QUALITATIVE AND QUANTITATIVE STUDIES IN THE COATINGS OF POTAMOGETON PERFOLIATUS AND MYRIOPHYLLUM SPICATUM IN LAKE BALATON.

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With 3 Tables and 5 Figures in the text.

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In the autumn of 1946 investigations were made of the coatings on the larger aquatic vegetation of Lake Balaton. Under "coatings" („Aufwuchs") we understand, according to RUTTNER „. . . alle einer festen Unterlage anhaftenden aber (im Gegensatz zu dem im Boden wurzelnden Pflanzen oder gewissen Parasiten) n i c h t in diese eindringenden Organismen." (RUTTNER, 1940, p. 118.) (LENZ, 1928, p. 115.) In what follows the expression "coating" will be used in its wider sense. We are to understand not only the living organisms covering the surface of the plant, but also the detritus deposited among them, as well as particles of mud, precipitated lime, etc. I made my investigations on the most common submerged water plants, *Potamogeton perfoliatus* and *Myriophyllum spicatum.* These form growths of greater or smaller extent. (ENTZ-SEBESTYÉN, 1946, p. 331—337.) Investigations in reed-coatings in Lake Balaton carried on throughout the entire year were made by A. MESCHKAT (1934).

The present investigations of *Potamogeton* and *Myriophyllum* growths were pursued in small areas in the neighbourhood of the Tihany Peninsula. I was interested in the coating structure, its fauna and the relations of the organisms to one another. My aim was to inquire into the differences which are to be seen in the coatings, as to habitat (bays, open water), plant species *(Potamogeton, Myriophyllum)* and different strata.

I collected the plants at Tihany in the neighbourhood of the Biological Institute (F i g u r e 1.). The two *Myriophyllum* growths extended over scarcely more than a few square meters. The one (I) ran parallel to the north shore of the Kis-öböl (a small bay); the other (IV) close to a pipeline in the open water. Both of them grew in thick and homogeneous groups several metres in length and a metre and a half wide.

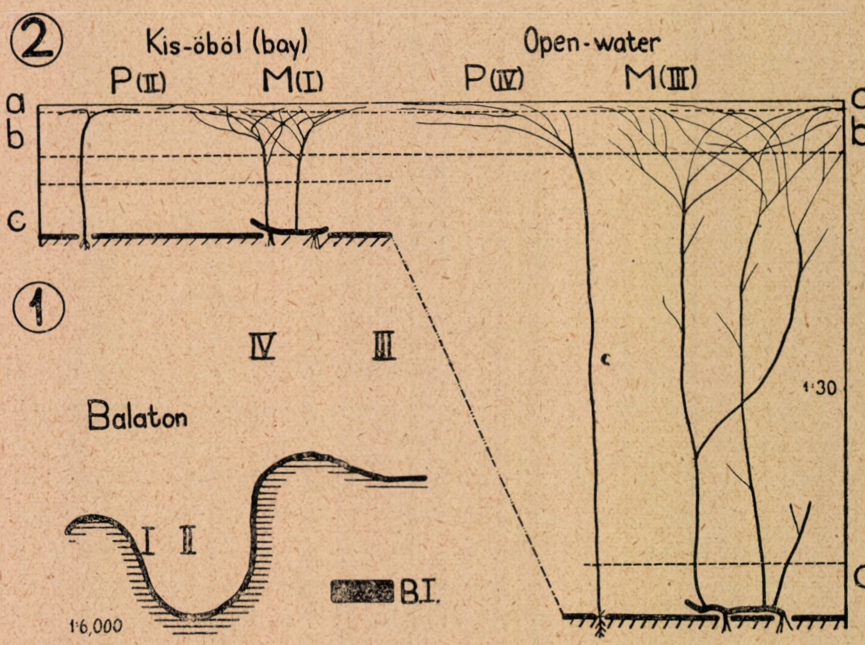

Fig. 1.

Places of collecting. I. Myriophyllum growth running parallel to the shore of the Kis-öböl. Water depth 50 cm. II. Potamogeton growth in the midst of the bay. Water depth 50 cm. III. Potamogeton growth in the open water, cca. 100 m off the shore. Water depth 180 cm. IV. Myriophyllum growth in the open water cca. 80 m off the shore. Water depth 180 cm. B. I. = Biological Institute.

Fig. 2.

Habit of Potamogeton and Myriophyllum plants in the bay and in the open water. P = Potamogeton, M = Myriophyllum. I—IV. places of collecting (see Fig. 1.) a, b, c strata.

The two *Potamogeton* growths were not to be found in such homogeneous groups as the *Myriophyllum*. They were more widely dispersed, and here and there mixed with *Myriophyllum*. As I carried out my investigations on these small plant groups (characteristic, however,

TABLE I.

1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.
VIII. 30	I	a	I	M	16	8	1.0	21.0	24.0	Gentle S-wind	
„	„	b	I	„	21	9	1.2	„			
„	„	c	I	„	48	8	2.0	—			
IX. 4	II	a	II	P	16	14	1.2	21.0	27.0	Calm	Potamogeton at its full development
„	„	b	II	„	27	20	1.8	„			
„	„	c	II	„	20	12	3.0	—			
IX. 10	III	b	I	M	86	53	6.8	22.0	22.0	Breeze	Collection after a storm
„	„	c_1	I	„	64	15	3.4	„			
„	„	c_2	I	„	180	50	10.6	—			
IX. 13	IV	a	III	P	35	13	3.4	20.8	23.2	Calm	Potamogeton very much decayed
„	„	b	III	„	66	34	4.5	„			
„	„	c	III	„	37	5	1.6	—			
„	„	d	III	„	43	6	1.9	—			
IX. 22	V	a	IV	M	75	34	4.4	17.5	19.2	Gentle N-wind	
„	„	b	IV	„	478	127	20.0	„			
„	„	c	IV	„	57	12	1.6	—			
IX. 27	VI	b	II	P	35	17	2.0	20.0	21.0	Calm	
„	„	c	II	„	23	11	2.8	—			
X. 1. 9h	VII	b	III	P	115	76	9.6	17.6	15.5	Gentle S-wind	Only few plants of Potamogeton rich the surface
„	„	c	III	„	75	7	2.5	—			
X. 1. 14h	VIII	b	III	P	131	67	7.6	18.2	20.2	Calm	
„	„	c	III	„	48	5	1.7	—			
X. 1. 20h	IX	b	III	P	76	45	7.1	18.0	13.2	Calm	
„	„	c	III	„	65	11	2.3	—			
X. 8	X	b	IV	M	198	96	12.5	13.2	11.2	N-wind	Previously windy days
„	„	c	IV	„	145	30	4.7	—			

Circumstances at collecting. 1. Data. 2. Number of the collection. 3. Stratum. 4. Locality. (I—II = Kis-öböl, III—IV = open water) 5. P = Potamogeton, M = Myriophyllum. 6. Stem-length in cm. 7. Number of leaves (Potamogeton) resp. number of leaf-groups (Myriophyllum) 8. Surface of samples in dm^2. 9. Water temperature in C°. 10. Air temperature in C°. 11. Wind. 12. N. B.

of the Balaton) my conclusions cannot be said to be valid for growths of great extent.

