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by Hartmut Bick and Sigrid Kunze

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A Review of Autecological and Saprobiological Data on Freshwater Ciliates

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Among protozoans, the ciliates constitute a group of organisms which is widely distributed in fresh water and may attain considerable importance, both as species and as individuals, particularly in waters where strong bacterial decomposition processes take place. Generally speaking, the ciliates are important biotic elements within the overall structure of aquatic ecosystems. They are also of special importance to sewage biology, since many ciliates serve as index forms for certain degrees of saprobity or standards of water quality. A detailed knowledge of the ecological potential of the different species is absolutely necessary in order to understand the role played by individual ciliates in the complex framework of an ecosystem. This knowledge of the essential conditions of life is equally important as a basis for the classification of individual species into certain systems of index organisms, such as the saprobe system. Therefore an attempt has here been made to strike a balance between available individual findings which are widely scattered in the literature, and to prepare comprehensive environmental spectra. The paper was deliberately restricted to such species for which more extensive ecological data were available, since exact but isolated data are not sufficiently representative in the absence of a wider series of observations.

* Translated from: Int. Revue ges. Hydrobiol. 56 (3.), 1971, pp. 337-384

Within the range of material available, the ecological potential of the species selected was compiled for the following abiotic factors: temperature, pH (only more recent values electrometrically measured), actual O_2-content, percentage of oxygen saturation, BSB_5*, free CO_2, ammonium (NH_4), free NH_3, H_2S and salinity (thalassogenous and athalassogenous** separately).

As for environmental factors, the bacterial population of the habitat milieu was taken into account. Since methods to establish the number of bacteria differ among the various authors and thus are not readily comparable, a differentiation was made between (1) indirect determination of the number of bacteria by means of the plate method according to KOCH, (2) direct count by phase-contrast microscopy, and (3) count on a membrane filter. The factors mentioned permit a good characterization of the milieu; the number of bacteria and the content of O_2 or CO_2, respectively, confirm or supplement each other to a certain extent, since active bacterial decomposition of organic matter is accompanied by O_2-consumption and formation of CO_2.

(338)

Saprobiologically, the species used as indicators have been listed as they are classified in the saprobiont system (KOLKWITZ 1950, LIEBMANN 1962), but the classification is frequently not uniform. This difference in classification by the individual authors is understandable when it is remembered that ciliates are not generally stenotopic and thus are not restricted to a narrow environmental range, but that they are largely of a eurytopic nature. These facts are taken into account by the 10-Points-Method of ZELINKA & MARVAN (1961) which indicates by a number of points the distribution of a species within the series polysaprobic, alphamesosaprobic, betamesosaprobic, alphaoligosaprobic to betaoligosaprobic,

*biological oxygen demand (BOD_5)

**NB thalassogenic and thalassogenous are used synonymously throughout

i.e. the number of points attributed to each grade corresponds to the relative frequency of findings in this area. For each species, the number of points in the individual saprobic grades adds up to the sum of 10 in each case. Thus, basically a distribution curve for the saprobity spectrum is characterized by numerical values. It must be emphasized that the different distribution maxima are not so much explained by a preference of the respective species for certain abiotic conditions, but rather by their ability to tolerate extremely abiotic conditions and thus to make use of the nutrients available without pressure of competition from the more sensitive species.

The above-mentioned numbers of points of "saprobic valency" (cf. Table 1, p.339) serve, together with the "indicator value" (i), as the basis for a mathematical determination of the degree of saprobity of the water (for the method, see ZELINKA & MARVAN 1961). The indicator value (i) was calculated according to the method proposed by SLADECEK (1964); it is high in the case of relative saprobic stenovalency (e.g. Cyclidinium glaucoma, Table 1) and low at euryvalency (e.g. Cinetochilum margaritaceum, Table 1). Since the 10-Points-Method reflects the often variable limits of distribution in the saprobity spectrum in a much clearer manner than the point-classification of KOLKWITZ or LIEBMAN is able to do, 72 species have been classified according to the method of ZELINKA & MARVAN in Table 1 (p.339); original data as well as data from the literature are used in this Table.

When preparing the environmental spectra, a large number of publications reviewed which do not supply directly usable data, but still contain essential contributions to the ecology of ciliates.

The last literature survey on the "Ecology of free-living Protozoa" (NOLAND & GOJDICS, Bibliography No.141) only deals with papers up to 1963 and is so oriented as to place less emphasis on the limnological aspect. Therefore, it is intended to compile here briefly the more all/recent papers , in particular, on the individual subject complexes of relevance, while providing at the same time a key to the more detailed literature.

General aspects of the ecology of protozoans are dealt with by BRAGG (1937), FAURE-FREMIET (1950,1961), and KUDO (1966). The paper by HAIRSTONE & KELLERMANN (1964) describes a new aspect of the collecting technique. Detailed autoecological analyses are presented by B ICK (1966 a and b). BAHR (1954), CURDS & VANDYKE (1966), and GRITTNER (1951) wrote on the importance of ciliates as bacteriophages. With regard to their subject matter, these papers follow the earlier investigations by LIEBMANN (1936b).

Within the overall group of ciliates, the peritrichans were studied in more recent times by KRALIK (1957/58, 1961), NUSCH (1970), and STILLER (1968). Sapropel ciliates as an ecologically clearly defined group were the subject of a mainly morphological revision by JANKOWSKI (1964) which is a continuation of the paper by SCHULZE (1958) and of the classical articles on sapropel ciliates by LAUTERBORN (1894, 1901), LIEBMANN (1937, 1938 b), RYLOV (1924), (341 and WETZEL (1928).

Protozoans in flowing water were studied by GRAY (1952), KRALIK (1957/58), KALTENBACH (1961), MÄDLER (1958/59), MORAVCOVA (1962), SRAMEK-HUSEK (1956 b), STILLER (1957), and WILHELM (1954).

Data on ciliates are supplied by research on barrage dams by the following authors: NUSCH (1970), SLADECEK & SLADECKOVA (1962), SLADECKOVA (1960), SLADECKOVA & SLADECEK (1963).

WILBERT (1909) gives a detailed population-dynamics study of ciliates from an eutrophic pond. LEGLER (1964) studied ciliates on floating leaf plants, again in small eutrophic water bodies. BICK (1958), DINGFELDER (1962), GELEI et al. (1954) KRAMER (1962), and PROKESOVA (1959) worked on pond ciliates.

Numerous authors have studied the ciliates of waters laden with sewage. Sewage-biological investigations of flowing waters stem from BOCK (1960), MÄDLER (1958/59), NOWAK (1940), WILHELM (1964); BICK & SCHOLTYSECK (1960) and KAUFMANN (1958) studied sewage ponds. Special investigations of activated sludge originate from BAINES et al. (1953), BUCK (1968), CURDS (1964), CURDS & VANDYKE (1966), and HAMM (1964). The papers by BEER (1964), SLADECEK (1961, 1964 a), SLADECKOVA & SLADECEK (1963, 1965), SRAMEK-HUSEK (1956 a, 1958), STILLER (1954), and VENTZ (1964) on the importance of individual ciliate species as indicators for investigations of water quality include a wealth of ecological data.

ZELINKA & MARVAN (1961), SLADECEK (1964 a, 1969), and SLADECKOVA & SLADECEK (1966) deal especially with the "saprobic valency" (cf. Table 1).

The boundary region between limnetic and marine areas, i.e. the brackish water, and particularly the problem of salt tolerance by freshwater ciliates, were studied by AX & AX (1960), BICK (1964 a, 1964 b, 1967 a, 1968 b), DIETZ (1964), FAURE-FREMIET (1948), FINLEY (1930), FRISCH & JOHN (1935), HAYES (1930), OBERTHÜR (1937), REUTER (1961), and STILLER (1963, 1968).

Autoecological Characterization and Environmental Spectra of Selected Ciliate Species

Preliminary Note: In order to save space, authors are referred to in the following by the relevant bibliography number. In addition, the following abbreviations have been used:

(1) To characterize the degrees of saprobity:

ams = alphamesosaprobic

bms = betamesosaprobic

aos = alphaoligosaprobic

bos = betaoligosaprobic

ps = polysaprobic

os = oligosaprobic

i = indicator value (Table 1)

(2) In the case of salinity:

th = thalassogenous brackish water

ath = athalassogenous brackish water

(3) In the case of the number of bacteria;

D = direct count by phase-contrast microscope,

MF = count on the membrane filter,

PM = plate method according to KOCH, using peptone agar.

