CONTRIBUTIONS TO THE ANALYSIS OF VERTICAL DISTRIBUTION OF CILIATES (PROTOZOA: CILIOPHORA) IN THE PARAMARINES AND MARINES SEDIMENTS IN THE CENTRAL AREA OF THE ROMANIAN SEASHORE

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Abstract. *The hereby research paper presents the analysis results of the vertical distribution of ciliates from marine sediments, as well as lacustrine areas, seaside lakes from the south of Cap Midia. The methodology used took into consideration the issues proposed by Fenchel (FENCHEL, 1966). According to detailed research papers of Mrs. PhD. Adriana Petran (PETRAN, 1977), developed between the 70s, I focused on presenting a range of investigations in the seaside of Modern beach, from Constanta, as well as sediments of the lacustrine complex Siutghiol-Tăbăcărie. The vertical distribution has been analysed on 63 species from the seaside field, Modern beach and 37 species from Siutghiol, respectively 28 species from Tăbăcărie. The results that were obtained highlight the fact that most of species are airfield species, with a high concentration in the first three centimetres of the sediments.*

Keywords: *ciliates, ecological features, basins within Constanța Museum Complex, vertical distribution.*

Rezumat. Contribuţii la cunoaşterea distribuţiei pe verticală a ciliatelor (Protozoa-Ciliophora) din sedimentele paramarine şi marine din zona centrală a litoralului românesc. *Actuala lucrare cuprinde date referitoare la comunităţile de ciliate care populează domeniul sedimentar şi perifitonul anexei lacului Tăbăcărie din incinta CMSN Constanţa; aspectele calitative sunt însoţite de informaţii referitoare la ecologia fiecareia din cele 34 de specii identificate. În compoziţia calitativă a epibiozei bazinelor cu apă sărată în care este adăpostit patrimoniul viu al secţiei Delfinariu, a fost identificată o selecţie interesantă de ciliate aparţinând la 74 de specii, rezistenţa la variaţii semnificative ale salinităţii şi concentraţiei de hipoclorit de sodium, substanţă introdusă zilnic în bazine în scopul limitării proliferării faunei bacteriene.*

Cuvinte cheie: *ciliate, caracteristici ecologice, bazine incinta Complex Muzeal Constanţa, distribuţie pe verticală.*

INTRODUCTION

The interstitial environment represents a special biotope for a large variety of invertebrates among which the protozoa ciliates dominates the other groups by means of the diversity of species and their density.

The study of ciliates distribution in the depth of sandy sediments was initiated by Fenchel (FENCHEL, 1967) who also created the corresponding method. The ciliates fauna in the sediments of low depth areas of nearshore lakes have been studied by us over a long period of time (1997-2004) (DUMITRACHE, 2004; DUMITRACHE, 2006).

Until the date of our study dedicated to this aspect, we have not found in the Romanian specialised literature information on this subject for the lakes Siutghiol and Tăbăcărie. The vertical distribution of ciliates in the mediolittoral of different points on the Romanian Black Sea seashore has been studied by Petran (PETRAN, 1976), therefore we have limited ourselves only to the study of the vertical distribution of the ciliates on the "Modern" beach; the reasons for choosing this sampling unit are based on the diverse aggregate grading of the sediments and the large quality spectrum of species in August: 63.

MATERIAL AND METHODS

The results of the sampling process and the study of the samples collected in the months of August of 2004-2008 are focused on establishing the vertical distribution of ciliates in the sandy and muddy sediments of lake and marine areas. For the paramarine lakes Siutghiol and Tăbăcărie, the samples have been collected from the sediments of the low depth areas; the number of the sampling units was 4 and the weekly rhythm consisted in 5 samples per sampling unit (map). For the study of the vertical distribution of the ciliates on Constanta "Modern" beach, there were created two units in sheltered areas of the main bays, the weekly rhythm being 7 samples per sampling unit. The average values of the abiotic factors such as temperature and salinity for the points "Casino - Modern" Constanta are mentioned in Table 1; the salinity in the samples collected from the Tăbăcărie lake varied between 1.2-1.5 PSU.

