CONTRIBUTIONS TO STUDIES ON SOIL PROTOZOA OF THE CILIATA GROUP, WITH SPECIAL REGARD TO THEIR ADAPTATION TO SOIL CONDITIONS.

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During investigation of ciliate soil protozoa the question arose whether these animals, which have relatively large bodies in comparison with the other protozoa, are occasional visitors in the soil, or whether, in spite of its varying water content, they could be considered permanent inhabitants. The question became of still greater interest from the surprising discovery that most of the ciliate species observed in the soil were originally described as inhabitants of puddles, moss and running water, that is to say, from areas where there is much more water than in the soil. If I had based my investigations on this alone, then the reply to the question would already have been that the ciliate protozoa in the soil are only occasional visitors in areas with little sub-soil water — capillary and adhering water as well as seepage. But other points of view had also to be taken into consideration, on the basis of which the soil-dwelling propensities of a certain group of ciliates could not easily be denied. The question had to be approached from a different angle, for instance, because identical species of Ciliata could be found in soils of different consistencies, provided they had the same hydrogen ion concentration. If it had been a question merely of the protozoa brought to the soil by the wind, the species found here would have had to be of very heterogeneous character. But the truth was that the dimensions, shape, movement, food, as well as, in many cases, the propagation also seemed to conform in accomodating themselves to the small water volume of the soil.

In what follows, therefore, I wish to record to what extent ciliates were found in my investigations to be constant inhabitants of the soil.

QUESTIONS OF METHOD

In the literature no good method for demonstrating the ciliate protozoa which interest us is given. The methods used in investigating free-water creatures are available first of all. But, though the ciliates live in the soil as aquatic animals, they cannot be studied by these methods, for the water in the soil is never so abundant that the ciliates in it can be drawn up with a pipette and studied under a microscope. It seemed indicated to use a process whereby water was poured on the soil (tap or rain water), and to try to take up the ciliates from this solution with a pipette. This method was not satisfactory, however, for in must of the soils the part suspended was so great that the field of vision under the microscope was no longer transparent. It is true, of course, that after a day or two the water on the soil becomes clearer, but in the meantime many animals could emerge from their cysts (which they would not have done in soil with little water volume) thus including the inhabitants of cysts brought by the wind as well.

In preliminary investigations I used the following method (DEMETER, 1936) to some extent: Small clods of the soil under investigation are put on the object glass, with a glass cover, then water is rapidly released from a pipette on to the bits of soil. The water streams in under the cover glass and carries part of the soil protozoa with it. We thus get an idea of the ciliates present in the soil in an active state. But as this method was not sufficient for closer identification, we remedied the defect by comparing the animals thus found with those found after a day or two with the soil diluted with well water to twice its volume (when the water on the soil was already fairly clear), taking into consideration among the latter only those which could also be seen under the cover glass.

This method has several defects, however: In the case of muddier soil, grains of earth also get under the glass on flooding it with water and often impede the view. Conversely, we cannot be sure that the more adherent animals will get in under the glass. It follows that this method is only partly suitable for qualitative determinations, and not at all for quantitative.

For both qualitative and quantitative investigations I employed a new method, which was, briefly, that I attached the two poles of an electric torch battery to two opposite sides of a Boveri cup. I put 1 g of the soil under investigation into this cup, previously emulsified with 10 ml filtered and sterilized, 20-times diluted soil solution. Attracted by the electric current, the animals assemble at one pole. I gathered them up with a pipette, then, using the same electric method, washed them several times in a 20-times diluted soil solution and thus got them into good condition for examination. The animals so prepared were then investigated by the microtechnical method of the Gelei school (V. Recapitulation, GELEI J. and J. HORVÁTH, 1934, 1937, 1940). For rapid staining Breslau opal-blue was used.

During the investigation it became necessary to cultivate clons of the different species of ciliates, to determine exactly which seemed labile For this purpose I prepared a soil extract of the soil from which I had isolated the animals in question, diluting it suitably to make an environment favourable to them (a dilution of from ten to twenty times always served the purpose). I dissolved a little gelatine in this nutrient solution and adjusted it to the original pH value with HCL or NaOH. The ciliates preferring bacterial diet were fed on soil bacteria cultivated on gelatine and agar; the carnivorous ones were given suitable ciliates.