In principle, the environmental spectra indicate the extreme values of occurrence; optimal areas are characterized by bold-faced values in brackets.

Table 1. Saprobic Valencies and Indicator Values (i) of 72 Ciliated Protozoa.

10-Points-Method of ZELINKA & MARVAN. Original data unless otherwise indicated.

For key to abbreviations see page 341.

	bos	aos	bms	ems	ps	i	Author
Acineria incurvata	—	—	—	3	7	4	
Amphileptus tracheloides	—	7	3	—	—	4	SLÁDEČEK 1969
Aspidisca costata	—	1	5	3	1	1	
A. lynceus	—	—	2	7	1	3	
Bursaria truncatella	—	—	8	2	—	4	
Campanella umbellaria	—	—	5	5	—	3	SLÁDEČKOVÁ & SLÁDEČEK 1966
Carchesium polypinum	—	—	2	7	1	3	SLADEČKOVÁ & SLÁDEČEK 1966
Chaetospira mülleri	—	1	8	1	—	4	SLÁDEČKOVÁ & SLÁDEČEK 1966
C. remex	—	—	3	7	—	4	SLÁDEČKOVÁ & SLÁDEČEK 1966
Chilodonella cucullulus	—	—	2	5	3	2	
C. uncinata	—	—	1	8	1	4	
Cinetochilum margaritaceum	—	1	2	5	2	1	
Cohnilembus pusillus	—	—	1	6	3	3	
Coleps hirtus	—	1	3	4	2	1	
Colpidium campylum	—	—	—	1	9	5	ZELINKA & MARVAN 1961
C. colpoda	—	—	—	3	7	4	SLÁDEČEK 1964
Colpoda cucullus	—	—	—	7	3	4	
C. steini	—	—	—	4	6	3	
Cyclidium citrullus	—	—	1	8	1	4	
C. glaucoma	—	—	—	9	1	5	SLÁDEČEK 1969
Dendrosoma radians	—	—	5	5	—	3	SLÁDEČKOVÁ & SLÁDEČEK 1966
Dexiotrichides centralis	—	—	—	2	8	4	
Didinium nasutum	—	1	6	2	—	3	
Dileptus anser	—	2	8	—	—	4	
Epistylis plicatilis	—	—	5	5	—	3	
Euplotes affinis	—	1	6	3	—	3	
E. patella	—	—	8	2	—	4	SLÁDEČEK 1969
Frontonia acuminata	—	2	6	2	—	3	
Gastrostyla steini	—	—	2	7	1	3	
Glaucoma scintillans	—	—	—	2	8	4	SLÁDEČEK 1964
Halteria grandinella	—	1	6	3	—	3	
Heliophrya rotunda	—	—	5	5	—	3	SLÁDEČKOVÁ & SLÁDEČEK 1966
Hemiophrys bivacuolata	—	—	1	3	6	3	
H. pleurosigma	—	1	4	5	—	2	
Lacrymaria olor	—	2	6	2	—	3	
Litonotus fasciola	—	—	1	8	1	4	SLÁDEČEK 1964

(Table 1 continued)

	bos	aos	bms	ams	ps	i	Author
L. lamella	—	—	1	7	2	3	
Metacineta mystacina	—	—	5	5	—	3	Sládeček 1964
Opercularia coarctata	—	—	2	7	1	3	
O. nutans	—	—	7	3	—	4	Sládečková & Sládeček 1966
Phascolodon vorticella	—	—	10	—	—	5	Sládeček 1969
Ophridium sessile	—	2	3	5	—	2	Sládečková & Sládeček 1966
Oxytricha fallax	—	—	1	8	1	4	
Paramecium bursaria	—	—	2	6	2	2	Zelinka & Marvan 1961
P. caudatum	—	—	—	5	5	3	Zelinka & Marvan 1961
P. trichium	—	—	1	5	4	2	
Plagiopyla nasuta	—	—	—	—	10	5	
Platycola truncata	—	2	4	4	—	3	Sládečková & Sládeček 1966
Podophrya fixa	—	—	2	8	—	4	Sládečková & Sládeček 1966
Platynematum sociale	—	—	2	7	1	3	
Spirostomum ambiguum	—	—	2	8	—	4	
S. teres	—	—	2	6	2	3	Sládeček 1969
Stentor coeruleus	—	—	4	6	—	3	Sládeček 1964
S. polymorphus	—	—	4	6	—	3	
S. roeseli	—	—	5	5	—	3	Sládeček 1964
Stylonychia mytilus	—	—	1	9	—	5	Sládeček 1969
S. putrina	—	—	2	7	1	3	
Tachysoma pellionella	—	—	5	5	—	3	
Tetrahymena pyriformis	—	—	—	3	7	4	
Thuricola folliculata	—	2	6	2	—	3	
Tintinnidium fluviatile var. *emarginatum*	—	3	7	—	—	4	Sládečková & Sládeček 1966
Trachelius ovum	—	1	7	2	—	3	
Trimyema compressum	—	—	—	2	8	4	
Urocentrum turbo	—	—	2	7	1	3	
Uronema marinum	—	—	1	8	1	4	
Urotricha farcta	—	—	4	6	—	3	
Urozona buetschli	—	—	—	2	8	4	
Vaginicola ingenita	—	—	6	4	—	3	Sládečková & Sládeček 1966
Vorticella campanula	—	1	6	3	—	3	Sládečkova & Sládeček 1966
V. convallaria	—	—	3	6	1	3	
V. microstoma	—	1	1	2	6	2	
V. striata var. *octava*	—	—	8	2	—	4	Sládečková & Sládeček 1966

Acineria incurvata DUJ. (342)

Occurrence in stagnant and slow-flowing waters, in activated sludge (24). Predator, feeds i.a. on Colpidium, Cyclidium, Glaucoma. Also associated with Paramecium caudatum. Numerous in ps zones, sporadic in the ams range (118). For saprobic valency, see table 1. Tolerates thalassogenic brackish water up to 2.5 % (55).

Amphileptus carchesii STEIN

Stagnant and slow-flowing waters, also in brackish and in sea water. Predator, feeds on Carchesium, Vorticella. ams (61).

Observed at (1, 89, 99):

Temperature	1—25,5 °C.
O_2	0— 8,9 mg/l.
CO_2 (free)	2—58 mg/l.

Amphileptus claparedei STEIN

(= A. meleagris CLAP. & LACH.)

Stagnant and running waters, in small pools, eutrophic ponds, waste water fish-ponds, activated sludge, also in brackish and in sea water. Predator, feeds on Carchesium, Opercularia, Vorticella. ams (61, 79), ps to ams (28).

Observed at (79, 88, 99, 40):

Temperature	3,5— 22,5 °C.
pH	6,5— 8,4
O_2	0,2— 15,3 mg/l.
O_2-saturation	0,2—170 %
CO_2 (free)	0 — 25 mg/l.

Amphileptus tracheloides (ZACH.) MASKEL

Occurrence in stagnant and running waters, planktonic (103). Polyphagous nutrition: mainly algae, ciliates, rotatorians. Increased occurrence in early summer (108). Frequent in the os range, sporadic in bms zones (61). For saprobic valency, see table 1.

Observed at (40, 61):

Temperature	0 —22,2 °C.
O_2	6,4—13,5 mg/l.
CO_2 (free)	0 — 3,3 mg/l.

Above all, in layers of the epilimnion which are rich in oxygen and strongly irradiated. (108).

Askenasia volvox CLAP. & LACH.
(= A. elegans BLOCHMANN)

In stagnant and slow-flowing waters, particularly in small pools. Phytophagous nutrition: algae. Occurrence in summer, increased occurrence in June (133).

Observed at (40, 133):

Temperature	2 — 9 °C	
pH	5 — 7,5	(31)
O_2	6,4—15,2 mg/l.	
CO_2 (free)	6,4— 7 mg/l.	(343)

Aspidisca costata (DUJ.)