Table 1. Average values of temperature and salinity for the sampling unit Constanţa Casino-Modern (Constanta NIMRD analysis).
Tabel 1. Valorile medii ale temperaturii şi salinităţii pentru staţia Cazino Constanţa-Modern (determinari INCDM Constanţa).

Year	Temperature (average values) (0^0C)	Salinity (average values) (PSU)
2004	22.2	14.60
2005	24.3	13.56
2006	23.4	15.68
2007	23.7	15.74
2008	24.5	12.83

The technique applied was the one recommended by Fenchel (FENCHEL, 1968). After separating the sediments into Petri dishes, there followed a general examination with the binocular eyeglasses. The separation of the ciliates from the sandy and muddy sediments was carried out by means of Uhlig method (DRAGESCO & DRAGESCO-KERNÉIS, 1986) and then this step was followed by that of diagnosis. Certain species were identified "in vivo", others required green colours such as acetic methyl; other species imposed the application of the techniques Bodian and Chatton-Lwoff, Wilbert variant (DRAGESCO & DRAGESCO-KERNÉIS, 1986).

RESULTS AND DISCUSSIONS

The diversity of the ciliates in the analysed samples was significant including 37 (from the total amount of 45 species) in the sediments of Siutghiol Lake, 28 (from the total amount of 34 species) in Tăbăcărie Lake and 63 in the mediolittoral of Constanța "Modern" beach.

The large qualitative spectrum of marine and freshwater ciliates is doubled by a taxonomic diversity as they belong to 22 families and 33 genera. The ciliates identified have euryhaline affinities with x number of genera being represented both in the marine ecosystem and in the lake ecosystems.

The analysis of the samples collected highlighted a maximum concentration in the first 3-4 centimetres from the top of the sediment, the qualitative and quantitative spectrum decreasing while the depth increases (Table 1, 2 and 3). The results are rendered in percentages expressing the species frequency in the samples.

Table 1. Vertical distribution in the sediment depth of certain ciliates on Modern beach (frequency in samples-percentages).
Tabel 1. Distribuția verticală în adâncimea sedimentului a unor populații de ciliate de la plaja Modern (frecvența în probe-valori procentuale).

No.	SPECIES	LAYER (cm)							
		0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8
1	*Holophrya oblonga* (SCHEWIAKOFF 1895)	2	1	1	-	-	-	-	-
2	*Holophrya* sp. 1	1	0.5	0.5	-	-	-	-	-
3	*Prorodon marinus* (CLAPAREDE & LACHMANN 1858)	2	1	1	0.5	-	-	-	-
4	*Prorodon* sp.	2	1	0.5	0.5	-	-	-	-
5	*Dinophrya* sp.	3	2.5	2	0.5	-	-	-	-
6	*Coleps pulcher* (SPIEGEL 1926)	1	1	0.5	-	-	-	-	-
7	*Coleps* sp.	1	1	0.6	-	-	-	-	-
8	*Lacrymaria coronata* (CLAPAREDE & LACHMANN 1858)	3	2.5	0.5	0.5	-	-	-	-
9	*Lacrymaria delamarei* (DRAGESCO 1960)	2.5	2	1	1	-	-	-	-
10	*Lacrymaria lagenula* (CLAPAREDE & LACHMANN 1858)	2.5	1	0.5	0.5	-	-	-	-
11	*Lacrymaria* sp. 1	3	2	1	1.5	-	-	-	-
12	*Didinium nasutum* (MULLER 1786)	2.5	1	0.5	0.5	0.5	-	-	-
13	*Didinium* sp.	1.5	1	1	0.5	0.5	-	-	-
14	*Mesodinium pulex* (CLAPAREDE & LACHMANN 1858)	4	2.5	2	-	-	-	-	-
15	*Mesodinium rubrum* (LOHMANN 1908)	2	2	0.5	-	-	-	-	-
16	*Lionotus lamella* (EHRENBERG 1838)	3	2.5	1	1	0.5	0.5	-	-
17	*Loxophyllum helus* (STOKES 1884)	2	1	0.5	0.5	0.5	-	-	-
18	*Loxophyllum setigerum* (QUENNERSTEDT 1867)	3	1.5	2	0.5	0.5	-	-	-
19	*Hemionotus caudatus* (KAHL 1933)	2	2.5	1.5	1	1	0.5	0.5	-
20	*Trachelocercida* sp. 1	1	1	0.5	-	-	-	-	-
21	*Trachelocercida* sp. 2	1	1	0.5	-	-	-	-	-
22	*Trachelocercida* sp. 3	1	1	0.5	-	-	-	-	-
23	*Trachelocercida* sp. 4	1	1	0.5	-	-	-	-	-
24	*Trachelocercida* sp. 5	1	1	0.5	-	-	-	-	-
25	*Trachelocercida* sp. 8	1	1	0.5	-	-	-	-	-
26	*Trachelocercida* sp. 9	1	1	0.5	-	-	-	-	-
27	*Trachelocercida* sp. 12	1	1	0.5	-	-	-	-	-
28	*Remanella multinucleate* (KAHL 1933)	2	1.5	1	0.5	-	-	-	-
29	*Remanella rugosa* (KAHL 1933)	1	1	0.5	0.5	-	-	-	-
30	*Remanella margaritifera* (KAHL 1933)	1.5	1	1	0.5	-	-	-	-

