The Etosha Pan in Namibia (Southwest Africa): A Biodiversity Centre for Soil Ciliates (Protozoa, Ciliophora)

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Introduction

Fascinated by the rich diversity of microhabitats, soils, plants, and animals in the Etosha Pan, I commenced a research program on soil ciliates in 1994. The program, later supported by the Austrian Science Foundation (FWF), has two main goals: (i) to identify the ciliates present and to describe the new species found, and (ii) to provide a reliable estimation of the number of undescribed soil ciliates globally. My presentation will concentrate on the Etosha Pan, although samples were taken also from other sites in Namibia, especially the Namib Desert, which is also full of soil (sand) ciliates. Furthermore, I emphasize that the data are preliminary because the study is still in progress. The final data, including the descriptions of the new species, will be published as a book in 2001 or 2002.

The Pan and its soils

The Etosha Pan covers an area of about 5000 km^2 and is circa 120 km long and 55 km wide. Annual precipitation is about 450 mm, and annual mean temperature is 22.5°C. The origin of the Pan is still in discussion, but it is clear that it an old formation providing sufficient time for an independent evolution of life. One hypothesis assumes that the Pan originated by wind erosion about 60 million years ago. An other theory suggests a pliocenic origin 5 – 1.6 million years ago (HERDTFELDER 1984).

The Pan soil is a very special mixture of clay, lime, and salt (NaCl, Na_2CO_3, Na_2SO_4) having a pH range of about 7.6 – 9.7; the air-dried mixture is like a stone, but quickly doubles its volume and becomes a fluffy pancake when it is rewetted. Around the Pan, the salt content gradually decreases causing a strong zonation of flora and fauna. Here, thick, brownish layers of only partially decomposed leave and grass litter form innumerable microhabitats of very different size and composition. Furthermore, the soil is covered by a more or less continuous layer of filamentous cyanobacteria, which become reactivated when the Pan is flooded.

Methods

Soils samples were taken and processed as described in FOISSNER (1998). The material collected included the top soil (0 – 5cm, rarely up to 10cm) with the humic layer and fine plant roots as well as the leave and grass litter from the soil surface. Usually, about 10 small subsamples were taken from an area of 10 – 100 m^2 and mixed to a composite sample, which was air-dried for at least one month and then sealed in plastic bags. For studying the ciliates, samples were put in a Petri dish (15 cm across, 2 – 3 cm high) and saturated but not flooded with distilled water. Such cultures were analyzed by inspecting about 2 ml of the run-off on days 2, 7, 14, 21 and 28. This so-called "non-flooded Petri dish method" is selective, that is, only a small proportion of the resting cysts present in a sample is reactivated. Thus, the real number of species, described and undescribed, is very likely much higher than shown in Table 1. Unfortunately, a better method for broad analysis of soil ciliates is not known.

Species were identified from life and after silver impregnation. I usually apply the morphospecies concept, that is, classify new species as such only when populations can be separated from their relatives by at least one distinct morphological feature. Furthermore, I try to identify species with poorly described taxa, giving them a firm identity by redescription and neotypification.

Table 1. Preliminary data on ciliate species numbers and main abiotic factors in 18 soil samples from the Etosha Pan.

Sample no.	Salinity[1)]	pH[2)]	Total number of species[3)]	New species	New species %
57	++++	8.7	21	4	19
58	++++	8.7	8	3	38
59	++++	9.0	8	4	50
61	++++	9.0	13	8	62
65	++++	8.0	40	7	18
67	++++	9.7	23	8	35
69	++++	9.7	10	4	40
53	+++	8.9	22	7	32
54	+++	8.0	38	17	45
70	+++	8.4	60	14	23
71	+++	7.6	11	4	36
55	++	6.7	11	1	9
56	+	7.8	57	12	21
60	+	8.6	43	11	26
64	+	6.3	34	2	6
62	–	7.7	28	1	4
63	–	7.7	37	1	3
66	–	7.2	16	2	13