In stagnant and slow-flowing waters, particularly in small pools, sewage purification plants. Polyphagous nutrition: algae, bacteria, and detritus. Associated with Aspidisca lynceus, A. turrita. Increased occurrence in autumn. bms (61, 79), bms – ams (28). For saprobic valency, see table 1.

Environmental spectrum:

Temperature	0 — 30 °C.		(1, 18, 23, 40, 46, 80, 83, 88, 99)
pH	5,4— 9,4		(18, 23, 46, 80)
O_2	0 — 22,4 mg/l.		(1, 18, 80, 88, 99, 133)
O_2-Sättigung (saturation)	0 —230 %		(80, 88)
CO_2 (frei)	0 — 42 mg/l.		(18, 67, 80, 88)
NH_4	0 — 31 mg/l.		(1, 18, 46, 80)
NH_3 (frei) (free)	0 — 2,3 mg/l.		(18)
H_2S	0 — 2 mg/l.		(1, 80)

salinity: th: up to 2.5 ‰ (18, 38, 55)
ath: up to 0.75 ‰ (18)

number of bacteria per ml. : PM: 200 to 3.5 x 10^6 (18)

Aspidisca lynceus EHR.

Occurrence in stagnant and slow-flowing waters, particularly in small pools and bogs, sapropel, sewage purification plants, also in brackish and in sea water. Polyphagous nutrition: mainly algae, bacteria, detritus. Associated with A. costata, A. turrita, Vorticella microstoma. Numerous in ams zones (79), bms (61), sporadic in os ranges (121). For saprobic valency see table 1.

Environmental spectrum:

Temperature	0 — 25 °C.		(1, 23, 40, 88, 95, 99)
pH	6,5— 9,8		(23, 80, 88, 120)
O_2	0 — 24,8 mg/l.		(1, 20, 23, 80, 88, 120, 132)
O_2-saturation	0 —234 %		(80, 88, 132)
CO_2 (free)	0 — 27,6 mg/l.		(1, 23, 80, 88, 99)
NH_4	0 — 25 mg/l.		(80, 123, 138)
H_2S	0 — 1 mg/l.		(80)
NO_2	0 — 1 mg/l.		(80)

Aspidisca turrita EHR.

In stagnant and running waters, in activated sludge, trickling filters, also in brackish and in sea water. Polyphagous nutrition: algae, bacteria, detritus. Associated with A. costata, A. lynceus. bms (121).

Observed at (1, 40, 99):

Temperature	2 —19	°C.
O_2	3,2—17,8	mg/l.
CO_2 (: free)	0 —16,2	mg/l.

Blepharisma lateritium (EHR.)

Occurrence in stagnant and slow-flowing waters, especially frequent in small pools, sapropel. Polyphagous nutrition: algae, bacteria, detritus. bms (61), os (56).

Observed at (1, 88, 99):

Temperature	1,8—21,3 °C.
O_2	0 —10 mg/l.
O_2-saturation	0 —90 %
CO_2 (free)	0 —21,5 mg/l.

Brachonella spiralis (SMITH) JANKOWSKI

(= Metopus spiralis SMITH M.contortus LEV.)

In stagnant and slow-flowing waters, particularly in small pools, sapropel, Emscher tanks, Imhoff tanks, trickling filters. Bacteriophagous nutrition, mainly sulphur bacteria. Associated with Caenomorpha, Epalxella, Metopus, Pelodinium, Saprodinium. Increased occurrence in early summer and summer (12). bms (61), ps (79). Observed at:

Temperature	1 —20 °C.	(99, 130)
pH	6,2— 7,2	(9)
O_2	0 — 0,8 mg/l.	(9)
CO_2 (free)	3,5—24 mg/l.	(99)
NH_4	0 — 5 mg/l.	(9)
H_2S	0,8— 4,8 mg/l.	(9)

salinity: th: up to 0.3 % (55) (th: up to 0.1 %) (2)

Indicator for an autopurification process which has been stopped by H_2S.

Bursaria truncatella O. F. M.

In stagnant and slow-flowing waters, particularly in small pools, sapropel, also in brackish water and in sea water. Polyphagous nutrition: algae, ciliates, flagellates, rotatorians, pollen grains. bms to os (61)m ps (121). For saprobic valency, see table 1.

Observed at (1, 64, 100):

Temperature	7 —28 °C.
pH	4 — 7,5
O_2	5,4— 8,7 mg/l.
CO_2 (free)	7,9—17,5 mg/l.
NH_4	0,2— 1,5 mg/l.

Bursellopsis spumosa SCHMIDT

Occurrence in stagnant waters, planktonic. Polyphagous nutrition: mainly diatoms, flagellates, rotatorians. Increased occurrence in late summer. Observed at (40) :

Temperature	8,1—18,6 °C.
O_2	7 —13 mg/l.
CO_2 (free)	0 — 4,4 mg/l.

(345)

Caenomorpha medusula PERTY

In stagnant and slow-flowing waters, particularly in small pools, sapropel (70), also in thalassogenic brackish water and in sea water. Feeds on sulphur bacteria. Associated with Brachonella, Epalxella, Metopus, Pelodinium (77,78). ps (79), bms (62), ps and ams (60). Indicator for a standstill reached in the conversion of organic waste in a medium containing H_2S.

Environmental spectrum (20, 66, 80, 88, 95):

Temperature	3,6— 20 °C.
pH	6,2— 8,6
O_2	0 — 20,8 mg/l.
O_2-saturation	0 —246 %
CO_2 (free)	3,6—101 mg/l.
NH_4	0,1— 18 mg/l.
H_2S	0 — 22 mg/l.

Campanella umbellaria LINNE

Occurrence in stagnant and running waters (47, 63, 90), sapropel, also in athalassogenic brackish water. Feeds on bacteria. Associated with Vorticella campanula. Increased occurrence in June (47). ams and bms (119), ps (70). For saprobic valency, see table 1. Mostly at low O_2- content (47).

Carchesium polypinum (LINNE) (including C.polypinum f. corymbosum PENARD)

In stagnant and running waters, particularly in small pools, waste water fish-ponds (58), aeration tanks, trickling filters (24), also in thalassogenic brackish water and in marine waters. Polyphagous nutrition: mainly algae, bacteria. Associated with Amphileptus carchesii (enemy !), Chilodonella uncinata, Paramecium caudatum. Maximum distribution in winter. Numerous in ams zone (61, 79), sporadic in bms ranges (120). For saprobic valency, see table 1.

Environmental spectrum (20, 89, 90, 130; optimum: 20):

Temperature	0 —25 °C.	(4— 8 °C)
pH	6,4— 8,3	(7— 7,5)
O_2	0,2—14 mg/l.	(7—12 mg/l)
BSB_5	4,1—13,5 mg/l.	
CO_2 (free)	0 —14 mg/l.	(3— 7 mg/l)
NH_4	0 —18 mg/l.	(0— 1 mg/l)
H_2S	0	

number of bacteria per ml.: MF: 10^6 to 10^7 (about 5 x 10^6)

Chaetospira mülleri LACHMANN

Occurrence in stagnant waters. Polyphagous nutrition: algae, bacteria, flagellates. For saprobic valency see table 1.

Environmental spectrum (20):

Temperature	12 —19 °C.
pH	7,6— 9
O_2	5,1—14 mg/l.
CO_2 (free)	0 —11 mg/l.
NH_4	0 — 0,5 mg/l.

(346)

Chaetospira remex HUDSON

Occurrence in stagnant and slow-flowing waters. Polyphagous nutrition: mainly algae and flagellates. Increased occurrence in summer (90). For saprobic valency see table 1.

Environmental spectrum (137):

Temperature	15 —22 °C.
pH	7,1— 8.
O_2	10 —12 mg/l.
CO_2 (free)	0 — 6 mg/l.
NH_4	0 — 1 mg/l.

Chilodonella cucullulus (O.F.M.)

In stagnant and running waters, particularly in small pools, in moss, purification plants. Polyphagous nutrition: algae, bacteria, detritus, flagellates. Increased occurrence in spring. In ams zones (61,79), bms ranges (119), ps zone (56). For saprobic valency see table 1.