SOILS INVESTIGATED

Two essentially contrasting kinds of soil were chosen for these investigations. The one was garden earth, the other sandy soil which had never been subjected to agricultural cultivation. Investigation of garden earth was also made upon two areas. One of them was the flower garden of a university building in Ady Square, the other farm garden belonging to the Szeged Teachers' Seminary. The sandy soil derived from the flood area of the Tisza beach at Szeged, an area inundated by the Tisza floods at most once a year. I wanted to ascertain from study of the latter area whether the proximity of the Tisza, or the yearly inundations influenced the occurrence of active protozoa in the soil.

The chief constituent in the two garden soils was marshy loess; the sandy soil contained ordinary loess as well as sand. There was a great difference in humus content in these soils. That from the Ady Square garden had the richest humus content, about 9%, that of the farm garden of the Teachers' Seminary had 2%, and the average humus value of the Tisza flood area was 1%. The high $CaCO_3$ content assured approximately uniform pH values to all three soils.

From now on, for simplicity, the Ady Square soil will be called Area No. I. the farm garden II, and the food area soil III.)

SPECIES FOUND ON THE AREAS INVESTIGATED, AND THEIR ADAPTATION TO THE SOIL

Systematic research on Area I was begun in November 1938, when the humidity of the soil leapt up to 17% as effect of rainfall. From the soil samples then taken all the species given in Table *A* were found. From the middle of December of that year until the middle of March no active ciliates were found in the soil samples. From then till June 1939 the same species were again found, then from the first days in June till October no Ciliata in an active state were to be demonstrated. In these spring and autumn months, with about 13% greater soil moisture, ciliates in an active state could still be demonstrated, though they appeared in largest quantity at 17—18% or even greater humidity.

In Table *A* are summarized the characteristics typical of the animals found in area I, data on their size, movements, possible body changes, nutriment, as well as the places so far known from the literature to be their habitats.

We see that of the 22 species found the length of 13 was 50 μ or less, but none was less than 25 μ. There is only 1 species between 50 and 100 μ, whereas between 100 and 150 there are 8, yet none exceeding 150 μ. It is true that, according to the literature, the *Gastostyla steini* can attain to 350 μ, though I never isolated any of such dimensions from the soil.

From the standpoint of locomotion, among these species only *Halteria decemsulcata* requires great water volume, though according to my observations this species thanks to its small size (25 μ) is also capable of living in areas with less, such as the capillary, adherent and seepage water of the soil. It is remarkable that in 18 of the 22 species we find a sliding or walking movement, which adduces a great degree of adaptation to the small water volume, or to the detours occasioned by the particles of earth. Four species are not thus provided for (2 *Cyclidium*, 1 *Halteria* and 1 *Vorticella* species) but one of these (*Vorticella*) was sessile and two (the *Cyclidium*) were inclined to be. Furthermore all these four species were of very small proportions compared with the others.

A still more interesting connection between the size of the body and the animal's flexibility was discovered: The animals longer than 100 μ were all flexible. They had adapted themselves in this way to the small water areas in the soil. Only two of the species smaller than 100 μ were flexible, the others having the regular body form. Their small size apparently allowed them ease of locomotion in the small water areas, so that pliancy of body was superfluous.

In the matter of nutriment it is interesting that the animals with large bodies were generally carnivorous, 6 in number, whereas the smaller ones fed on bacteria, fungi, detritus and algae. In some groups in the animal world the larger-sized of a species are herbivorous and the smaller carnivorous. This also applies to the ciliates living in free-water areas. Neither is it a case in our biotopes of the carnivorous growing to be larger than the herbivorous, for — with a few exceptions — these species are of the same sizes as the average specimens present in free water areas. Here we can merely state that the herbivorous animals living in the soil are smaller than the carnivorous. Apparently the environment does not suit the larger-sized herbivorous animals. I also see characteristic adaptation in the fact that bacteria and fungi form the principal food of the herbivorous, i. e., the nutriment in the soil corresponds to their needs.