[1)] ++++ very high, +++ high, ++ moderate, + low, – lacking
[2)] In water
[3)] Correlations (Spearman's coefficient): Total species /salinity = - 0.373 ($p < 0.1$)
New species/salinity: + 0.369 ($p < 0.1$)
Total species/pH = - 0.249 ($p > 0.1$)
New species/pH = + 0.464 ($p < 0.05$)

The ciliate community (Table 1)

In the 18 samples investigated, 210 species were found, of which about 73 (=35%) were undescribed, that is, new to science. Most belong to the following groups, each containing some or many new species: colpodids (27%), hypotrichs (26%), gymnostomatids (24%), nassulids (8%), and hymenostomes (7%). Compared to the world soil ciliate community (FOISSNER 1998), hypotrichs are underrepresented in the Etosha Pan and in Namibia in general (40% in world fauna vs. 30% in Namibian fauna), possibly because most of them are k-selected. Colpodids (14% vs. 20%) and nassulids (5% vs. 7%), on the other hand, are over-represented. The former are mainly r-selected having the ability to use optimally the short wet periods typical for this country. The latter prefer filamentous cyanobacteria as main food source and obviously profit from the cyanobacterial mat covering large areas of the Pan and its surroundings. There is a clear tendency ($p < 0.1$) that total species richness/sample decreases with increasing salinity, while the number of new species/sample increases with salinity and pH (Table 1).

Obviously, extreme biotopes produce special species not only in multicellular but also in unicellular organisms. Although there is a tendency for highest species numbers in the salt bush (*Suaeda*) and grass (*Sporobolus*) zone, rich samples occur in both highly saline (sites 65, 70; Table 1) and non-saline (site 63) areas, indicating that soil microstructures and plant communities have greater influence on the ciliate community than salinity.

How many species of free-living ciliates? (Table 2)

FINLAY & FENCHEL (1999), two well-known protozoan ecologists, suggest that global diversity of free-living (= freshwater, marine, soil) ciliates probably does not exceed 3000 species, while FOISSNER (2000) estimates that there are probably 30 000 free-living ciliate morphospecies, most of which are still undescribed. These contrasting views have, in my opinion, two main reasons. First, the entire field is heavily under-researched because, as compared to higher plants and animals (e.g. butterflies), very few educated people have ever looked for protozoan diversity. Thus, the data available are too incomplete for any reliable estimation. Second, protists are notoriously "undersampled", mainly because they are small and encysted most of their life. Only when the appropriate conditions set in, do they excyst and become visible. These and other problems, briefly discussed in FOISSNER (1997, 2000), become evident if large sample collections from a large region are analyzed (Table 2).

Table 2. Data summary on diversity of soil ciliates in Europe, Africa, Australia and Antarctica (from FOISSNER 1997).

Characteristics	Europe (99 samples)	Africa (92 samples)	Australia (157 samples)	Antarctica (90 samples)
Total number of species[1)]	345	507	361	95
Species/sample (mean)	26	35	23	4
Undescribed species	185	240	154	14
Undescribed species (%)	54	47	43	15
Undescribed species/sample (mean)	1.9	2.6	1.0	0.2
Undescribed species/sample (%)	7.2	7.5	4.4	3.9
Corrected number of undescribed species[2)]	–	1032	477	34
Undescribed species (%)	–	80	74	70
Estimated global diversity (~)	–	2000	1540	1330

[1)] Each sample collection was considered as a unique entitiy. Thus, a new species found, for instance, in Africa and Australia, was classified as "undescribed" in each of the data sets.
[2)] See FOISSNER (1997) for the statistics applied.

Although the individual samples contain only one to three (4 – 7%) new species on average, the sample collective shows that up to 50% of the species found are undescribed.

When such data are statistically corrected for differential capture rates between described and undescribed species, it becomes evident that 75 – 80% of the ciliates are still unknown (Table 2). Finally, about 170 of the 410 ciliate species found in the 73 samples from Namibia are undescribed. Such a number shows more clearly than any experiment or statistics that FINLAY & FENCHEL heavily underestimate global diversity of free-living ciliates and that most of their diversity is still undescribed.

References

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