Environmental spectrum:

Temperature	0 — 40 °C.		(1, 18, 23, 52, 88, 99, 130)
pH	6,3— 8,5		(18, 23)
O_2	0 — 69,4	mg/l.	(18, 23, 88, 99, 130)
O_2-saturation	0 —132		(88, 130)
CO_2 (free)	0 — 72	mg/l.	(18, 23, 67, 88, 130)
NH_4	0,1—100	mg/l.	(18)
NH_3 (free)	0 — 20	mg/l.	(18)
H_2S	0	mg/l.	(18)

salinity: th: up to 1.0 % (1, 18, 38, 55)

ath: up to 0.7 % (18)

number of bacteria per ml.: PM: 1.4 x 10^5 - 10^7 (18)

Chilodonella uncinata EHR.

(= C. dentata FOUQUE)

In stagnant and running waters, particularly in small pools, in moss, sapropel, purification plant. Polyphage: feeds on algae, bacteria, detritus, flagellates. Increased occurrence in spring and autumn. ams (61,79), bms (121). For saprobic valency see table 1.

Environmental spectrum (18, 81, 88, 142; optimum: 18, 142):

Temperature	0— 50 °C.	(35 °C)
pH	4— 9,5	(6,5—7,5)
O_2	0— 15,2 mg/l.	(0,1—1 mg/l)
O_2-saturation	0—170 %	
CO_2	0—200 mg/l.	(10—25 mg/l)
NH_4	0—150 mg/l.	(0— 2 mg/l)
free NH_3	0— 20 mg/l.	(0— 0,5 mg/l)
H_2S	0— 2 mg/l	(0)

salt content: th: up to 2.8 % (freshwater) (347)

ath: up to 1.5 %

number of bacteria per ml.: PM $3 \times 10^2 - 17 \times 10^7$ (over 10^6)

Chilodontopsis depressa PERTY

Occurrence in stagnant and running waters, particularly in small pools, in moss (108). Feeds on algae. Increased occurrence during the summer.

Environmental spectrum (1, 80, 88):

Temperature	4 — 15,3 °C.	
pH	7,4— 9,2.	
O_2	2,1— 24,8 mg/l.	
O_2-saturation	4 —280 %	
CO_2 (free)	1,5— 23 mg/l.	
NH_4	0 — 4 mg/l.	
H_2S	0 mg/l.	

Chilodontopsis vorax (STOKES)

(= C.transversa KAHL)

In stagnant and running waters, sapropel. Phytophagous nutrition: mainly algae. Increased occurrence in summer. In ams and bms zones (121).

Observed at (23):

Temperature	5,5—23 °C
pH	7,2— 8
O_2	8,5—12,1 mg/l.
CO_2 (free)	0 —11,5 mg/l

salinity in per cent: th: up to 2.5 (55)

Special ecological literature: BRAGG (1960).

Cinetochilum margaritaceum PERTY

in moors

In stagnant and running waters, particularly in small pools,/in moss, sapropel, purification plants. Polyphagous nutrition: algae, bacteria, detritus. Associated with Cyclidium glaucoma, Paramecium caudatum. bms (61), ams (18), bms to ps (83). For saprobic valency see table 1.

Environmental spectrum:		
Temperature	0 —45 °C.	(15 °C)
	(18, 88, 99, 119, 130, 142)	(142)
pH	6,1— 9,7	(6,4—7,2)
	(18, 83, 120)	(18, 66)
O_2	0 —22,5 mg/l.	(0—6 mg/l)
	(1, 18, 66, 88, 130, 99)	(18)
BSB_5	11 —86 mg/l.	
	(130)	
CO_2 (free)	0 —48 mg/l.	(15—30 mg/l)
	(18, 88, 00, 130)	(18)
NH_4	0 — 80 mg/l.	(0—20 mg/l)
NH_3 free)	0 — 0,8 mg/l	

salinity: th: up to 1.56 %
ath: up to 1.0 % (18)

number of bacteria per ml.: PM: 300 to 9 x 10^6

Cohnilembus pusillus (QUENNERSTEDT) KAHL

In stagnant and running waters, particularly in small pools, in activated sludge, trickling filters. Bacteriophage. Associated with Cyclidium lanuginosum, Uronema marinum (79). ps (79). For saprobic valency see table 1.

Observed at (88, 137):

Temperature	0 —25 °C.
pH	7 — 9
O_2	0,3—17,0 mg/l.
CO_2 (free)	0 —15 mg/l.

salinity: : th: up to 2.0 %

Cohnilembus verminus (O.F.M.)

In stagnant and running waters, bacteriophage.

Observed at (1, 40, 88):

Temperature	9 —11 °C.
O_2	2,3— 9,7 mg/l.
CO_2 (free)	0 —10 mg/l.
NH_4	0 — 0,2 mg/l.

Also in marine habitats. (56).

Coleps biscuspis NOLAND

Occurrence in stagnant and running waters. Polyphagous nutrition: feeds on algae, detritus. Increased occurrence in late summer.

Observed at (1, 23):

Temperature	13 —27 °C.
pH	6,8— 8,8
O_2	2,5— 9,2 mg/l.
CO_2 (free)	0 —29,5 mg/l.
NH_4	up to 0,5 mg/l.

Coleps hirtus (NITZSCH)

In stagnant and running waters, particularly in small pools, in activated sludge, Imhoff tanks, trickling filters. Polyphagous nutrition: feeds on carrion, algae, ciliates, detritus, flagellates. Associated with Cinetochilum margaritaceum, Cyclidium citrullus, C. glaucoma. Increased occurrence in spring and autumn. In bms zones (61, 79), ams and os (119). For saprobic valency see table 1.

Environmental spectrum:

Temperature	1 — 30 °C.	(16—20 °C)
	(1, 18, 23, 40, 80, 88, 99, 130)	(1, 40, 66)
pH	4,7— 9,5 (18, 23, 31, 80)	(6,5—7,5) (18)
O_2	0 — 38 mg/l.	(0,1—2,0 mg/l)
	(1, 18, 23, 40, 80, 88, 99, 130)	
BSB_5	6 — 15 mg/l	
	(82, 130)	
CO_2 (free)	0 —140 mg/l.	(10—15 mg/l.
NH_4	0 — 26 mg/l.	(0,1—0,5 mg/l)
NH_3 (free)	0 — 1,5 mg/l.	(0 —0,05 mg/l)
H_2S	0 — 2,1 mg/l.	

salinity: th. : up to 0.35 % (2, 18)

ath: up to 0.35 %

number of bacteria per ml.: PM 300 to 2 x 10^7

Special ecological literature: BICK 1966 b).

Colpidium campylum (STOKES)

In stagnant and slow-flowing waters, particularly in small pools, in activated sludge plants, Imhoff tanks, trickling filters. Polyphage: feeds mainly on bacteria, detritus, small flagellates. Often associated with Colpidium colpoda. Enemies: Enchelys mutans, Litonotus lamella, Stentor coeruleus. Increased occurrence in autumn (133). ps (119), sporadically in ams zone, concentration in ps range (140). For saprobic valency see table 1.

Environmental spectrum (18, 83, 121):

Temperature	3 — 30	°C
pH	4 — 8,9	
O_2	0 — 11	mg/l.
CO_2 (free)	0 —200	mg/l.
NH_4	0,2—160	mg/l.
NH_3 (free)	0 — 15	mg/l.

salinity: th : up to 0.35 %

number of bacteria per ml.: D: 20×10^6 to 15×10^7
PM: 9×10^3 to 4×10^6

optimum over 10×10^7 or over 10^6, respectively.

Colpidium colpoda (EHR.) STEIN

In stagnant and running waters, particularly in small pools, in moss, waste water fish-ponds, activated sludge, aeration tanks. Polyphagous nutrition: mainly algae, bacteria, detritus, flagellates. Associated with Cinetochilum margaritaceum, Colpidium campylum, Glaucoma scintillans. Increased occurrence in spring and autumn. ps(79), ps - ams (61), bms (119), rarely in ams ranges (79). For saprobic valency see table 1.

Environmental spectrum:

Temperature	1,5— 30	°C.	(18, 88, 99, 119, 130)
pH	6,2— 8,3		(18, 119)
O_2	0 — 16	mg/l.	(18, 81, 88, 99, 130, 132)
BSB_5	2 —310	mg/l.	(81, 130)
CO_2 (free)	0 — 56	mg/l.	(18, 88, 99, 119, 130)
NH_4	0,1— 25	mg/l.	(18, 123, 138)
NH_3 (free)	up to 25	mg/l.	(122)
H_2S	up to 18	mg/l	(79)

salinity: th : up to 0.6 % (2, 18, 26, 38)

number of bacteria per ml.: PM: $2.2 \times 10^4 - 1.7 \times 10^7$ (18, 138)

Colpoda cucullus O.F.M.