The literary data on the habitats of these animals are assembled in a separate column in Table *A. Kahl's* (1935) summarizing work has been the principal source for this. According to his showing there are only 4 species which are expressly earth and mud dwellers. Seven species are recorded in mosses. Five are shown to be from water containing putrifying plant material, and research so far has produced 6 of our animals in fresh water. A great many of the moss-dwellers, however, were demonstrated by pouring water on collected moss, letting the „raw" culture thus produced stand for a while and then describing the animals present in the culture as moss-dwellers. But with this method it is not in the least certain that these Ciliata really live in the moss, for there is no question but that, in collecting earth mosses, for example, bits of earth also get into the culture and with them the cysts of soil-dwelling ciliates. Let us suppose, however, that ciliates also live in an active state in water adhering to moss. The question of how they got there still remains. It seems beyond doubt, from the soil. This naturally applies only to earth mosses. The species described as inhabiting water were also shown from moss infusions and, as we see in the Table from notes on their distribution, they are not frequent in these environments — whereas, as I have already mentioned, I always found them, given the necessary soil humidity. We can therefore confidently state that the soil is the original habitat of the moss-dwellers.

TABLE A

Ciliata Protozoa found in Area I

(Explanation of signs: R = regular (= having constant shape); F = flexible; B = Bacteria; Fu = fungus; A = algae; C = predaceous; S = swimmer; Sl = slider; W = walker; Cr = creeper).

Name	Length, shape	Food	Locomotion	Habitat, distribution, food
1. Holophrya simplex	32 μ F	A C	S Sl	Frequent in fresh water. Oahu island. Feeds on: Bodo, Monas and small Ciliates.
2. Platyorphrya lata	105 μ F	C	S Sl	From moss infusions; Wide-spread; feeds on: Algae, Ciliates.
3. Prorodon terres	120 μ F	A C	S Sl	In earth and saline pools; feeds on: diatoms, Rhodobacteria, Ciliates.
4. Prorodon (Holophrya) discolor	60-80 μ F	A C	S Sl	Frequents inland waters; feeds on: Algae, Ciliates.
5. Spthidium amphoriforme	120 μ F	BAC	S Sl	In Mitterwald and Zittertal, among mosses.
6. Chilodonella algivora	50-70 μ R	B A	S Cr	Among grasses and algae; very wide-spread.
7. Colpoda maupasi	35-70 μ R	B Fu	S Sl	From straw infusions.
8. Colpoda steini	25-30 μ R	B Fu	S Sl	In decaying water plants.
9. Colpoda fastigata	55-60 μ R	B Fu	S Sl	Fresh water; frequent.
10. Colpoda inflata?	30-40 μ R	B Fu	S Sl	From moss infusions.
11. Colpoda Aspera	30-50 μ R	B Fu	S Sl	In mud.
12. Glaucoma myriophilli	100 μ F	A B	S Sl	In Myriophyllum.
13. Cyclidium terricola	30-40 μ R	B	S	In earth-moss at Hamburg, in Alpine mosses; rare.
14. Cyclidium glaucoma	25-30 μ R	B	S	Among decaying plants.
15. Halteria decemsulcata	25 μ R	B Fu	S	From soil.
16. Kahlia simplex	120 μ F	B Fu	S W	From soil.
17. Amphisiella milnei	100 μ F	A Fu	S W	From sand, at Kiel. Eats: diatoms, Ciliates.
18. Gastrostyla steini	150-350 μ F	B Fu C	S W	Frequent in fresh water.
19. Opistrotricha similis	100 μ F	B Fu	S W	Frequent in fresh water.
20. Gonostomum affine	50 μ F	A B Fu	S W	Detritus feeder. In moss.
21. Euplotes muscicola	40-70 μ R	B Fu	S W	In European and American mosses; European soil.
22. Vorticella microstoma	35 μ R	B	Sessile	In water containing decaying plants.