31	*Remanella granulose* (KAHL 1933)	2	2	0.5	0.5	-	-	-	-
32	*Remanella minuta* (DRAGESCO 1960)	1	1.5	0.5	0.5	-	-	-	-
33	*Remanella swedmarki* (DRAGESCO 1960)	2	1.5	1	1	-	-	-	-
34	*Remanella* sp.	1	0.5	0.5	0.5	-	-	-	-
35	*Kentrophoros gracilis* (RAIKOV 1963)	2	2	0.5	0.5	1	1.5	1	0.5
36	*Ciliofaurea* sp.	1	1	0.5	-	-	-	-	-
37	*Geleia* sp.	1.5	0.5	0.5	-	-	-	-	-
38	*Plagiopyla nasuta* (STEIN 1860)	1	1	0.5	2.5	2	2	1	1.5
39	*Plagiopyla* sp.	0.5	1	1	0.5	2	2.5	2	0.5
40	*Coelosomides teissieri* (DRAGESCO 1960)	1	1	0.5	0.5	-	-	-	-
41	*Paraspathidium fuscum* (KAHL 1928)	1.5	2	2	1.5	0.5	0.5	-	-
42	*Paraspathidium* sp.	1.5	2	2	1.5	0.5	0.5	-	-
43	*Cryptopharinx setigerum* (KAHK 1928)	0.5	0.5	1	0.5	-	-	-	-
44	*Frontonia marina* (FABRE -DOMERGUE 1891)	1.5	0.5	1	0.5	-	-	-	-
45	*Uronema marinum* (DUJARDIN 1841)	0.5	0.5	1	1	1.5	1	0.5	0.5
46	*Vorticella* sp.	0.5	0.5	-	-	-	-	-	-
47	*Blepharisma steini* (KAHL 1932)	1.5	1	0.5	0.5	-	-	-	-
48	*Metopus contortus* (KAHL 1931)	2	1	1	0.5	1.5	0.5	0.5	0.5
49	*Condylostoma arenarium* (SPIEGEL 1926)	3	1.5	1	0.5	1.5	1	1	0.5
50	*Strombidium arenicola* (DRAGESCO 1960)	3.5	1.5	1	1	0.5	0.5	0.5	0.5
51	*Strombidium faurei* (DRAGESCO 1960)	2	1	1	1	0.5	0.5	0.5	0.5
52	*Strombiddium sauerbrayae* (KAHL 1930)	2	1.5	1	1	0.5	0.5	0.5	0.5
53	*Strongylidioum arenicolus* (DRAGESCO 1960)	1.5	0.5	-	-	-	-	-	-
54	*Epiclintes ambiguous* (MULLER 1786) BUTSCHLI 1889	1	0.5	-	-	-	-	-	-
55	*Trachelostyla caudate* (KAHL 1932)	2	1	0.5	-	-	-	-	-
56	*Trachelostyla dubia* (DRAGESCO 1960)	2	1	0.5	-	-	-	-	-
57	*Uroleptus rattulus* (STEIN 1859)	0.5	0.5	1	0.5	-	-	-	-
58	*Oxytricha gibba* (MULLER 1786)	0.5	0.5	-	-	-	-	-	-
59	*Euplotes* sp. 1	0.5	1.5	0.5	-	-	-	-	-
60	*Euplotes* sp. 3	0.5	1	1.5	0.5	-	-	-	-
61	*Euplotes* sp. 4	0.5	0.5	-	-	-	-	-	-
62	*Diophrys scutum* (DUJARDIN 1841)	1	0.5	-	-	-	-	-	-
63	*Uronychia transfuga* (MULLER 1786)	1	0.5	-	-	-	-	-	-