In stagnant and slow-flowing waters, particularly in small pools and bogs, in moss, waste water fish-ponds. Polyphage: algae, bacteria, detritus, flagellates. Associated with Paramecium caudatum, P. putrinum. Enemies: Leucophrys putrinum. Numerous in ams zones (61, 79), bms (121), ams - ps zone (107). For saprobic valency see table 1.

Environmental spectrum (1, 18, 20, 38, 40, 100, 130, 142):

Temperature	5 — 40	°C.
pH	4,4— 8,6	
O_2	0,4— 8	mg/l.
BSB_5	13,5— 24,5	mg/l.
CO_2 (free)	0,3—136	mg/l.
NH_4	0,2— 25	mg/l.
NH_3 (free)	up to 2	mg/l.

salinity: : th: up to 0.35 %

number of bacteria per ml. : 1.2×10^6 to 4.5×10^6

Colpoda steini MAUPAS

In stagnant waters, particularly in small pools, in moss. Bacteriophage. ps (18). For saprobic valency see table 1.

Environmental spectrum (18):

Temperature	5— 45	°C.	(+ 1, 83, 142)
pH	4— 9,5		(+ 83)
O_2	0— 12,3	mg/l.	(+ 117)
CO_2 (free)	0—200	mg/l.	
NH_4	0—120	mg/l.	
NH_3 (free)	0— 30		

salinity: : th : up to 1.4 % (+ 38)

ath: up to 1.0 %

number of bacteria per ml.: D: 2.5×10^6 to 135×10^6

PM: 4.7×10^5 to 2×10^7

Condylostoma vorticella (EHR.)

In stagnant waters, particularly in small pools. Polyphagous nutrition; algae, ciliates, flagellates, and detritus. Increased occurrence in winter(68).

Environmental spectrum (80):

Temperature	2 — 19	°C.
pH	7,4— 9,25	
O_2	0,2— 38	mg/l.
O_2-saturation	2 —360	%
CO_2 (free)	1,8— 38	mg/l.
NH_4	0 — 4	mg/l.
H_2S	0 — 1,1	mg/l.

(351)

salinity: : th: up to 0.92 % (31)

Cothurnia annulata STOKES

In stagnant waters, Polyphagous nutrition: feeds on algae, bacteria. Increased occurrence in spring and autumn.

Environmental spectrum (90):

Temperature	7 —21	°C.
pH	7,2— 7,8	
O_2	9 —13	mg/l.
CO_2 (free)	um 3	mg/l.
NH_4	0 — 0,5	mg/l.

number of bacteria per ml.: MF: 10^6 – 3 x 10^6

Special ecological literature: NUSCH (1970).

Ctedoctema acanthocrypta STOKES

In stagnant and running waters, particularly in small pools. Feeds on bacteria and detritus. Increased occurrence in winter.

Environmental spectrum (1, 80):

Temperature	2 — 20,5	°C.
pH	7,4— 8,8	
O_2	0,3— 22,4	mg/l
O_2-saturation	3 —206	%
CO_2 (free)	1,5— 26	mg/l.
NH_4	0 — 4	mg/l.
NH_3 (free)	0 — 0,6	mg/l.

Cyclidium citrullus COHN

In stagnant and running waters, in small pools, in moss, waste water fish-ponds, trickling filters. Bacteriophage. Increased occurrence in autumn (133). ams (61,79), ps (53). For saprobic valency see table 1.

Environmental spectrum (1,18, 142):

Temperature	0 — 40	°C.	(25 °C)
pH	5,7— 9,8		(6,5—7,5)
O_2	0 — 16	mg/l.	(0,1—0,5 mg/l)
CO_2 (free)	0 — 64	mg/l.	
NH_4	0 —110	mg/l.	(0—1 mg/l)
NH_3 (free)	0 — 2	mg/l.	(unter 0,05 mg/l)
H_2S	0 — 1,3	mg/l.	(0) less than

salinity: : th: up to 5.2 % (+ 30, 38, 55) (less than 0.05 %)

ath: up to 3.5 %

In case of mass propagation, it characterises the ams zone (18).

Special ecological literature: BICK (1966a).

Cyclidium glaucoma (O.F.M.)

In stagnant and running waters, particularly in small pools and in bogs, in moss, sapropel, activated sludge, Imhoff tanks, trickling filters. Polyphage: feeds on algae, bacteria. Associated with Cinetochilum margaritaceum, Coleps hirtus. ams (61), in a - bms and ps ranges (121). (352)

For saprobic valency see table 1.

Environmental spectrum:

Temperature	1 — 51 °C.	(1, 23, 40)
pH	7,4— 9	(23, 108)
O_2	0 — 15,9 mg/l.	(1, 23, 40, 88, 94)
O_2-saturation	0 —235 %	(88)
CO_2 (free)	0 —114,2 mg/l.	(1, 23, 67, 88, 99)
NH_4	0 — 7,5 mg/l.	(1)

salinity: : th: up to 3.1 % (38, 85)

Cyclidium lanuginosum PENARD

In stagnant and running waters, particularly in small eutrophic pools, in activated sludge, trickling filters. Stenophage: feeds on bacteria. ams (79).

Environmental spectrum (80, 137):

Temperature	2,7— 22 °C.
pH	7,4— 9,2
O_2	0,2— 24,8 mg/l.
O_2-saturation	2 —235 %
CO_2 (free)	0 — 28 mg/l.
NH_4	0 — 4 mg/l.
H_2S	0 — 1,2 mg/l.

salinity: : th: up to 2.0 % (55)

Cyrtolophosis mucicola STOKES

In stagnant and slow-flowing waters, particularly in small pools and moss. Polyphagous nutrition: algae, bacteria.

Environmental spectrum (18, 99):

Temperature	10 —50 °C.
pH	6,4— 8,6
O_2	0 — 8,7 mg/l.
CO_2	0 —30 mg/l.
NH_4	0 —18 mg/l.

salinity: : ath: up to 3.7 %

Dendrosoma radians EHR.

In stagnant and running waters, in waste water fish-ponds, also in thalassogenic brackish water. Predator: feeds on ciliates. Associated with Campanella umbellaria, Carchesium polypinum, Heliophrya rotunda. Increased occurrence in summer (51, 113). In ams and bms zones (51a), ams to os (98). For saprobic valency see table 1.

Observed at:

temperature 0 – 21 °C. (40)

Dexiotrichides centralis (STOKES)

In stagnant and running waters. Bacteriophage. Associated with Trimyema compressum. ps (79). For saprobic valency see table 1. Facultatively anaerobic, sensitive to pH-variations(79).

(353)

Didinium nasutum (O.F.M.)

In stagnant waters, particularly in small eutrophic ponds, in purification plants, also in brackish water and in seawater. In plankton and benthos. Predator: feeds on Halteria grandinella, Paramecium. Associated with Nassula ornata. Increased occurrence in autumn (66). bms (61, 79), ams (121). For saprobic valency see table 1.

Environmental spectrum (11, 31, 40):

Temperature	0 – 25 °C.
pH	6 – 8
O_2	0,6 – 13,5 mg/l.
CO_2	0 – 4,2 mg/l.
NH_4	0 – 1,8 mg/l.

Dileptus anser (O.F.M.)

In stagnant and slow-flowing waters, particularly in small eutrophic pools and ponds, in trickling filters, also in thalassogenic brackish water and in sea water. Predator, feeds on ciliates, flagellates, planarians, rotatorians. Increased occurrence in autumn (66). os (61, 79), sporadically in bms ranges (121). For saprobic valency see table 1.

Observed at (1, 40, 82, 99):

Temperature	0 – 22 °C.
O_2	4 – 14,5 mg/l.
NH_4	0,1 – 0,5 mg/l.

Dileptus gigas (CLAP. & LACH.)

Particularly in small pools, but also in/other types of water.

In activated sludge. Predator: feeds on ciliates and flagellates. Increased occurrence in summer (133).