TABLE B

Ciliata Protozoa found in Area II
(For abbreviations see Table A)

Name	Length, shape, locomotion	Food	In active state in the samples, 1939 May—November						
			V	VI	VII	VIII	IX	X	XI
1. Holophrya simplex	34 μ F S Sl	A C			+	+	+	+	+
2. Platyophrya lata	105 μ F S Sl	Cu			+	+	+	+	+
3. Prorodon terres	120 μ F S Sl	A C			+	+	+	+	+
4. Prorodon (Holophrya discolor	60-80 μ F S Sl	A C			+	+	+	+	+
5. Enchelys agricola nov. sp.	60-70 μ F S Cr	C			+	+	+	+	+
6. Spathidium spatula	150-160 μ F S Cr	B C		+	+	+	+	+	+
7. Spathidium sp.	100-120 μ F S Cr	A B C	+	+			+	+	+
8. Nassula sp.	65-70 μ R S	A B		+			+	+	+
9. Chilodonella algivora	50-70 μ R S Cr	B A	+				+	+	
10. Colpoda aspera	30-50 μ R S Cr	B Fu	+	+	+	+	+	+	+
11. Colpoda maupasi	35-70 μ R A Cr	B Fu	+	+	+	+	+	+	+
12. Colpoda steini	25-30 μ R S Cr	B Fu	+	+	+	+	+	+	+
13. Colpoda fatigata	55-60 μ R S Cr	B Fu	+	+	+	+	+	+	+
14. Colpoda inflata?	30-40 μ R S	B Fu	+	+	+	+	+	+	+
15. Glaucoma myriophylli	100 μ F S S	A B	+	+	+	+	+	+	+
16. Glaucoma scintillans	40-75 μ R S Sl	B Fu	+	+					
17. Halteria decemsulcata	25 μ R S	B Fu	+	+	+	+	+	+	+
18. Kahlia simplex	120 μ F S W	B Fu						+	+
19. Gastrostyla steini	150-350 μ F S W	B Fu C	+	+				+	+
20. Opistotricha similis	100 μ F S W	B Fu			+		+	+	+
21. Opistotricha terrestris nov. sp.	80 μ F S W	B Fu	+	+	+	+	+	+	+
22. Gonostomum affina	50 μ F S W	A B Fu	+	+	+	+	+	+	+
23. Euplotes muscicola	40-70 μ R S W	B Fu	+	+	+		+	+	+

In No. *I* soil I found five species which the literature recognizes as being from „putrifying water", or from water which contains decaying plant material. It is known, however, that in damp soil, under partially anaerobic conditions, there is a certain degree of putrifaction. Here in the soil we also find the bacterial food which experience has shown to satisfy the optimum requirements of the ciliates preferring such putrifying water. Indeed the soil is really the primary biotope of bacteria which effect mineralization in this way. If we classify the five species in question as soil-dwellers on the basis of what has been said, this does not in the least imply that every ciliate preferring „putrifying water" is at the same time a soil-dweller, for many such species are limited by the small area offered by the soil and by their size, shape and state of movement, favourable or unfavourable to it. *Paramecium caudatum* can be cited as an example of this. This species was found at Szeged at all seasons in the section of the city's sewers which empties into the Tisza, and J. Gelei (verbal communication) found *Paramecium* in a very vigorous form and in great quantities in the septic tank of the Tihany Biological Institute. In this environment, therefore, the actively rotting anaerobic bacteria flourish, as well as in moist soil. Conversely, *Paramecium caudatum* was never found in the soil, as its size, movement and shape prohibit its living in such a habitat. Indeed its complicated and prolonged way of encysting and excysting would have prevented it. (The encystment is known only experimentally; *Paramecium* cysts have never yet been seen free in nature.)

In Table *A*, finally, we find 6 species which are known in the literature as being fresh water inhabitants. It has been demonstrated of three of these that they are unquestionably ubiquists and hence can also be regular inhabitants of the soil, given the other necessary morphological conditions. The other three species, on the other hand, as we have seen in the foregoing, are capable of adapting themselves to the environment provided by the soil.

The ciliate protozoa on experimental area No. *II.* were studied for what was essentially a different purpose (see *Horvàth*, 1943), but during the investigations I naturally kept in mind the considerations stated at the beginning of this paper. This garden was constantly watered, so that it had about 16% moisture from June till October 1939, and during the rest of the period of investigation — in October and November — this percentage was at times greater, due to rainfall, at times slightly less.