Table 2. Vertical distribution of ciliates in the sediments of Siutghiol Lake (frequency in samples-percentages).
Tabel 2. Distribuţia verticală a ciliatelor în sedimentele lacului Siutghiol (frecvenţa în probe, valori procentuale).

No.	**SPECIES**	**LAYER (cm)**						
		0-1	**1-2**	**2-3**	**3-4**	**4-5**	**5-6**	**6-7**
1	*Holophrya atra* (SCHEWIAKOFF 1893)	1	0.5	-	0.5	-	-	-
2	*Holophrya ovum* (SCHEWIAKOFF 1893)	0.5	-	-	-	-	-	-
3	*Holophrya nigricans* (LAUTRBORN 1894)	0.5	-	-	-	-	-	-
4	*Holophrya* sp.2	0.5	-	-	-	-	-	-
5	*Urotricha globosa* (CLAPAREDE & LACHMANN 1857)	10	10	10	15	10	2	0.5
6	*Plagiocampa rouxi* (KAHL 1930)	0.5	0.5	0.5	-	-	-	-
7	*Lagynophria rostrata* (KAHL 1930)	0.5	-	-	0.5	-	-	-
8	*Lagynophria acuminate* (KAHL 1930)	0.5	0.5	-	-	-	-	-
9	*Lacrymaria olor* (MULLER 1788)	2	3	1	1	-	-	-
10	*Trachelophyllum sigmoides* (KAHL 1931)	2	0.5	0.5	-	-	-	-
11	*Spathidium* sp.	1	0.5	-	1	-	-	-
12	*Lionotus lamella* (SCHEWIAKOFF 1896)	3	3	1	2	1	0.5	-
13	*Loxodes striatus* (ENGELMANN 1862)	1	0.5	-	0.5	-	-	-
14	*Plagyopila nasuta* (STEIN 1860)	1	1	0.5	1	5	5	2

15	*Bresslaua* sp.	0.5	-	-	-	-	-	-
16	*Colpoda cucullus* (MULLER 1786)	1	1	0.5	-	-	-	-
17	*Colpoda steini* (KAHL 1935)	1	-	-	0.5	-	-	-
18	*Nassula picta* (EHRENBERG 1933)	1	1	0.5	-	-	-	-
19	*Tetrahymena cf. pyriformis* (EHRENBERG 1830); LWOFF 1947	10	15	15	10	6	3	1
20	*Ophryoglena atra* (EHRENBERG 1831)	1	0.5	0.5	1	2	-	-
21	*Dexiostoma campylum* (FOCKE 1836)	2	1	1	0.5	-	-	-
22	*Paramecium caudatum* (EHRENBERG 1838)	5	3	1	2	-	-	-
23	*Paramecium cf. aurelia* (EHRENBERG 1838)	1	1	-	0.5	-	-	-
24	*Paramecium putrinum* (HILL 1752)	1	1	2	2	3	1	-
25	*Paramecium trichium* (HILL 1752)	1	-	-	-	-	-	-
26	*Paramecium* sp.	0.5	-	-	-	-	-	-
27	*Lembadion bullinum* (PERTY 1852)	5	6	4	2	1	1	0.5
28	*Uronema nigricans* (MULLER 1786)	10	10	15	15	-	0.5	-
29	*Cyclidium glaucoma* (MULLER 1786)	20	20	15	10	10	5	0.5
30	*Spirostomum teres* (CLAPAREDE & LACHMANN 1858-1859)	3	3	2	2	0.5	-	-
31	*Metopus* sp. 2	1	1	4	5	7	5	2
32	*Strombidium sauerbrayae* (KAHL 1930)	2	2	6	2	3	2	0.5
33	*Strombidium viride* (FOISSNER 1986)	2	2	4	2	1	-	0.5
34	*Saprodinium* sp.	1	1	3	2	3	1	2
35	*Uroleptus* sp.	6	5	5	7	10	15	10
36	*Oxytricha* sp.1	0.5	1	-	0.5	-	-	-
37	*Euplotes patella* (MULLER 1786) EHRENBERG 1838	0.5	0.5	-	0.5	-	-	-