Observed at (88):

Temperature	0 —21,3 °C.
O_2	2,0— 9,2 mg/l.
CO_2 (free)	3,6—21,1 mg/l.

Epistylis coronata NUSCH

In stagnant waters. Polyphagous nutrition, feeds on bacteria, detritus. Increased occurrence in winter (90).

Observed at (90):

Temperature	2 —12 °C.
pH	7,2— 7,6
O_2	9 —14 mg/l.
CO_2 (free)	2 — 8 mg/l.
NH_4	0 — 2 mg/l.

Special ecological literature: NUSCH (1970).

Epistylis galea EHR.

In stagnant and running waters. Phytophagous nutrition: feeds, above all, on algae. Increased occurrence from spring to autumn.

Observed at (90):

Temperature	5 —21 °C.
pH	7,2— 7,8
O_2	6 —12 mg/l.
CO_2 (free)	1,5—12 mg/l.
NH_4	0 — 2 mg/l.

(354)

number of bacteria per ml.: MF $7 \times 10^5 - 8 \times 10^6$

Special ecological literature: NUSCH (1970)

Epistylis hentscheli KAHL

In stagnant waters. Bacteriophagous nutrition.

Observed at (90):

Temperature	2 —15 °C.
pH	7,2—7,6
O_2	7 —12 mg/l.
CO_2 (free)	2 — 8 mg/l.
NH_4	0 — 2,5 mg/l.

number of bacteria per ml.: MF: $10^6 - 7 \times 10^6$

Special ecological literature: NUSCH (1970).

Epistylis plicatilis EHR.

In stagnant (87) and running waters (62a), particularly in small eutrophic pools, ponds, in activated sludge, in trickling filters. Polyphage: feeds on bacteria, detritus. Associated with Tokophrya quadripartita (enemy !). Increased occurrence in summer. ams (61), bms (79). For saprobic valency see table 1.

Environmental spectrum (62a, 63, 90, 129):

Temperature	4 —27 °C.
pH	6,5—12
O_2	2 —12 mg/l.
CO_2 (free)	0 — 8 mg/l.
NH_4	0 —10 mg/l.

number of bacteria per ml.: MF: 1.1. x 10^6 – 8 x 10^6

Euplotes affinis DUJ. (E.charon (O.F.M.) STEIN)

In stagnant and slow-flowing waters, particularly in small pools and eutrophic ponds, in waste water fish-ponds, activated sludge, trickling filters. Polyphagous nutrition: algae, flagellates, bacteria, detritus. bms (61, 79), ams to bms (62). For saprobic valency see table 1.

Environmental spectrum (18):

Temperature	0 —25 °C. (+ 1, 95, 99, 130, 138)	
pH	6,2— 9,2 (+ 116)	(7—7,5)
O_2	0,1—38 mg/l. (+ 1, 95, 99, 130, 138)	(0,1—1 mg/l)
BSB_5	4,8—24,5 mg/l. (130)	
CO_2 (free)	0 —64 mg/l. (+ 1, 95, 99, 130, 138)	
NH_4	0 —18 mg/l. (+ 116, 138)	(0—0,5 mg/l)
NH_3 (free)	0 — 0,2 mg/l.	
H_2S	0 — 1,2 mg/l. (+ 80)	

(355)

salinity: : th: up to 3.5 % (+ 2, 38, 85) (less than 0.35 %)

number of bacteria per ml.: PM: 370 to 12 x 10^6 (+ 138)

Euplotes patella (O.F.M.) EHR.

In stagnant and running waters, particularly in small pools and ponds, mainly on decomposing plant material. Increased occurrence in summer (133). bms (61), ps (83), os and bms (121). For saprobic valency see table 1.

Environmental spectrum:

Temperature	0 —25 °C. (1, 18, 40, 55, 139)	(11—20 °C) (1, 66)
pH	5,7— 9,3 (18, 95, 83)	(6,5—7,2) (18, 66)
O_2	0 —38 mg/l. (18, 40, 80, 88)	(0,1—1,0 mg/l) (18)
CO_2 (free)	0 —66 mg/l.	(18, 40, 80, 83, 88)
NH_4	0 —10 mg/l.	(18)
H_2S	0 — 1 mg/l.	

salinity: th: up to 3.1 % (2, 13, 38, 55, 139) (fresh water)

ath: up to 0.2 % (13)

number of bacteria per ml.: D: 1.2×10^6 to 6×10^7

PM: 8000 to 16×10^6 (18)

Frontonia acuminata EHR.

In stagnant and running waters, particularly in small eutrophic ponds and lakes. Also in bogs and moss, in waste water fish-ponds (58). Feeds on algae, bacteria, ciliates. Increased occurrence in autumn (66). os (61, 79), ams and bms (121). For saprobic valency see table 1.

Environmental spectrum (9, 23, 66, 80, 88, 99, 133):

Temperature	1 — 31 °C.
pH	6,2— 9,3
O_2	0 — 22,4 mg/l.
O_2-saturation	0 —207 %
CO_2 (free)	0 — 37 mg/l.
NH_4	0 — 3,1 mg/l.
H_2S	0 — 1,1 mg/l.

Frontonia leucas EHR.

(including : F. leucas var. vernalis EHR.)

In stagnant and running waters, in small pools and bogs, in moss, in trickling filters. Polyphagous nutrition: mainly algae, ciliates, detritus, flagellates, rotatorians. Associated with Frontonia vesicula. Maximum of

distribution in autumn (133). Numerous in ams zones (121), more (356)
rarely in bms or os ranges (121).

Environmental spectrum:

Temperature	1 — 32 °C.	(1, 40, 80, 88, 99)
pH	7,2— 9	(80, 117)
O_2	0 — 24,8 mg/l.	(1, 88, 130)
O_2-saturation	0 —234 %	(80, 88, 130)
CO_2 free)	0 — 57,6 mg/l.	(1, 80, 88, 99, 130)
NH_4	0 — 6,2 mg/l.	(80)
H_2S	0 — 5,7 mg/l.	(80)

salinity: th: up to 7.2 % (optimum below 0.1%)
(2, 25, 91) (2)

Gastrostyla steini ENGELMANN

In stagnant and running waters. Polyphagous nutrition: algae, bacteria, ciliates, flagellates. For saprobic valency see table 1.

Environmental spectrum (18):

Temperature	5 —35 °C.	(142)
pH	6,5— 9,5	
O_2	0 — 9 mg/l.	
CO_2 (free)	0 —72 mg/l.	
NH_4	0,1—55 mg/l.	

salinity: ath: up to 1.0 % fresh water

number of bacteria per ml.: PM: $6 - 10^4 - 8 \times 10^6$

Special ecological literature: BICK (1968a).

Glaucoma scintillans EHR.

In stagnant and running waters, particularly in small pools, in waste water fish-ponds, activated sludge, Emscher tanks, Imhoff tanks, trickling filters. Polyphagous nutrition: algae, bacteria, detritus. Associated with Colpidium colpoda, Tetrahymena pyriformis, Paramecium putrinum. Increased occurrence in autumn (66). ps (79), ps to ams (61), for saprobic valency see table 1.

Environmental spectrum (18):

Temperature	0 — 35 °C.	(+ 1, 40, 88, 119)
pH	3,8— 8,6	(7—8)
O_2	0 — 14,2 mg/l. (+ 1, 40, 88, 119)	(0—1 mg/l)
CO_2 (free)	5 —200 mg/l. (+ 88)	
NH_4	0 —300 mg/l. (+ 138)	(15—30 mg/l)
NH_3 (free)	0 — 10 mg/l.	(0—2,5 mg/l)
H_2S	0 — 5 mg/l. (79)	

salinity: th: up to 0.6 % (+38) (less than 0.05%)

ath: up to 0.2 %

number of bacteria per ml.: D: 2.5 x 10^6 to 148 x 10^6 (over 100 x 10^6)

Special ecological literature: BICK (1966a).

(357)

Halteria cirrifera KAHL

In stagnant water. Phytophagous nutrition, feeds mainly on algae. Increased occurrence from spring to autumn (137). os (79).