The investigations took place between August 30th and October 8th, 1946. During this time dry, temperate weather reigned and neither the water-level nor the temperature showed any appreciable variation. In general the wind velocity remained under 3 m/sec. During the collecting periods the greatest wind velocity was 4.6 m/sec (on one occasion, September 21st) but that also caused no large waves in the regions where the collections were made, as they were in wind-protected places. Thus neither the water plants nor their coatings suffered any damage by wave action. The slow, seasonal, normal decay of the *Potamogeton* was to be observed in its usual autumn progress. (T a b l e I.)

Meschkat, in his quantitative studies, always used 20 cm pieces of reed stem (Meschkat, 1934, p. 446). They all had about the same surface ($\pm$ 0.63 dm^2). I used not only the stems but also the leaves of the *Potamogeton* and *Myriophyllum* in my studies. It is almost impossible to choose samples with equal surfaces because their habit differs from that of the reed, they differ from each other *(Potamogeton* and *Myriophyllum),* and also differ in different plants of the same species (size and number of leaves, growth of stem, etc.). Therefore in my collecting I took into consideration only the depth in which the samples were taken. Both plants grow perpendicularly erect. When their length exceeds the depth of the water they bend and lie parallel with the surface. I took my specimens in general from 3 strata: 1.) From immediately below the surface, from that part of the plant which lies parallel with the surface of the water (stratum "a"). 2.) The second specimens were taken from surface level to about 20 cm lower (stratum "b"). 3.) Immediately above the bottom, 20 cm long stems (stratum "c"). 4.) In open water one specimen was taken from a depth of 1 m (stratum "d"). (See F i g u r e 2.)

The complete portion of the plant was collected, in whatever stratum, without regard to the lenght of the stem, the number of branches or leaves. The samples were all considered separately, in respect to strata, locality and plant species, in a way to be described below.

The collections were made from a boat. Wherever possible plants with intact leaves were chosen. In shallow water the whole plants were carefully gathered at their roots. The pieces selected, as described above, were cut and put into a vessel containing running water. In deep water the specimens from the different strata were taken without regard for its being the same plant.

TABLE II.

A B	Myriophyllum spicatum											Potamogeton perfoliatus															
	Ia	Ib	Ic	IIIb	IIIc1	IIIc2	Va	Vb	Vc	Xb	Xc	IIa	IIb	IIc	IVa	IVb	IVc	IVd	VIb	VIc	VIIb	VIIc	VIIIb	VIIIc	IXb	IXc	Total
1. Punctodora sp.	567	336	1071	49	374	230	114	80	150	231	229	179	308	88	9	69	48	103	1036	1211	730	2523	649	15	6	104	10509
2. Nitocra inuber	240	589	297	120	31	19	1	6	8	20	117	163	218	96	17	55	24	210	329	407	91	278	49	8	49	256	3698
3. Corophium curvispinum	0	40	66	2	6	3	25	83	426	47	350	26	250	46	6	148	162	190	623	205	67	148	97	74	18	124	3232
4. Chironomida larvae	44	305	47	215	112	48	57	106	44	50	81	121	205	42	67	29	16	72	340	43	50	111	22	73	35	521	2856
5. Rotatoria	604	300	192	101	32	4	110	41	20	28	70	594	134	31	61	107	0	10	19	7	77	0	8	37	31	63	2681
6. Dreissena polymorpha	0	11	263	0	0	0	20	51	106	63	243	5	39	26	2	102	146	463	3	65	25	173	54	341	17	71	2289
7. Nais ssp.	13	150	32	7	19	15	35	7	17	38	11	26	98	29	7	28	16	50	149	91	115	65	69	301	21	99	1508
8. Polycentropida larvae	6	0	41	0	8	10	0	2	8	4	12	0	42	25	0	24	237	184	3	36	7	108	15	119	73	219	1183
9. Stylaria lacustris	19	300	116	59	4	23	3	8	7	23	12	37	84	262	0	1	36	10	30	58	0	33	2	11	3	5	1146
10. Sida crystallina	13	0	0	0	0	0	0	5	0	3	3	263	7	0	31	277	0	10	13	4	101	43	34	7	149	27	990
11. Chaetogaster langi	0	5	22	1	12	5	17	2	0	5	8	0	53	15	13	1	36	40	9	164	16	0	14	63	17	53	573
12. Turbellaria	82	16	19	3	8	7	0	0	8	5	0	21	14	80	6	0	0	7	0	9	1	3	2	0	5	11	307
13. Aeolosoma quaternarium	38	0	6	0	13	3	0	0	28	5	5	0	21	4	0	0	4	13	0	23	0	0	2	7	1	27	200
14. Acroperus harpae	145	0	0	6	1	0	0	0	0	3	1	21	3	0	0	4	0	0	0	0	7	8	0	0	0	0	199
15. Cyclops serrulatus	19	21	0	6	0	0	0	0	0	26	4	0	0	2	0	16	0	0	0	20	3	13	6	0	15	27	178
16. Hydra sp.	0	0	0	0	2	0	0	0	0	1	41	0	0	19	22	3	0	7	0	0	1	0	0	0	0	0	96
17. Ephemerida larvae	0	0	3	0	0	1	0	0	0	0	0	0	4	29	0	0	0	0	0	7	0	0	0	0	0	0	44
18. Dorylaimus sp.	0	5	3	0	4	0	0	0	0	7	5	0	4	0	0	0	0	0	0	0	0	0	2	0	0	3	33
19. Alona sp.	0	0	9	3	0	0	0	1	0	1	0	0	4	0	0	3	0	0	0	2	0	0	0	0	4	0	27
20. Helobdella sp. cocon	0	0	0	0	0	0	0	0	0	0	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	17
21. Hydracarina	0	0	6	0	0	0	0	0	0	0	1	0	6	0	0	0	0	0	0	0	0	0	0	0	0	0	13
22. Daphnia cucullata	0	0	0	0	0	0	0	0	0	6	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	11
23. Diaptomus gracilis	0	0	0	0	0	0	0	0	0	1	3	0	0	0	0	0	0	0	0	0	1	3	1	0	1	0	10
24. Chaetogaster diaphanus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9	0	1	0	0	0	0	0	10
25. Ectinosoma Edwardsii	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	4	0	3	0	0	0	0	0	0	0	0	8
26. Notonecta sp.	0	0	0	0	2	1	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6
27. Limnaea sp.	0	0	0	0	1	2	0	0	0	0	0	0	0	2	0	1	0	0	0	0	0	0	0	0	0	0	6
28. Lepidoptera larvae	0	0	3	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	5
29. Agraylea sp.	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
30. Herpobdella	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
31. Unionida (juv.)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	2
32. Ostracoda	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Total	1790	2078	2202	572	631	371	385	392	822	568	1213	1456	1494	796	241	872	725	1372	2563	2354	1298	3509	1027	1056	445	1612	31844

Results of collections

A = species or other syst. group. B = Number and depth of collection. Total number of animals found in callestious. (Abbremated.) (The whole material calculated to the surface of 6.3 dm^2.)