The results of this experiment are summarized in Table *B*. It appears first of all from this that in habitats thus artificially assured Ciliata in an active state were also found during the summer months. During the six months of the experiment (from May to December) I collected altogether 23 species of Ciliata from this area. If this list of ciliates is compared with those in Table *A*, we see that, with the exception of six species, they are the same on areas I and II. But two of the six occurred in such small numbers that — as can be seen — we could not identify them more exactly. (They are: *Spathidium sp.* and *Nassula sp.)* Two new species were also found: *Enchelys agricola* and *Opisthotricha terrestris*. *Spathidium spatula* and *Glaucoma scintillans* are also new species not found in area No. I. How do these four species adapt themselves to the environment offered by the soil? *Enchelys agricola nov.* sp. is a carnivorous species, 60—70 μ in size. Because of its small dimensions we might think it adapted to the small water water areas in the soil, and even more so because of its very pliant shape, which can really be said to be contractile. This characteristic makes it capable of slipping through the small clods of earth and thus always capable of getting about and finding its food, the ciliata required by its carnivorous nature.

The other new species, *Opisthotricha terrestris,* is a small-sized Hypotrichus (80 μ in length): its shape differs nowise from the other local representatives of its order. Thus on the whole it adapts itself well to the environment offered by the soil in question.

Spathidium spatula is a 160—170 μ, very flexible, carnivorous Hymenostomata protozoön. Besides being carnivorous it was also, according to my observations, capable of feeding on bacteria and fungi. These qualities enable it to live in the water volume provided by the soil.

Glaucoma scintillans, with a length of 40—60 μ, is characterised chiefly by its huge mouth, which enables it to whirl masses of bacteria into its gullet. According to previous literary data, it occurs in large numbers chiefly where there are bits of rotting plant material in the water, a thing obviously related to its preference for bacterial diet. These requirements are to be found in garden soil also.

Though these four latter species seem regular soil dwellers, they could not be found in soil No. I. I can give no other reason for it than that the pH of investigative area II, though it rose to 8 during my investigations, was also round about 6, whereas soil No. I more regularly gave about an 8 pH value. The differences in humus content mentioned above may also have had an influence on the differences in the occurrence of this fauna in the two areas, which can be said in any case to be insignificant.

In Table *B* the monthly occurrence of the different species is noted separately. On scrutinizing this it is apparent that all the species are chiefly in an active state in the autumn. Touching on this problem, I reported in another work (see *Horváth,* 1943) that the herbivorous ciliates are the first to appear in the soil in an active state, the carnivorous only later. But it is possible that there is some other cause for the differing presence of the species: In connection with research area No. I we have said that in autumn and spring all the species in Table A were always found there, whereas on area No. II this was the situation only in autumn. The amount of soil humidity, examined each month, could not be the cause of the difference, for we get nearly the same percentage throughout the whole investigation. It seems likely that the effect of the temperature ought to be taken into consideration as acting on this phenomenon, or as one of the factors bringing it about. *Varga* (1936), for example, found in connection with the protozoa in forest soil that they generally occur in an active state in cold weather, and showed that forest-soil protozoa are cold-stenothermous forms. From the data in Table B this could not be said to be generally true of garden

TABLE C

Ciliata Protozoa found in Area III

(For explanation of signs see Table A)