Table 3. Vertical distribution of ciliates in the sediments of Tăbăcărie Lake (frequency in samples-percentages).
Tabel 3. Distribuția verticală a ciliatelor în sedimentele lacului Tăbăcărie (frecvența în probe, valori procentuale).

No.	**SPECIES**	**LAYER (cm)**							
		0-1	**1-2**	**2-3**	**3-4**	**4-5**	**5-6**	**6-7**	**7-8**
1	*Holophrya ovum* (SCHEWIAKOFF 1893)	3	1	-	-	-	-	-	-
2	*Urotricha globosa* (CLAPAREDE & LACHMANN 1857)	5	7	7	-	3	0.5	2	1
3	*Plagiocampa rouxi* (KAHL 1930)	7	3	0.5	-	-	-	-	-
4	*Lagynophria rostrata* (KAHL 1930)	3	1	0.5	-	-	-	-	-
5	*Phithothorax processus* (KAHL 1931)	1	-	-	-	-	-	-	-
6	*Trachelophyllum sigmoides* (KAHL 1931)	1	-	0.5	-	-	-	-	-
7	*Spathidium* sp.	5	2	0.5	-	-	-	-	-
8	*Litonotus lamella* (SCHEWIAKOFF 1896)	5	3	1	0.5	-	-	-	-
9	*Loxodes striatus* (ENGELMANN 1862)	2	-	0.5	-	-	-	-	-
10	*Plagyopila nasuta* (STEIN 1860)	1	-	2	4	7	2	0.5	0.5
11	*Colpoda steini* (KAHL 1935)	1	1	0.5	-	-	-	-	-
12	*Nassula picta* (EHRENBERG 1933)	3	1	-	-	-	-	-	-
13	*Tetrahymena cf. pyriformis* (EHRENBERG 1830); LWOFF 1947	10	10	7	5	3	1	1	1
14	*Ophryoglena arta* (EHRENBERG 1831)	3	1	0.5	0.5	-	-	-	-
15	*Paramecium cf. aurelia* (EHRENBERG 1838)	1	2	2	-	-	-	0.5	-
16	*Paramecium caudatum* (EHRENBERG 1838)	5	3	-	0.5	-	-	-	-
17	*Paramecium putrinum* (HILL 1752)	3	7	2	7	3	1	0.5	-
18	*Paramecium trichium* (HILL 1752)	1	-	-	1	-	-	-	-
19	*Lembadion bullinum* (PERTY 1852)	6	8	2	0.5	2	0.5	0.5	-
20	*Uronema nigricans* (MULLER 1786)	15	10	7	1	-	-	2	-
21	*Metopus* sp. 2	1	2	5	7	7	3	2	0.5
22	*Saprodinium* sp.	1	5	7	5	3	1	1	-
23	*Strombidium sauerbrayae* (KAHL 1930)	3	6	10	10	5	2	2	1
24	*Uroleptus* sp.	3	5	15	10	15	15	10	10

25	*Paruroleptus* sp.	2	4	-	0.5	-	-	-	-
26	*Oxytricha* sp.1	5	5	-	1	-	-	-	-
27	*Euplotes patella* (MULLER 1786); EHRENBERG 1838	1	0.5	-	0.5	-	-	0.5	-
28	*Aspidisca* sp.	1	1	0.5	1	-	-	-	-

a. The number of the identified species in the first 3 centimetres of the "Modern" beach was around 60 (Figs. 1-3), whereas in the 3-4 cm layer the number decreases beyond 35; the ciliates identified at a depth of 7-8 cm, tolerant to the decrease of oxygen concentration, belong only to 10 species.