Environmental spectrum (90):

Temperature	2,9— 11,5 °C.
pH	7,4— 8,8.
O_2	1,4— 38 mg/l.
O_2-saturation	12 —360 %
CO_2 (free)	4,4— 23,4 mg/l.
NH_4	0,1— 2,5 mg/l.
H_2S	0 — 1,2 mg/l.

Halteria grandinella (O.F.M.)

In stagnant and slow-flowing waters, particularly in small pools and bogs, in moss, sapropel, in waste water fish-ponds, trickling filters. Polyphage: feeds on algae and bacteria. Associated with Cyclidium citrullus. Enemy: Didinium nasutum. Maximum distribution from spring to autumn. bms (61,79). For saprobic valency see table 1.

Environmental spectrum:

Temperature	0,8— 35 °C (1, 18, 23, 64, 92, 99, 142)	(um 25 °C) (142)
pH	5,2— 9,5 (18, 80, 92)	(6,4—7,5) (18, 66, 92)
O_2	0 — 38 mg/l (1, 18, 23, 64, 92, 99)	(0,1—5,7 mg/l) (18, 133)
O_2-saturation	0 —360 % (80,88)	
CO_2 (free)	0 — 56 mg/l (1, 18, 23, 64, 92, 99)	(5—30 mg/l) (18, 64)
NH_4	0 — 25 mg/l (18, 64, 80)	(0—0,5 mg/l) (18)
NH_3 (free)	0 — 0,8 mg/l (18)	(0) (18)
H_2S	0 — 2,3 mg/l (18, 80)	

salinity: th: up to 0.35% (2,18,38,55) (fresh water) (18)

ath: up to 0.2 % (18)

number of bacteria per ml.: PM: 33 - 17 x 10^6 (18, 64)

Special ecological literature: BICK (1968a).

Heliophrya rotunda (HENTSCHEL) MATTHES

In stagnant and running waters, also in thalassogenic backish water. Predator, feeds on ciliates. Associated with Campanella umbellaria, Carchesium polypinum, Epistylis hentscheli. Increased occurrence in autumn. bms to os (98). For saprobic valency see table 1.

Hemiophrys bivacuolata KAHL

(including H. bivacuolata f. polysaprobica KAHL)

In stagnant and running waters, also in thalassogenic brackish water. Polyphage: bacteria, ciliates, detritus, flagellates. Associated with Colpidium campylum, Glaucoma scintillans. ams and bms (20), os (56), ps (118). (358) For saprobic valency see table 1.

Hemiophrys pleurosigma (STOKES)

In stagnant and slow-flowing waters, particularly in small pools. Predator, feeds on ciliates, flagellates. Associated with Colpidium campylum, Coleps hirtus, Halteria grandinella. Increased occurrence in late autumn (133). In bms zones (119). For saprobic valency see table 1.

Environmental spectrum (1, 20, 80, 116):

	Temperature	1,4— 25 °C
	pH	6,2— 9
	O_2	0 — 22,4 mg/l
O_2	-saturation	0 —230 %
	CO_2 (free)	0 — 52 mg/l
	NH_4	0 — 18 mg/l
	H_2S	0 — 0,8 mg/l

salinity in %: th: up to 0.35 %

number of bacteria per ml.: PM: up to 18 x 10^6

Lacrymaria coronata CLAP. & LACH.

In stagnant and running waters, particularly in small pools, in sapropel, in settling ponds (135). Predator, feeds mainly on ciliates and flagellates. Associated with Blepharisma coeruleum, Lacrymaria olor, Ophryoglena oblonga. In os zones (86).

Observed at:

Temperatur	6 —19 °C	(1, 99, 134)
O_2	1,8—10,7 mg/l	(1, 99)
CO_2 free)	4 —18 mg/l	(1)

salinity: th: up to 2.13 % (85, 134)

Lacrymaria olor (O.F.M.)

In stagnant and running waters, particularly in small pools, in sapropel. Polyphagous nutrition: mainly algae, amoebae, ciliates, detritus, flagellates. Increased occurrence in autumn. os (61), sporadically in bms ranges (61). For saprobic valency see table 1.

Environmental spectrum:				
Temperature	0 — 25	°C	(1, 20, 23, 40, 88, 99, 130)
pH	6,4— 9		(20, 23, 66)
O_2	0,2— 13	mg/l	(1, 20, 23, 88, 99, 130)
O_2-saturation	0,2—100	%	
CO_2 (free)	0 — 56	mg/l	(1, 20, 23, 88, 99, 130)
NH_4	0 — 10	mg/l	(20)
NH_3 (free)	0,3— 3,8	mg/l	(130)
H_2S	up to 0,5	mg/l	(20)

salinity: th: up to 2.5 % (55)

Lembadion bullinum PERTY

In stagnant and slow-flowing waters, particularly in small pools, Polyphagous nutrition: mainly algae, bacteria, detritus, flagellates. (359)
Associated with Nassula ornata. Increased occurrence in autumn (66). bms (61). Observed at (1, 40, 66, 88):

Temperature	3,5—20	°C.
pH	6,4— 7,2	
O_2	3,7—12,3	mg/l.
O_2-saturation	32 —71	%
CO_2 (free)	1,1—15,2	mg/l.

Litonotus fasciola (EHR.)

In stagnant and running waters, in activated sludge, Imhoff tanks, trickling filters. Predator: feeds on ciliates, flagellates. Maximum distribution in autumn. ams (79), bms (61). For saprobic valency see table 1.

Environmental spectrum:

Temperatur	0 —24,8 °C	(20, 99, 88, 129)
pH	7,1— 8	(20, 88)
O_2	0,3—22,5 mg/l	(20, 88, 99)
CO_2 (free)	0 —57,6 mg/l	(88, 99)
NH_4	0 — 1,5 mg/l	(1)
H_2S	0 mg/l	(20)

salinity: th: up to 4.0 % (2, 20, 55, 85, 88)

Litonotus lamella (EHR.) SCHEW.

In stagnant and running waters, particularly in small pools, in moss, sapropel, activated sludge, in Imhoff tanks and trickling filters. Predator: feeds on ciliates, flagellates. Increased occurrence in autumn (66). bms (61), ams (18). For saprobic valency see table 1.

Environmental spectrum (18):

Temperature	0 —35 °C	(25 °C)
	(+ 1, 40, 129, 142)	(142)
pH	6,0— 9,4	(6,5—7,5)
O_2	0 —13 mg/l	(0—1 mg/l)
	(+ 1, 40, 129)	
CO_2 (free)	0 —64 mg/l	(10—20 mg/l)
NH_4	0 —30 mg/l	(0— 2 mg/l)
NH_3 (free)	0 — 0,6 mg/l	
H_2S	0 — 5 mg/l	(0)

salinity: th: up to 3.5 % (fresh water)

ath: up to 0.35 %

number of bacteria per ml.: PM: $400 - 11 \times 10^6$

Optimal living conditions in ams zone. Special ecological literature: BICK (1966a).

Loxocephalus granulosus KENT

In stagnant and slow-flowing waters, particularly in small pools and bogs, in sapropel, activated sludge, Imhoff tanks, trickling filters, also in thalassogenic brackish water and in sea water. Polyphagous nutrition: algae, bacteria, detritus. In ams zones (61).

Observed at (88, 99):

Temperature	0– 17,5 °C
O_2	0– 22,5 mg/l
CO_2 (free)	0–114,2 mg/l

Loxocephalus plagius (STOKES)

In stagnant and slow-flowing waters, particularly in small eutrophic pools, in sapropel. Bacteriophagous nutrition. In ms – ps zones (56).

Environmental spectrum (18):

Temperature	5 –25 °C
pH	6,4– 8,5
O_2	0 – 8 mg/l
CO_2 (free)	0 –65 mg/l
NH_4	0,3–18 mg/l
H_2S	0 – 1,5 mg/l

salinity: th: up to 0.35 %; ath: up to 0.2 %

number of bacteria per ml.: D: 10^6 – 165 x 10^6

Loxodes rostrum (O.F.M.)

In stagnant and slow-flowing waters, particularly in small pools and bogs, in sapropel, activated sludge, in trickling filters, also in brackish water and in sea water. Polyphagous nutrition: mainly algae, bacteria, detritus. Associated with Tachysoma pellionella, Spirostomum ambiguum. Increased occurrence in autumn. bms (121).

