	---	+	+	+
26. *Halteria grandinella (*Müller, 1786)	---	+	+	+	+
27. *Novistrombidium apsheronicum* (Alekperov and Asadullayeva, 1997)	---	---	+	---	---
28. *S. sulcatum* Claparede et Lochman, 1859	+	+	+	+	+
29. *S.caspicum* Alekperov and Asadullayeva, 1997	+	+	+	+	+
30. *S.obliquum* Kahl, 1932	+	+	+	+	+
31. *S.nabranicum* Alekperov, Snegovaya, 2006	---	---	---	---	+
32. *Strombidiopsis azerbaijanica* Alekperov, Asadullayeva, 1997	+	+	+	+	+

33. *Strobilidium lacustris* Foissner, Skogstad, Pratt, 1988	+	+	+	+	+
34. *Tintinnopsis tubulosa* Levander, 1900	---	---	+	+	+
35. *T.cylindrica* Daday, 1892	+	+	---	---	+
36. *T.meunieri* Kofaiel and Campbell, 1029	+	+	+	+	+
37. *T.baltica* Brandt, 1896	+	+	+	+	+
38. *Codonella relicta* Minkiewich, 1905	+	+	+	+	+
39. *C.lagenula* (Cloporede et Lachmann, 1858)	+	+	+	+	+
40. *Favella ehrenbergi* (Cloporede et Lachmann, 1858)	---	---	---	+	+
41. *Parafavella obtuse* Kahl, 1932	---	---	+	+	+
42. *Diophrys pentacirratus* Alekperov, 1984	+	+	+	+	+
43. *Euplotes alatus* Kahl, 1932	---	---	---	---	+
44. *E.pseudoraikovi* Alekperov, 2005	---	---	---	---	+
45. *Uronychia caspica* (Alekperov and Asadullayeva,1999) Rotifera	+	+	+	+	+
Rotifera					
46. *Trichocerca caspica caspica* (Tschugunoff, 1921)	+	+	+	+	+
47. *T.caspica longicaudata* (Tschugunoff, 1921)	---	---	+	+	---
48. *T.pusilla* (Jennings, 1903)	---	---	---	+	+
49. *T.heterodactyla* (Tschugunoff, 1921)	+	+	+	+	+
50. *Synchaeta stylata* Wierzzyski, 1893	+	+	+	+	+
51. *S.tremula* (Müller, 1786)	+	+	+	+	+
52. *S.pectinata* Ehrenberg, 1832	+	---	---	---	---
53. *Polyarthra vulgaris* Carlin, 1943	+	+	+	+	+
54. *Asplanchna priodonta priodonta* Gosse, 1850	+	+	+	+	+
55. *A.priodontaver* kursiihelvetica Imho, 1884	+	+	+	+	+
56. *Lecane luna* (Müller, 1776)	---	---	---	+	+
57. *L.crepida* Harring, 1914	---	---	---	+	+
58. *Euchlanis dilatata* Ehrenberg, 1832	---	---	---	+	+
59. *Brachionus angularis angularis* Gosse, 1851	+	+	+	+	+
60. *B.angularis bidens* Plate, 1886	---	---	+	+	+
61. *B.rubens* Ehrenberg, 1838	---	---	---	+	+
62. *B.urceus urceus* (Linnaeus, 1758)	---	---	---	+	+
63. *Keratella tropica* (Apstein, 1907)	+	+	+	+	+
64. *K.quadrata* (Müller, 1786)	+	---	+	+	+
65. *Notholca squamula* (Müller, 1786)	+	+	---	+	+
Cladocera					
66. Daphnia longispina (Müller, 1776)	---	---	+	+	+
67. *Moina micrura* Kurz, 1874	---	+	+	+	+
68. *Ceriodaphnia quadrangula* (Müller, 1785)	---	---	---	+	+
69. *Chydorussphaericus*(Müller, 1776)	---	---	+	+	+
70. *Bosmina longirostris* (Müler, 1776.)	---	---	---	+	+
71. *Polyphemusfexiguus* Sars, 1897	+	+	+	+	+
72. Evadne anonyx typical Sars, 1897	+	+	+	+	+
73. *E.anonyx prolongata* Behning, 1938	+	+	---	---	---
74. *Podonevadne trigona (*Sars, 1897)	+	+	+	+	+
75. *P.trigona typica* Sars, 1897	+	+	+	+	+
76. *Caspievadne maximowitschi* (Sars, 1902)	+	+	---	---	---
Copepoda					
77. *Limnocalanus grimaldii* (Guerne, 1886)	+	+	---	---	---
78. *Calanipeda aquaedulcis* Krischagin, 1873	+	+	+	+	+
79. *Eurytemora grimmi* Sars, 1897	+	+	+	+	+
80. *E.minor* Behning, 1938	+	+	+	---	---
81. *E.velox* Lilljeborg, 1853	---	---	---	+	+
82. *E.affinis* (Poppe, 1880)	---	---	---	+	+
83. *Eucyclops orthostylus* Lindberg, 1953	---	---	---	+	+
84. *E.serrulatus speratus* (Fischer, 1851)	---	---	---	+	+
85. *Paracyclops fimbriatus* (Eischer, 1853)	---	---	---	+	+
86. *Caspiocyclops mirabilis* Kiefer, 1931	---	---	+	+	---
87. *Acanthocyclops gigas* (Claus, 1857)	---	---	+	+	+
88. *Acartia tonsa* Dana, 1849	+	+	+	+	+
89. *A.clausi* Giesbrecht, 1889	+	+	+	+	+

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