In the mediolittoral of "Modern" beach there were identified a series of species with strictly aerobe affinities, their existence being limited by this abiotic parameter to the top 1-3 cm: species of *Holophrya*, *Coleps*, *Geleia*, *Strongylidium*, *Trachelocerca* etc.

Other ciliates are tolerant to the decrease of oxygen concentration and are to be found in the 3-5 cm layer; this is the case for species from the genera *Didinium, Loxophyllum, Paraspathidium.*

Finally, other species present a special resistance to certain microaerophile and even anaerobe conditions, their representatives being identified at the top layer until 7-8 cm limit in the sandy sediment: *Kentrophoros gracilis* (RAIKOV 1963), *Plagiopyla nasuta* (STEIN, 1860), *Uronema marinum* (DUJARDIN, 1841), *Metopus contortus* (KAHL, 1931), *Strombidium* species.

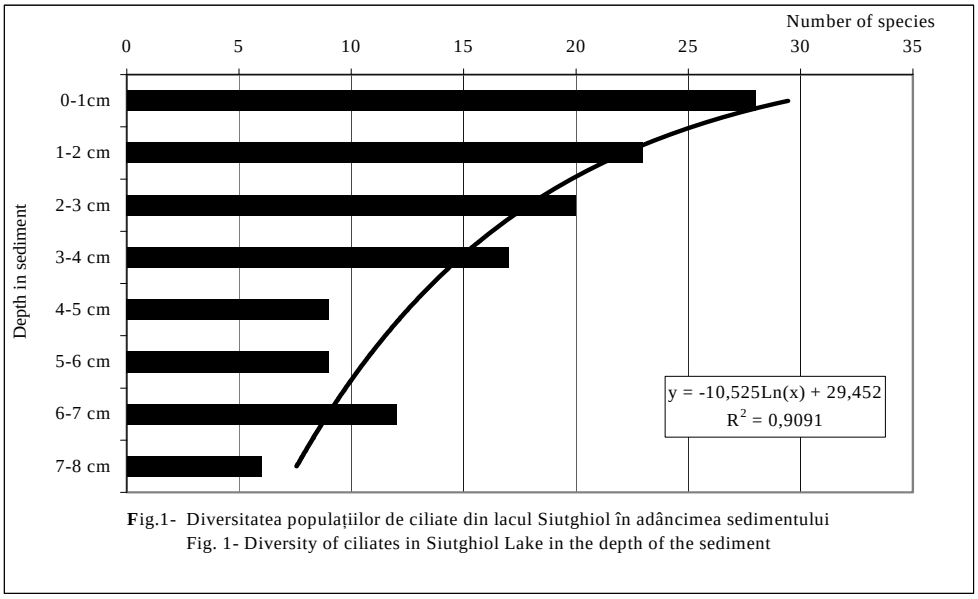

Fig.1- Diversitatea populațiilor de ciliate din lacul Siutghiol în adâncimea sedimentului
Fig. 1- Diversity of ciliates in Siutghiol Lake in the depth of the sediment