Examination took place immediately after the collecting, while the material was in a live condition. The water was filtered through a net of Swiss silk bolting cloth No. 6 (29 threads/10 mm), which let pass only the Protozoa and the Nematoda of the size of *Punctodora*. From the filtrate, stirring constantly, a sample was taken with a piston pipette of a known volume (5 cm^3), and the *Punctodora* in them counted; the number obtained was used in calculating the number of organisms *(Punctodora)* in the entire filtrate. After this all the organisms remaining in the filter were counted in a little water in a Petri dish marked in sq. cm, with the aid of a binocular praep. microscope, enlargement 20x. After this, by means of several rinsings and a final delicate rubbing, the coatings were entirely removed from the plant and the new material treated in the same manner.

As the specimens originating from the different strata varied exceedingly in habit and, in consequence of this, in surface, in order to compare the results the numerical data obtained regarding the animals found in the coating were calculated to one given surface (6.3 dm^2 = the surface of 10 pieces of 20 cm long reed stem). The surface of the plant was determined in the following way. From examples collected from the different strata and different localities, I classified the leaves and stems according to dimensions into different types (Both of *Myriophyllum* and *Potamogeton* 3 leaf, 2 stem types). From each type 10—10 examples were measured as to surface. After this I calculated the average surface characteristic of the type. The surface of the samples whose coatings were investigated quantitatively were determined with the help of the average type surfaces described, and data on the sample itself (type, leaf-number, stem-length). After this the numerical data regarding the animals found in the coating were reduced to the average surface (6.3 dm^2) (See T a b l e II). It may be noted that the average surface of an entire plant was also estimated: *Potamogeton* in the Kis-öböl has ± 15 dm^2, in the open water ± 15 dm^2; *Myriophyllum* in the Kis-öböl has ± 4 dm^2, in the open water ± 26 dm^2.

A statistical elaboration of the results of my investigations was provisonally not carried out, because the nature of the collections was not appropriate for this purpose, and because the number of collections made in the same circumstances was small.

Let us now examine the coating more closely. (See page 17.)

I classified the coatings on the basis of my observations according to thickness, in 5 empirical groups: Where the coating is very thin: 1x; somewhat thicker, sufficient to be easily remarked, 2x; fairly well developed, in the axil of the leaves a mass of sediment, 3x; thick coating, here and there a little woolly, 4x; the richest woolly coating which covers both stem and leaves, 5x.

We can scarcely speak of a coating on *Potamogeton* in the "a" stratum. Here at most the leaves are covered with a thin calcareous crust which is caused by assimilation (1x). Lower we find constantly thicker coatings (2x—5x), consisting principally of mud, detritus and Diatoms; this at 2—3 cm from the base of the plant is again thinner. The coating on *Myriophyllum* is never as rich as on *Potamogeton* but it seems more equally distributed (2x—4x). In this case a thin coating is also found near the surface (2x) of the water, the calcareous crust being entirely lacking. Lower the coating on *Myriophyllum* too is thicker (3x—4x) but near the bottom there are some stems without leaves entirely free of coating. Immediately above the bottom some *Cladophora* are to be found. In other cases a hard crust with a pitted surface is found (1x) which consists principally of cocoons of *Herpobdella,* small *Dreissena* and oval-shaped, very strongly attached Diatoms, which last often cover everything evenly.

The difference in coating formation between *Myriophyllum* and *Potamogeton* may partly be explained by the different habit of the plants, but partly may be due to the precipitated calcareous particles on *Potamogeton.* The roughness thus caused makes *Potamogeton* better suited for forming a coating, besides which it collects much sediment at the axil of its leaves. Because of the stiffness of the stem of *Potamogeton* and the undivided leaves, the waves more successfully attack this plant near the surface of the water and there can more easily wash away the coatings. On *Myriophyllum* a calcareous formation cannot be observed, and so its surface is perhaps less well adapted to forming coatings. Again, the stem of the plant is very flexible and its divided leaves "give" to the movement of the waves. Thus the coating can remain on them even near the surface of the water.

So far the quantity of the mass coating has been established only by careful observation and estimation; exact quantitative measurements are still lacking.

As will appear from Figure 3, the quantity and quality of the coatings seem to be in close relation to the number of inhabitants. This is true especially in the case of organisms with the least locomotion. These (Nematoda, Oligochaeta, Chironomida larvae above $\pm$ 2 mm, Chironomida pupae, adult *Corophium* and *Dreissena)* are always the most frequent near the bottom. If we take the occurrence expressed in percentage (A), in the open water these comprise 82.5% of the organisms on *Potamogeton*, 90.3% of those on *Myriophyllum;* therefore on both an average of 86.9%. This can be explained by the fact that in the "c" stratum of the deep water the movement of the water is the least effective and thus the coating can most richly develop (4x, 5x). In the Kis-öböl the bottom water is more often disturbed because of