Name	Length, shape	Food	Locomotion	Habitat, distribution, food*
1. Rhopalophrya elevans nov. sp.	16-20 μ R	A B	S	
2. Platyophrya lata	105 μ F	C	S Sl	
3. Cyclogramma sorex	55 μ R	B	S Sl	In fresh water, Geneva, Berchtesgaden, Werra district, California, Feeds on: large bacteria.
4. Chilodonella labiata	35 μ R	A B	S Cr	Among Utricularia.
5. Colpoda steini	25-30 μ R	B Fu	S Sl	
6. Colpoda fastigata	55-60 μ R	B Fu	S Sl	
7. Colpoda aspera	30-50 μ R	B Fu	S Sl	
8. Glaucoma reniformis	50 μ F	A B	S	Fresh water, near Sidney.
9. Colpidium campillum	50-150 μ R	B Fu	S Sl	Among decaying water plants.
10. Cinetochilum margaritaceum	15-45 μ R	B Fu	S Sl	Fresh water, moss-infusion.
11. Cyclidium glaucoma	25-30 μ R	B	S	
12. Pseudocristigera hymenofera nov. gen. nov. sp.	30-35 μ R	B Fu	S Cr W	
13. Halterioforma caudata nov. gen. nov. sp.	15-20 μ R	B Fu	S	
14. Halteria decemsulcata	25 μ R	B Fu	S	
15. Kahlia simplex	120 μ F	B Fu	S W	
16. Gastrostyla steini	150-350 μ F	B Fu C	S W	
17. Paruroleptus lacteus	110-120 μ F	A B	S W	Fresh water, Botanical Garden, Hamburg.
18. Tachysoma pellionella	95-85 μ R	B Fu	S W	In fresh water, frequent; feeds on: bacteria.
19. Oxytricha hymenostomata	80-100 μ F	A B	S W	Among Lemna.
20. Urosoma macrostya	120-150 μ F	A B	S W	Among Lemna.
21. Histrio complanatus	80 μ R	A B	S W	In puddles, in springtime.
22. Histrio muscorum	100-150 μ F	A B Fu	S W	In moss infusions, E. Germany, California.
23. Aspidisca costata	25-40 μ R	B	S W	In decaying water plants, very wide-spread.
24. Astylozoa pyriforme	50 μ R	B Fu	Sessile	In New Zealand, in hollows in forests.
25. Vorticella microstoma	35 μ R	B	»	

* Notes only on species not in previous Tables.

soil. As we see, there are species which are present both at warm and cold temperatures. They can therefore bear changeable temperatures, i. e., are eurythermous, e. g., the *Colpoda* species, *Opisthotricha terrestris* and *Gonostomum affine*. As the other species in the soil live an active life in cool weather, they can be classified as cold-stenothermous. Other of my observations, however, do not altogether confirm so simple a classification of the phenomenon. For example, I found *Kahlia* in an active condition on area No. II. in October and November. It might therefore be concluded that this species was a cold-stenothermous creature. The truth is, on the contrary, that it thrives best at 25—30° C room temperature. Furthermore, I found *Glaucoma scintillans* in an active state in May and June, but not during the dog days nor in the colder autumn, yet VARGA (1935) found them in the winter fauna of forest soil. From these examples it is evident that the presence of active ciliates in the soil here is not due merely to the temperature. It is to be supposed that many other factors are involved in the phenomena (such as the water-content of the soil) which, however, my observations failed to elucidate.

Area No. III was the high sandy beanch of the Tisza flood regions near Szeged. As I have already mentioned, this area was inundated on an average of once a year, usually during the early spring floods. Systematic investigations were carried out on this area from April to December of 1939, and from March to June 1940. Material for investigation was collected every two weeks and always from places where the sand was still wet. Active protozoa were generally found where the soil had a 16% water content, hence chiefly only in the spring and autumn months. The pH value of the soil at such times was 7·8 in the damp soils, i. e., slightly alkaline, and the drier soils containing no active protozoa had a 6.6 value.

In Table *C* are given the 25 species of ciliates which I succeeded in identifying on the third area investigated. Seven of these 25 also live in the two garden soils of territories I and II, and two, *Vorticella microstoma* and *Cyclidum glaucoma,* only in No. I. If now we take into consideration that the soil of area III was loose, sandy and permeable, and therefore in severe contrast with the soils of areas I and II (only in the pH reaction was there no sharp difference between them), then we must conclude that these seven species — by name *Platyophrya lata, Colpoda steini, C. fastigata, C. aspera, Halteria decemsulcata, Kahlia simplex, Gastrostyla steini* — are soil-ubiquist creatures. Of the other 17 species, the Table shows eight to be of 50 μ or less we find five between 50—100 μ, and three between 100 and 150 μ. Most of the species found here belong, therefore, to the small-sized ciliates. Here too the rule is valid that the animals with larger bodies are flexible, whereas the smaller ones have regular bodies and thus both accomodate themselves to their environment in the tortuous little water fields. In general it can be said that on experimental area No. III there were no open-water forms at all. Previous researchers had found 8 of these species in fresh water, two in moss or moss infusions, three in water containing constituents of rotting plants, while I myself isolated three new species from the soil. This habitat seems in interesting contrast to areas I and II, in that there only two carnivores among the ciliates found here, the others feeding on bacteria, fungi and algae.