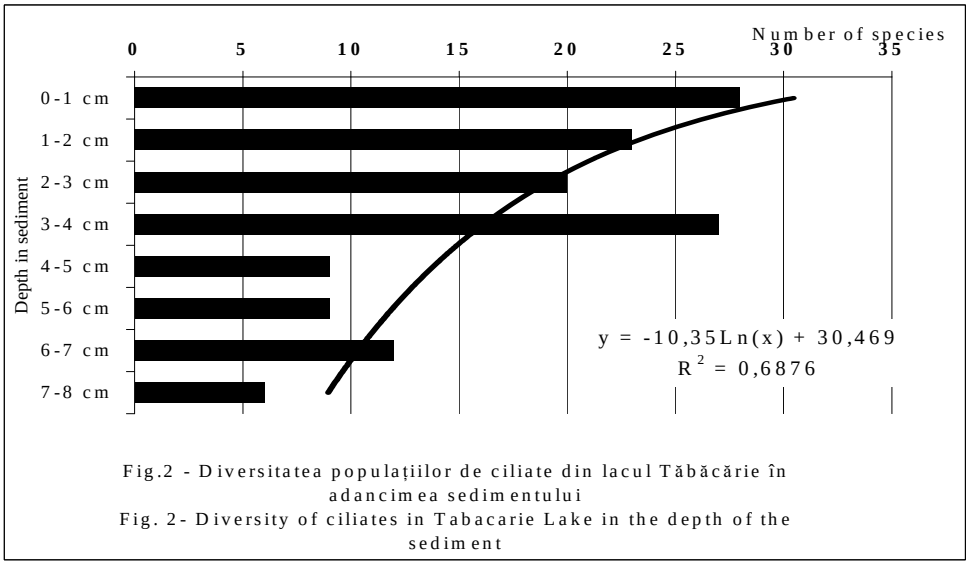

Fig.2 - Diversitatea populațiilor de ciliate din lacul Tăbăcărie în adancimea sedimentului
Fig. 2- Diversity of ciliates in Tabacarie Lake in the depth of the sediment

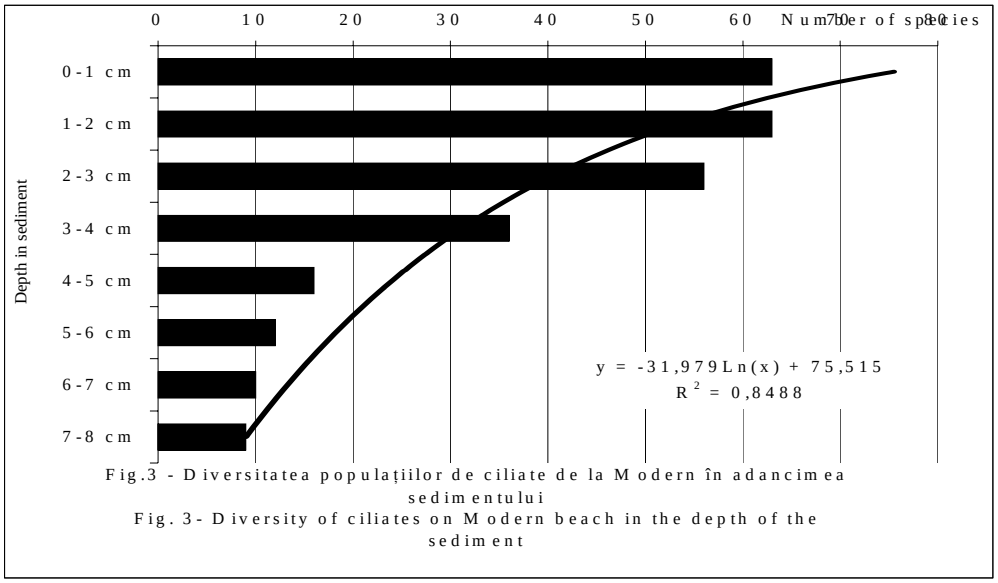

Fig.3 - Diversitatea populațiilor de ciliate de la Modern în adancimea sedimentului

Fig. 3- Diversity of ciliates on Modern beach in the depth of the sediment

The tolerance of the species to the oxygen concentration variation in the sediments is also completed by euritherme characteristics, almost half of the species identified in the summer months being also identified in the other periods of the year.

b. The analysis of the samples collected from the sediments of the low depth areas of the lakes Siutghiol and Tăbăcărie (with the annex building of CMSN Constanta) highlighted the fact that the ciliates fauna is also concentrated in the first top 3 centimetres (Figs. 1-3).

While in the first top centimetre of the sediments of Siutghiol Lake there were identified 37 species, respectively 28 species in Tăbăcărie Lake, in the 2-3 cm layer there were identified around 20 species for both ecosystems and in the 7-8 cm layer there were identified about 5 species.Among the oxyphile there can be quoted: *Lagynophra acuminate* (KAHL, 1830), *Nassula picta* (EHRENBERG, 1833), *Bresslaua* sp., *Phythothorax processus* (KAHL, 1931). A series of examples belonging to the species: *Lionotus lamella* (EHRENBERG, 1838), *Lembadion bullinum* (PERTY, 1852), species of *Strombidium*, *Uroleptus* etc., are tolerant to progressive decrease of oxygen concentration along with depth increase in the sediment.

In conclusion, the oxygen represents an abiotic factor limitative to ciliates distribution in sediments, the results acquired being encouraging for continuing the research in this direction.

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