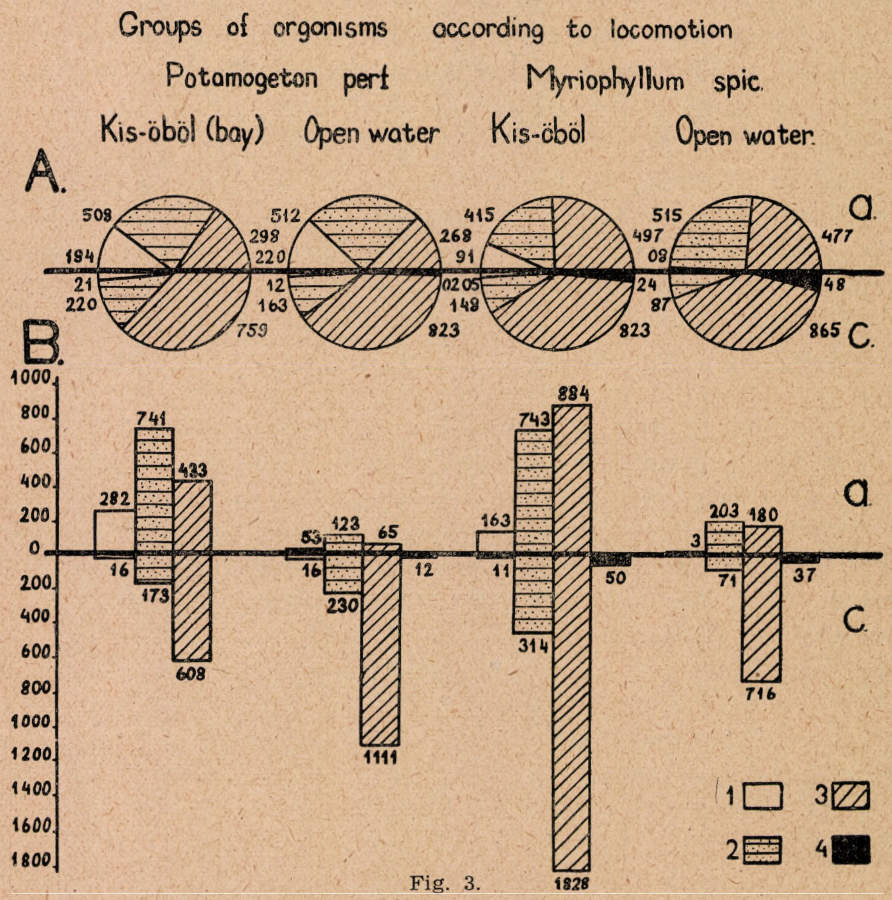

Fig. 3.

Groupings of organisms according to locomotion. Occurrence of the various types on different substrata and localities in % (A), number of individuals (B). 1.) Most active organisms (Sida, Acroperus, Alona) 2.) Active organisms, creeping and swimming on the surface of coating. (Turbellaria, Rotatoria, Cyclops, juv. Chironomidae, juv. Dreissena, juv. Corophium, Ephemerida larvae.) 3.) Less active organisms, living in the coatings and feeding on it (Chironomida larvae) < 2 mm, (Polycentropidae, Nitocra, Punctodora, Oligochaeta) 4.) Sessile organisms (Adult Dreissena, Helobdella cocoons).

the bay's situation and shallowness. Here this group of organisms is not as frequent as in the open water (*Myriophyllum* 82.3, *Potamogeton* 75.9, average 79.1%). (Thickness of coating, 2x, 3x.)

Considering the same group of animals having the least locomotion much scantier results are obtained near the surface of the water. As has been mentioned, the coating on *Potamogeton* is the sparsest in the open water near the surface (1x). The percentage of the abovementioned group is in reality here the smallest (26.8%), in the protected Kis-öböl somewhat more (29.8%). On *Myriophyllum* near the surface we obtain larger values (open water 47.7, Kis-öböl 49.7%). (2x). Undoubtedly other factors also may take part in this phenomenon.

Just the contrary is true in the case of organisms with a higher rate of locomotion (Cladocera, Rotatoria, Turbellaria, juv. Chironomida, juv. *Corophium*, juv. *Dreissena)*. In these the largest values are obtained nearer the surface and the lowest near the bottom.

We arrive at similar results if not the relations in percentage but the number of individuals is examined (B). In the open water on the surface the quantity of individuals is small, in direct relation to the paucity of the coating (*Potamogeton* 231, *Myriophyllum* 385. 1x, 2x), while in the deep water the number of individuals is disproportionately greater (*Potamogeton* 1372, *Myriophyllum* 822). In the Kis-öböl where the distribution of the coating is more even, great differences between the surface and the bottom are not to be expected, (*Potamogeton* "a" stratum, 1496; *Myriophyllum* 1790; *Potamogeton* in "c" stratum, 796; *Myriophyllum*, 2202).

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In what follows I review the animal organisms of the coating according to their frequency.

NEMATODA

In all the coatings of *Potamogeton* and *Myriophyllum* great numbers of Nematoda, were to be found at each collecting place. These comprise 34% of the entire material. Of 10,542 Nematoda, 33 belong to the large, *Dorylaimus* genus, all the rest are *Punctodora* size, most of them *Punctodora* sp.*

* Elsewhere when *Punctodora* is mentioned, *Punctodora* -sized Nematoda are to be understood.

The relation which can be established between the quantity of the coating and the organisms living in it is specially well demonstrated by the *Punctodora*. It can be seen in their distribution in *Myriophyllum* and *Potamogeton* coatings:

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	Punctodora			Metazoa including Punctodora			
	Iindivid^{2}	%	Ind/dm^2	Individ	%	Ind/dm^2	Thickness of coating
Myriophyllum	3431	32.6	50.0	10994	34.6	145.3	2x
Potamogeton	7078	67.4	79.7	20850	65.4	231.0	3x

As will be seen later, it is apparent that the minimum of *Punctodora* in stratum "a" and maximum in stratum "c" depends also on the quantity of the coating.

HARPACTICIDA

After the *Punctodora* the most frequent are the Harpacticida. In the entire material there were 3698 individuals (11.6%, per dm^2 22.6 individuals). The *Nitocra inuber* were overwhelmingly greater in numbers than any other species. Of *Ectinosoma Edwardsii* only 8 specimens were found, and of *Canthocamptus staphylinus* only a couple. In every collection *Nitocra* was to be found on *Potamogeton* as well as on *Myriophyllum*. It appears that on *Myriophyllum* fewer individuals live than on *Potamogeton (Myriophyllum* 21; *Potamogeton* 26.5 per dm^2). It was definitely to be observed that in the Kis-öböl they were much more frequent (altogether 2416, 35/dm^2) and in the open water more rare (1282, 13.5/dm^2). In the Kis-öböl they were the most frequent in stratum "b"; in the open water their number increased gradually with the depth, reaching the maximum in the "c" stratum near the bottom. It is probable that the distribution of the *Nitocra* specimens — regardless of the locality, depth and plant — depends as in the *Punctodora* on the quantity of detritus in the coating, its chief source of nourishment. *Nitocra* nauplius, as well as other young organisms, (juv. *Corophium,* sphaerium form of *Dreissena)* were to be found only in the Kis-öböl and in the upper strata of the open water. The nauplius of *Nitocra* penetrates into the interior of the coating and there carries on its peculiar shaking movements. Normally this movement of the inorganic particles and detritus in the coating calls attention to the tiny, hardly perceptible creatures. But an exact count of them in the specially thick coating is very difficult even when they are alive, therefore their numerical data is not an exact valuation. The metanauplius can be distinguished from the adults by the large red spots which are already present in the eggs and the nauplius. The metanauplii and the adults swim swiftly among the particles of the coating and in the cavities. In the Petri dish the greater mass of them assembles in the darkest part, while a smaller number swims towards the light. The females with eggs also without exception sought out the darkest places.