This territory is particularly worthy of interest as contrasted with the two previous, because here there is the possibility for water ciliates to change into soil ciliates. How does this occur? In the beginning my idea of it was that after the withdrawal of the floods, the ciliate fauna characteristic of this soil develop in the remaining little puddles and afterwards simply get into the soil with the water seeping through. I investigated numerous small puddles containing little water. I found only 1—2 pelagic protozoa, and not one of the species given in Table *C*. It is therefore evident that in this soil it is not a question of a simple, seasonal faunal emigration. Hence the only remaining possibility is that the majority of the species remain attached to the soil even during floods. Whether they are encysted or in an active form I was unable to establish, as I could not avoid getting free water along with the sand taken from under water. We can therefore get an answer to the question only from general biological knowledge. It is known, for instance, that where any ciliate species lives an active life, there we should usually also find their cysts. (It is only in the laboratory that we can produce conditions under which the animals always live an active life). It is therefore probable that this soil-fauna develops from cysts remaining in the inundated soil after the water has withdrawn. That is to say, it is evident that the ciliates living an active life in the soil during floods drift into the upper regions of the water and that the flood carries them along. This applies only to the flood-area soil, lying high and evenly, for in excavations and deep flood areas we should in all probability find an entirely different state of affairs.

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ИССЛЕДОВАНИЯ ПРОТОЗОА, ПОЧВЫ ГРУППЫ РЕСНИЧНЫХ И В ОСОБЕННОСТИ ВОПРОС ОВ ИХ ПРИСПОСОБЛЕНИЯ К УСЛОВИЯМ ПОЧВЫ

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РЕЗЮМЕ

Мы исследовали фауну ресничных инфузориев в окрестности города Сегед (Венгрия) с точки зрения приспособления этих протозооа к жизненным условиям различных видов почвы.

Мы исследовали: 1. Почву сада, орошенного главным образом только дождем. 2. Почву сада, постоянно орошаемого. 3. Затопленную водой почву.

Наши результаты нижеследующие:

1. Приблизительно нейтральная почва должна содержать в среднем 16% подпочвенной воды, для того чтобы ресничные могли развить в ней активное существование.

2. Ресничные приспособывающиеся к условиям недостаточного увлажения почвы двоякого вида: *а)* ресничные постоянных форм и небольших размеров. *б)* более крупных размеров, но имеющих гибкое тело и также способных изменять свою форму.

3. Чаще всего длина видов, встречающихся в почве, не достигает 100 м.

4. Движение ресничных, проживающих в почве, происходит главным образом путем скольжения хождения и ползания в почве. Среди ресничных, исследованных в наших почвах, обнаружены, хотя и редко, оседлые или полу-оседлые типы, но никогда не встречались формы, проживающие в открытой воде.

5. Большая часть видов, проживающих в описанных выше почвах 1 и 2 встречается, по мнению прежних авторов, в настоях мха, или в воде содержащей гниющие растения. Более мелкие экземпляры, по мнению этих авторов, происходят из открытой воды.

Жизненные условия в средах, упомянутых выше, тождественны с условиями, имеющимися в почвах 1 и 2 потому, что и там можно определить периодическое гииение в почве. (навоз.)

В почве 3 мы встречали также и формы, характерные для свежей воды, в соответствии с характером почвы в области затопления, являющейся переходной стадией от жизненных условий сухой почвы до воды.

6. Большая часть ресничных, найденных в почве садов, является эвритермическими существами.) Это установление еще нельзя обобщать, так как имеются противоречащиеся наблюдения.)

7. Сравнивая результаты исследования всех трех видов почвы, мы нашли виды ресничных, встречающиеся в равной степени во всех трех видах почвы. Так как два из этих видов почвы существенно отличаются друг от друга — почва садовая и песчаная — мы назвали ресничных, встречающихся в обоих видах почвы: ,,везде сущими почвы“. На основе наших исследований можно установить, что в почве имеется постоянная, приспособленная к почве фауна ресничных.