COROPHIUM and DREISSENA

A really great number of specimens of one of the most common Amphipoda of the Balaton, *Corophium curvispinum* G. O. SARS forma devium WUNDSCH (3232, 10.2%, 19.7 ind/dm^2) was present, as well as *Dreissena polymorpha* PALL, the zebra mussel (2289, 7.2%, 14.0 ind/dm^2). Between these two organisms there is a very close relation. Both are of pontus origin, and both increased to an enormous extent in the Balaton during the 1930s. (ENTZ-SEBESTYÉN, 1946. p. 301—302). In 1931 when A. MESCHKAT investigated the reed-coatings of the Balaton he did not find a single example of any of them, while since then they are to be found very frequently (on reed too). On the plants now studied these two species were everywhere found. In one case only in the whole collection both were lacking, from *Myriophyllum* in the "a" stratum in the Kis-öböl. In one other case also, from *Myriophyllum* from the same place only *Corophium* was to be found, and of that only 6 examples. Adult examples of both species attach themselves fast to their substratum. The *Dreissena* fastens itself to the stem and leaves of the plants with byssus thread, while the *Corophium* builds its tube in the same places. Where the *Dreissena* occur in quantities they settle on one another, making clumps on the stems, usually just above the bottom. The *Corophium* prefers the angles of shells in building its tube. They seem to be alike as to their food and some life conditions. On the *Myriophyllum* both organisms occur in smaller numbers. But while the *Dreissena* in the adult stage seldom moves about, the young as well as the adult *Corophium* are good swimmers. In the "a" stratum neither of them occurs in quantity (Table II.). The examples to be found in stratum "a" are very young *Corophium* and the sphaeriums of *Dreissena;* adult types of both are found in "b" stratum, but still more in stratum "c".

In the *Dreissena* we see a gradual increase in numbers in the lower parts of the stem ("a" stratum 1.1, "b" stratum 8.1, "c" stratum 34.0 ind/dm^2), both in the bay and in the open water (see below). But in the Kis-öböl there were fewer specimens than in the open water (Kis-öböl 5.9, open water 19.6 ind/dm^2).

We find slightly different conditions among the *Corophium*. Here too can be observed in the open water the gradual increase of examples according to depth ("a" stratum 3.2, "b" 9.6, "c" 41.7 ind/dm^2), but in the bay the data strongly differs from this, for it was in the "b" stratum that the greatest number of specimens was found. This can perhaps be explained by the fact that in the Kis-öböl the number of young specimens was greater (Entz B. 1943 p. 37). In open water, where proportionately more adult than young *Corophium* are found (open water, adults 15%, Kis-öböl 6.2%), the increase in numbers of *Corophium* in the lower depths is more clearly to be seen.

Numbers of individuals of *Dreissena, Corophium* and *Nitocra* estimated to a surface of 1 dm^2 of the substratum: Open water 1) *Myriophyllum,* 2) *Potamogeton;* Kis-öböl, 3) *Myriophyllum,* 4) *Potamogeton.*

	Dreissena				Corophium				Nitocra			
Stratum	a	b	c	average	a	b	c	av.	a	b	c	av
1.	0.0	0.8	14.0	4.9	0.0	3.3	5.1	2.8	38.1	56.2	18.4	37.6
2.	0.8	2.2	4.8	2.6	4.1	69.2	19.7	31.0	25.9	45.9	39.9	37.2
3.	0.3	6.2	18.4	8.2	4.0	0.3	61.6	25.3	2.7	12.9	14.0	9.9
4.	0.0	7.8	52.5	20.1	1.0	9.0	21.8	10.6	0.15	2.0	9.9	4.0

If we take only the adult *Corophium* into consideration, the distribution is as follows:

Stratum:	a	b	c	average
Kis-öböl	0.0	2.2	0.8	1.0
Open water	0.08	1.3	6.4	2.6

CHIRONOMIDA

Chironomida larvae are also constant inhabitants of the coatings. Among them we find red ones in smaller numbers and colourless in masses (see Entz-Sebestyén, 1946, p. 348). The red ones are to be found round the middle of September. Thus on the 13th of September 65 specimens were found, later only one. They occurred principally on Potamogeton, always near the bottom *(Potamogeton* 48, *Myriophyllum* 18 ind.).

Of colourless specimens altogether 2756 were found, of which 1/5th (542) were ± 2 mm long or longer. The rest were very small, very active, and as transparent as water. Pupae occurred principally near the surface of the water (34 ind.). The young larvae moved about quickly in the Petri dish, and most of them assembled on the light side. In general in the daytime collections the most Chironomida would be found in stratum "b" (24.3 ind/dm^2). Fewer examples would be found in "a" stratum (11.1 ind/dm^2). In the evening collections in the "c" stratum many young specimens were found (504), and at this time many less in the upper strata. This can be explained by the young larvae's sensibility to light and their ease of locomotion. They occur with equal frequency on both substrata *(Potamogeton* 15.7 ind/dm^2; *Myriophyllum* 15.5). But they seem to be more frequent in the bay (20.6 ind/dm^2) than in the open water (9.16 ind/dm^2).

OLIGOCHAETA

A well distributed group is formed by the Oligochaeta, whose members creep about, swim in and feed off the coating in large numbers. Their total number is 3309, 10.5% of the total material. Several species of several genera are to be found. Their distribution varies. The most common are the species of the genus *Nais*. It is characteristic of them that they live everywhere in the coating, both in the Kis-öböl and in the open water, but never in large numbers. In their distribûtion as to depth they seem to resemble the *Corophium*. They avoid stratum "a"; in the bay they frequent the "b" stratum, in the open water the "c" stratum (Kis-öböl, "b" stratum, 94.8 ind/dm^2, "c" 35.2 ind/dm^2; open water, "b" 42.3; "c" 87.5 ind/dm^3). In the Petri dish they seek the light. Altogether I noted 1508; on an average of 8.7 examples per dm^2 surface.

Stylaria lacustris occurred almost in the same number — 1146 examples; 6.7 per dm^2. Most of them were collected in the bay (966, 13.9 ind/dm^2) and only a small number (133, 1.4 ind/dm^2) in the open water. The *Stylaria* also avoids stratum "a" and likewise is common in "b" and "c" strata.

Decidedly more rare is the *Chaetogaster langi*. The greater number occurred on *Potamogeton* (573, 1.9 ind/dm^2) and only a very few on *Myriophyllum* (77, 1.1 ind/dm^2). This fairly small *Chaetogaster* feeds exclusively on the Diatoms living in the coating. Much larger than this is the *Ch. diaphanus*, of which 10 examples were found on *Potamogeton*. The Oligochaeta mentioned penetrate with their strong muscles into the interior of the coating and a gentle rinsing does not remove them. The fairly frequent *Aeolosoma quaternarium* has not such strong muscles. As is well known, it moves principally not with muscles but with cilia (WESENBERG-LUND, 1939, p. 317). Though this also penetrates with very slow movements into the interior of the coatings, rinsing will wash away most of them. It occurs in the bay and in the open water, both on *Myriophyllum* and *Potamogeton*. In the "a" stratum with the exception of 1 case it was not to be found (Kis-öböl, *Myriophyllum*, VIII 30) and in the "b" stratum it was also rare. It was the most abundant at the bottom.

ROTATORIA

All the members of the groups so far discussed stand in close relation to the water plant, or rather to its coating, being at the same time very essential elements of the latter. They live in the coating, build their homes in it, feed on Diatoms living there, or on detritus deposited in it, or attach themselves immediately to the water plant as substratum. The representatives of another group, the Rotatoria (2681, 8.5%, 20.9 ind/dm^2), swim and creep on the surface of the coatings, penetrating into its cavities. Rinsing removes them easily from the coatings. More than two-thirds of the Rotatoria belong to the genus *Notommata* (EYFERTH-SCHOENICHEN II. p. 377—79), the others (790) are of various genera. These latter do not form a united ecological group and thus are not suitable for comparison. It is easy to recognize the *Notommata* which feed on Diatoms by their larger size and their relatively slow movements. Investigating their occurrence from the standpoint of substratum, time and place of collection, and depth, certain relationships may be recognised. For these comparisons I used only the data from collections I, II, IV and V, as later their numbers diminished, at first suddenly and later more gradually. In examining their appearance in the different strata, whether collectively, whether according to plant species *(Myriophyllum, Potamogeton)*, or whether to locality (Kis-öböl, open water), we can see that the numbers diminished in relation to depth (stratum "a" 41.3 ind/dm^2; "b" 19.7 ind/dm^2, "c" 8.2 ind/dm^2. (Fig. 4 A.) But the same regularity is apparent, not only in the numbers of individuals of *Notommata* found but also in the percentual proportion to the other organisms. However the diminution according to depth is not evident in the case of evening collections: (Fig. 4 B.). On the evening of October 1st the differentiation according to strata could not be observed.

According to locality it seems that the *Notommata* are more characteristic of the bay (33.5 ind/dm^2) than of the open water (7.7 ind/dm^2). Some differences can also be distiguished according to substratum (*Myriophyllum* 24.5 ind/dm^2, *Potamogeton* 16.8).

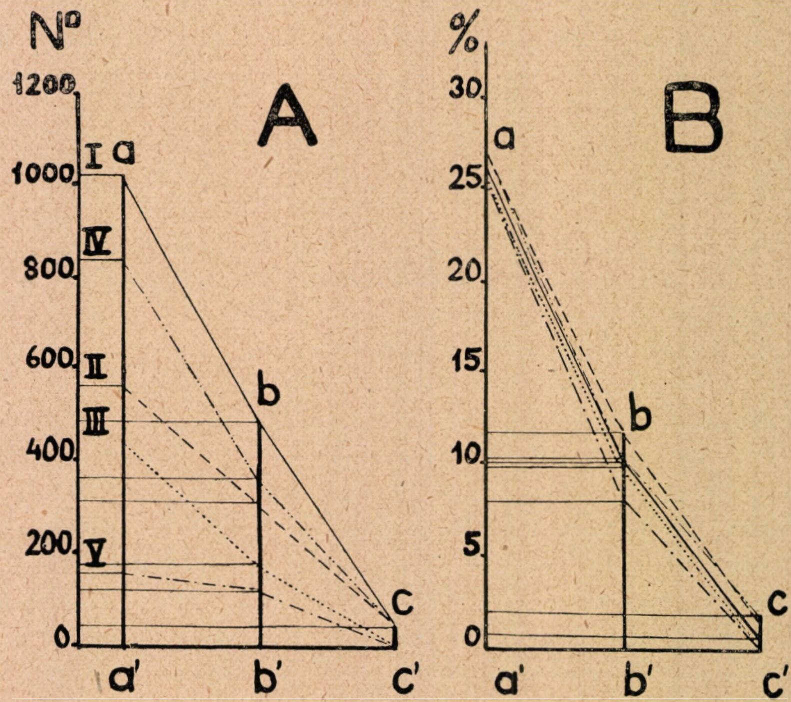

Fig. 4.

Occurrence of Notommata (B in % and A number of individuals), according to depth (a—á';, b—b';, and c—c'; strata), locality and substratum, from the four first collections. I (————) total number, II (— — — —) on Myriophyllum, III. (.........) on Potamogeton, IV. (..—..—) bay, V. (.—.—.—) open water.

POLYCENTROPIDA

The occurrence of the Polycentropida, which belong predominantly to the species *Ecnomus tenellus,* (ROUSSEAU E. 1921, p. 513.) forms — so to say — a mirror-picture of that of the *Notommata.* By this is meant that where *Notommata* are the most numerous Polycentropida are entirely lacking, and vice versa.

It is possible that it was only by chance, but it is interesting to note that where the Polycentropida formed more than 3% of all animals, the *Punctodora*, in other places present in large masses, were almost entirely lacking (scarcely 7% of all animals). However I could establish no direct relation between these organisms.

The Polycentropidae are carnivorous. In the Petri dish they sometimes ate up Chironomida larvae. Under the microscope they always fled into obscurity, and most of them assembled at the point the furthest distant from the light. They seem to prefer the deepest and darkest regions of the Balaton; they are almost entirely lacking in the Kis-öböl (1.7 ind/dm^2), while in the open water they are much more frequent (5.8 ind/dm^2). In the open water they are the most common in the "c" stratum (11.3 ind/dm^2), in strata "a" and "b" they are rare ("a" stratum only 1—2 examples; "b" 2.7 ind/dm^2). They occur much more frequently on *Potamogeton* than on *Myriophyllum* (*Potamogeton* 6.9 ind/dm^2 *Myriophyllum* 1.7). The most and biggest Polycentropida larvae were to be found in the muddy sediment deposited in the leaf axil of the *Potamogeton*, in which the specimens were almost entirely hidden.

At the evening collections they were present in larger numbers in the upper strata too. Therefore it is possible that these active and seemingly negative phototropic organisms, like the *Notommata* and the Chironomida, come to the surface of the water in the evenings.

The numerical distribution of Polycentropida on October 1st, 1946, per dm^2:

	Morning	Noon	Evening
"b" st.	7	15	73
"c" st.	108	119	217

CLADOCERA

Two species of Cladocera play a great role in the coatings, *Sida crystallina* (990 individuals, 3.1%, 6 ind/dm^2) and the *Acroperus harpae* (199, 0.6%, 1.2 ind/dm^2). Both water fleas live in the upper strata of the water. *Acroperus* is frequent on *Myriophyllum* (2.2 ind/dm^2), hardly occurring on *Potamogeton* (0.5 ind/dm^2), while *Sida* is almost exclusively found on *Potamogeton* (11.0 ind/dm^2). On

Myriophyllum it is very scarce (0.3 ind/dm²). The swimming of *Acroperus* is slow; it is rather a creeping on the coatings. In both localities it is the most common in stratum "a"; in "b" and "c" only one or two specimens are found. Regardless of locality the mean values of occurrence of *Acroperus* in the different strata are: "a" 6.6, "b" 0.4, "c" 0.08. They occurred principally in the Kis-öböl. The largest number of examples was noted there on *Myriophyllum* in stratum "a" (23 ind/dm²). In the open water it is much more rare (0.2 ind/dm²). The *Sida,* which adheres to the surface of *Potamogeton* and is a very good swimmer, is principally an open-water organism (open water 7.8 ind/dm²). On *Potamogeton* growing in both localities it was frequent in the two upper strata ("a" 12.2, "b" 11.4 ind/dm²), while in "c" stratum there were only a few examples (0.1 ind/dm²). However there are some differences as to locality; in the bay the largest masses were in the "a" stratum, while in the open water they were to be found in "b" stratum. The same phenomenon, that the maximum numbers of individuals occur in different depths in the bay and in the open water, is to be observed in other organisms too (see p. 26, 28).

TURBELLARIA

Under the microscope more of the smaller Turbellaria occurred fairly frequently (307, 1.0%, 1.9 ind/dm²). Though their number is never great they are to be found everywhere; the greater part of them belong to the genus *Dalyellia,* though other species were also observed. All of them are small worms which feed on Diatoms and swim above the coatings or in their cavities. In the Kis-öböl more (3.7 ind/dm²) and in the open water fewer (0.6 ind/dm²) were found, in equal numbers on *Myriophyllum* and *Potamogeton.*

CYCLOPS

As to frequency, *Ciclops strenuus* follows in rank, more than 100 specimens of it being found in the total material investigated. This swims here and there, "grazing" on the surface of the coatings, and swims away on the slightest disturbance. They occurred in about equal numbers in all collections.

There were also numbers of other organisms in the material collected but always so few in number that no regularity in distribution could be established. Hydra *(Pelmatohydra oligactis?) Alona sp.* were seen here and there. Ephemerida larvae (44 examples) occurred only in the Kis-öböl and there too an Ostracoda. With the plants growing in the open water were gathered some members of the plankton such as *Diaptomus gracilis, Leptodora Kindtii, Daphnia cucullata,* etc.

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* *

In working up the material it was apparent that with the first rinsing (see method) it was always the same organisms which were washed away in great numbers. In order to investigate this more closely, the samples from 12 collections were gently rinsed, later subjec-

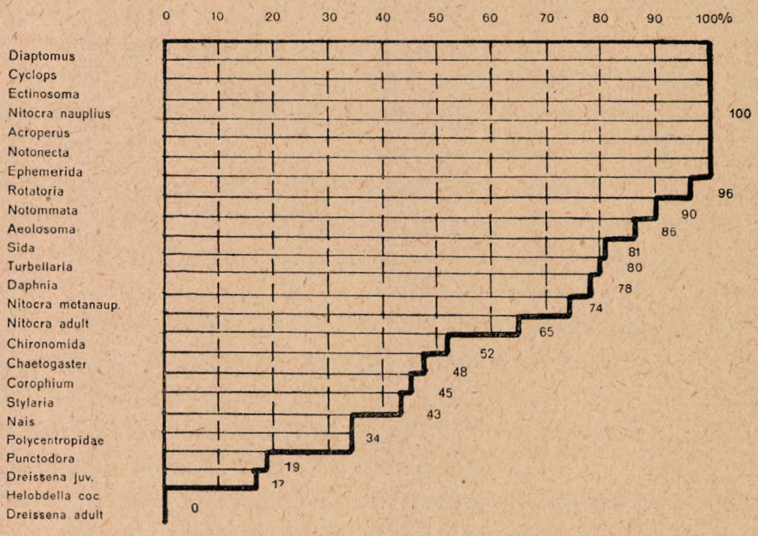

Fig. 5.

Percentual distribution of the animal organisms exhibiting degree of adherence when rinsing the plant. (For numbers see text.)

ted to strenuous shaking and rubbing. The number of organisms gained by this were compared. (Fig. 5.) The result was that the most active organisms were found to be those which could be 100% washed away by the first rinsing, meaning that they were not so closely related to the coating *(Cyclops, Acroperus,* juv. *Notonecta,* etc.).

80—90% washed away were those which, also active organisms, rest from time to time on the plant or on the surface of the coating *(Sida, Notommata,* etc.). These groups originated mostly from strata "a" and "b", being their characteristic inhabitants. Least easily washed away were the organisms living in the interior of the coating. These are characteristic of stratum "c" *(Punctodora,* Oligochaeta, *Dreissena,* etc.). As we see, this succession throws light on the degree of their locomotion, their methods and degree of adhering (from time to time, or permanently). But it appears also that in the upper strata occur principally the very active organisms. Near the bottom, on the other hand, occur those types which are in close relation to the water plant or its coatings.

The feeding conditions of the animals of the coatings are very interesting. The majority of them feed on detritus (79.8%). These are primarily the tiny sessile Nematodes, the sessile *Dreissena,* the tube-making *Corophium,* besides these the *Nais, Stylaria, Aeolosoma, Nitocra,* etc., which creep in the interior of the coating, and probably the greater part of the Chironomides. 11.9% of the animals feed on Diatoms. The greater part of these are animals easy of locomotion, swimming or creeping on the surface of the coating or in its cavities, such as the Rotatoria, *(Notommata)* Turbellaria, principally members of the genus *Dalyellia,* the *Chaetogaster langi* and the commonest *Cyclops, Cyclops strenuus.* Half of the remaining (4%) are carnivorous, primarily the Polycentropidae, which, at least in captivity, eat the Chironomidae larvae. The other half (3.8%) consist of Cladocera, primarily *Sida crystallina* and the *Acroperus harpae,* of which it is known that they are "minute feeders", or microphagous animals (Carpenter 1928 p. 58). It is to be remarked that in the entire material there were found only 5 examples of Lepidoptera larvae, (Lampert K. 1904 p. 87), which feed on the leaves of the plants. Thus the great majority of the animal organisms of the coatings employ the water plant only as a substratum, while they find their nourishment in the coating itself.

Let us assemble the resemblances and the differences from one another between the coatings of 1) *Myriophyllum* and *Potamogeton,* 2) of the Kis-öböl and the open water, and 3) of the "a", "b", and "c" strata.

1.) We see from Table III that the coatings on *Potamogeton* harbour more animals than do those of *Myriophyllum.* This very likely is connected with the development of the coating as such, which is richer on the *Potamogeton.* Thus, *Punctodora, Nitocra, Corophium, Dreissena* and the *Nais* (that is, the organisms most closely attached to the coatings) are naturally more frequent on *Potamogeton,* though

Stylaria and Chironomida larvae (which would seem to be also in close relation to the quantity of the coating) live in equal numbers on *Myriophyllum* and *Potamogeton.*

All these organisms — occurring on both plants — are such as are most closely attached to the coating. On the other hand, *Sida* (*Potamogeton* 11.0 ind/dm^2, *Myriophyllum* 0.3) and the Polycentropida (*Potamogeton* 11.6, *Myriophyllum* 1.3 ind/dm^2) live almost exclusively on *Potamogeton,* while *Acroperus* (*Potamogeton* 0.5, *Myriophyllum*

TABLE III.

Species or group	stratum „a"	stratum „b"	stratum „c"	Potamogeton	Myriophyllum	Kisöböl	Open water	Average
1. Punctodora sp.	34.5	31.5	56.0	79.7	50.0	78.6	56.8	64.2
2. Nitocra inuber.	16.7	34.4	24.2	26.5	21.0	37.9	12.3	22.6
3. Corophium curv.	3.2	18.0	29.0	22.9	15.4	18.3	21.6	19.7
4. Chironomidae	11.1	24.3	2.8	15.7	15.5	21.0	9.4	17.4
5. Notommata sp.	40.3	19.7	8.2	16.8	24.5	33.5	7.7	16.4
6. Dreissena polym.	1.1	8.1	34.0	15.7	10.9	5.9	19.6	14.0
7. Nais sp.	3.1	11.1	6.5	11.1	4.5	8.6	7.9	8.7
8. Polycentropidae	0.2	2.7	11.3	11.6	1.3	2.5	10.5	7.2
9. Stylaria lacust.	2.3	15.4	16.1	6.1	7.8	14.2	1.1	6.7
10. Sida crystallina	12.2	11.4	0.1	11.0	0.3	4.3	7.8	6.0
11. Rotatoria	14.0?	5.7?	5.9?	4.8?	6.3?	9.0?	2.1?	4.8?
12. Chaetogaster lan.	1.2	2.4	3.1	5.3	1.1	4.1	2.8	3.5
13. Turbellaria	4.3	1.2	4.5	1.9	2.1	3.7	0.6	1.9
14. Aeolosoma quater.	1.5?	0.9	1.6	1.1	1.4	1.6	1.0	1.2
15. Acroperus harpae	6.6	0.4	0.0	0.5	2.2	2.5	0.2	1.2
16. Cyclops sp.	0.8	1.6	0.1	1.2	1.0	1.0	1.2	1.1
Total	153.1	188.8	203.4	231.9	165.3	246.7	162.6	196.6

Average number of individuals of the most frequent species or groups according to strata, substrata and locality calculated to 1 dm^2 plant surface. For calculating the math. mean data the whole material of all the collections was used, except the mean regarding the depth, in calculating which only Collections I, II, V were considered.

2.2 ind/dm^2) prefers *Myriophyllum.* Both organisms are less closely attached to the coating. Probably there is some hidden relation between these organisms and their substratum but of what nature I was unable to determine. The Turbellaria, *Aeolosoma* and *Cyclops,* being organisms but loosely attached to the coating, are equally frequent on both substrata.

2.) There is scarcely any difference between animal members of the coating — in a qualitative sense — in the open water and the Kis-öböl, but quantitative differences can be remarked in the case of some organisms. Thus the greater number of *Nitocra inuber, Notommata,* and nearly all *Stylaria.* Turbellaria and *Acroperus* derive from samples of the Kis-öböl, while the greater number of *Dreissena* and *Sida* and nearly all Polycentropidae were to be found in the open water. In somewhat greater numbers were *Chaetogaster* and Chironomida larvae and the *Punctodora* in the bay; the *Corophium* in the open water.

3.) Where strata are concerned, several different types of differentiation can be made. Some organisms have their maximum in stratum "a" everywhere, and their numbers diminish precipitously in the lower strata. Such are *Notommata* and *Acroperus.* Others frequent preferably the lower depths of the open water, as of the Kis-öböl. This is specially characteristic of the *Sida* (Kis-öböl the maximum in "a" stratum; open-water maximum in "b" stratum) but the same can be observed of *Nitocra, Nais* and *Corophium* and Chironomida larvae. These last occur in the bay, all in stratum "b", while in the open water they are the most frequent in stratum "c". The cause of the difference can be sought in wave action.

Another group consists of those organisms whose numbers increase according to depth, in both collecting places. These always dwell in "c" stratum (Polycentropidae, *Dreissena).* Some organisms are also known which are distributed equally in all strata.

SUMMARY.

The coatings on small growths of *Potamogeton* and *Myriophyllum* in the open water and a bay of Lake Balaton, and the animal organisms living in them, were examined on the basis of material taken from different strata during 5 weeks at the beginning of the autumn of 1946. The organisms were examined and numbered in a live condition, and the numerical data uniformly calculated to a given surface. On the *Potamogeton* the coatings are very thin near the surface and very rich near the bottom. The difference is more remarkable in the open water than in the bay. On *Myriophyllum* the coating is not so rich but more equally distributed. Characteristic organisms living in the coating according to frequency are: *Punctodora, Nitocra* sp. *Corophium curvispinum, Chironomida* larvae, *Notommata* sp., *Dreissena poly-*

morpha, etc. The differences between the animals harboured by the coating of *Potamogeton* and *Myriophyllum* are chiefly quantitative, although some qualitative differences were also observed. The organisms in closest relation to the coating live principally near the bottom, those more independent of it in the upper regions. A relation can be shown between the rate of locomotion of the organism and the ease with which it is washed away. The majority of the inhabitants of the coating feed on the detritus in the coating, or on Diatoms or other animal organisms living in it, and only one or two specimens of a very few species were found to feed on the plant itself.

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