Observed at (1, 88, 99):

Temperature	1,5–21 °C.
pH	6,4– 7,2
O_2	0,3–10,9 mg/l
CO_2 (free)	1,4–57,6 mg/l

Optimum living conditions on the edge of the anaerobic zone (71).

Loxodes striatus (ENGELMANN) PENARD

In stagnant and running waters, particularly in small pools. Stenophagous nutrition: detritus. Associated with Prorodon viridis, Spirostomum teres.

Observed at (1, 71, 99):

Temperature	1 –25 °C.
O_2	0,1–14,2 mg/l
CO_2 (free)	2 –36 mg/l

salinity: th: up to 0.3 % (55)

Loxophyllum lamella CLAP. & LACH.

In stagnant and running waters. Predator: feeds on ciliates and flagellates. In bms ranges (61).

Observed at (88):

Temperature	1,2 —	22,5 °C
O_2	3,5 —	15,3 mg/l
O_2-saturation	38 —	169 %
CO_2 (free)	0 —	7,7 mg/l

Loxophyllum meleagris DUJ.

In stagnant and running waters, activated sludge, in trickling filters, also in thalassogenic brackish water and in sea water. Predator, feeds on ciliates, flagellates, rotatorians. ams (61), bms (121).

Observed at (88):

Temperature	5 —	8 °C
O_2	6,3 —	9,7 mg/l
O_2-saturation	53 —	75 %
CO_2 free)	1,6 —	2,1 mg/l

Mesodinium acarus STEIN

In stagnant and running waters, also in thalassogenic brackish water. Polyphagous nutrition: mainly bacteria, ciliates, flagellates, detritus. Increased occurrence in autumn.

Observed at:

Temperatur	2 — 18,5 °C	(1, 99, 134)
pH	6,4 — 7,2	(66)
O_2	8,8 — 11,1 mg/l	(1, 99)
CO_2 (free)	6,6 — 16,1 mg/l	(99)
salinity:	th: 2.28 %	

Mesodinium pulex CLAP. & LACH.

In stagnant and running waters, particularly in small pools, also in athalassogenic brackish water and in sea water Polyphagous nutrition: mainly algae, bacteria, ciliates, flagellates. bms and ams (109), bms to os (98).

Observed at (40, 88, 89):

Temperature	1 — 21	°C.
O_2	0 — 13	mg/l
CO_2 (free)	1,1 — 57,5	mg/l
salinity:	th: up to 6.0 %	(2, 55, 85)

Metacineta mystacina (EHR.)

In stagnant and slow-flowing waters, also in thalassogenic brackish water. Predator, feeds on Carchesium, Cyclidium, Halteria. Associated with Coleps hirtus, Stentor roeseli, Urotricha farcta. Increased occurrence in summer and autumn (51). For saprobic valency see table 1.

Environmental spectrum (20f):

Temperature	5 —25	°C.
pH	6,5— 7,5	
O_2	0,3—10	mg/l
NH_4	0 — 5	mg/l

Metopus es (O.F.M.) KAHL

In stagnant and running waters, particularly in small pools, eutrophic ponds, in sapropel, in Emscher tanks, Imhoff tanks, trickling filters, also in athalassogenic brackish water and in sea water. Polyphagous (362) nutrition: mainly algae, bacteria, detritus. Associated with Caenomorpha, Epalxella, Pelodinium, Plagiopyla, Saprodinium. Increased occurrence in summer and autumn (10, 136). ps (79), ps and ams (61), bms (62). The species should serve as index form for the decomposition of organic matter which has reached a standstill in the H_2S-medium.

Environmental spectrum (1, 9, 82, 88, 99, 136):

Temperature	1 —20	°C.
pH	6,2— 7,2	
O_2	0 — 7,3	mg/l
CO_2 (free)	0 —69	mg/l
NH_4	0 —10	mg/l
H_2S	0 — 4,8	mg/l

salinity: th: up to 0.3 % (55)

Special ecological literature: BICK (1957).

Microthorax pusillus ENGELMANN

In stagnant and slow-flowing waters. Polyphagous nutrition: algae, bacteria, detritus.

Environmental spectrum (18, 88, 130):

Temperature	1 — 25 °C.
pH	5,8— 8,3
O_2	0,8— 8 mg/l.
O_2-saturation	0 —100 %
BSB_5	13,5— 24,5 mg/l.
CO_2 (free)	0,3— 65 mg/l.
NH_4	0 — 13 mg/l.

salinity: th: up to 0.35 %

ath: up to 0.2 %

number of bacteria per ml.: PM: 300 - 25 c 10^5

Microthorax sulcatus ENGELMANN

In stagnant and slow-flowing waters, particularly in small pools, in sapropel, activated sludge, in trickling filters. Polyphagous nutrition: algae, bacteria, detritus. Asssociated with Holophrya discolor, Nassula elegans.

Observed at (88, 99):

Temperature	1—20,5 °C.
O_2	0—10,7 mg/l.
CO_2 (free)	0—68,4 mg/l.

Nassula aurea EHR.

In stagnant and slow-flowing waters, particularly in small pools and bogs. Phytophage, feeds mainly on Anabaena, Synedra, Synura. ams and bms (121).

Observed at (130):

Temperature	3,4—42 °C
O_2	3,2— 8,5 mg/l
O_2-saturation	33 —89 %
BSB_5	4,1—24,5 mg/l.
CO_2 (free)	0,3— 3,6 mg/l
NH_4	up to 3,7 mg/l.

salinity: th: up to 0.3 % (56) (363)

Nassula elegans EHR.

In stagnant and slow-flowing waters, particularly in small pools, bogs, in moss. Polyphagous nutrition: mainly algae and detritus. Associated with Nassula aurea, Tachysoma pellionella. os (79), bms (61).

Observed at:

Temperature	1,5—52 °C.	(1, 52, 99, 116).
O_2	0,2— 8,8 mg/l.	(1, 99)
NH_4	up to 0,1 mg/l.	(1)

salinity: th: up to 0.3 % (55)

Opercularia allensi STOKES

In stagnant and running waters. Polyphagous nutrition: algae, bacteria. Associated with Ophrydium crassicraule. Increased occurrence from spring to autumn.

Environmental spectrum (90):

Temperature	2 —20 °C.
pH	5,5— 8
O_2	3 —13 mg/l.
CO_2 (frei)	2 —12 mg/l.
NH_4	0 —10 mg/l.

number of bacteria per ml.: MF: $10^6 - 8 \times 10^6$

Special ecological literature: NUSCH (1970).

Opercularia coarctata(CLAP. & LACH.)

Occurrence in stagnant and slow-flowing waters, in waste water fish-ponds, activated sludge, trickling filters. Bacteriophagous nutrition. ams (61, 79), For saprobic valency see table 1.

Observed at (90):

Temperature	10—22 °C
pH	5— 8
O_2	9—11 mg/l.
CO_2 (free)	2—15 mg/l.
NO_2	up to 28 mg/l.

number of bacteria per ml.: MF: $2 \times 10^6 - 5 \times 10^6$

Special ecological literature: NUSCH (1970).

Opercularia nutans EHR.

In stagnant and running waters. Bacteriophagous nutrition. Increased occurrence in June. For saprobic valency see table 1.

Environmental spectrum (20 g):

Temperature	4 —25 °C
pH	6,5— 8
O_2	2 —12 mg/l.
NH_4	0 —12 mg/l.

Ophrydium crassicraule PENARD

In stagnant water. Polyphagous nutrition: mainly algae and bacteria. Associated with Opercularia allensi. Increased occurrence in spring and autumn.

Environmental spectrum (90):

Temperature	5 —17 °C.
pH	7,1— 7,8
O_2	7 —13 mg/l.
CO_2 (free)	2 —12 mg/l.
NH_4	0 — 2 mg/l.

number of bacteria per ml.: MF: 10^6 - 9 x 10^6

Special ecological literature: NUSCH (1970).

Ophrydium sessile KENT

In stagnant water. Bacteriophagous nutrition. Increased occurrence in summer and autumn. For saprobic valency see table 1.

Ophrydium versatile (O.F.M.)

In stagnant and running waters, particularly in small pools, eutrophic ponds and bogs, also in thalassogenic brackish and in sea water.. Polyphagous nutrition: algae, bacteria, detritus. Maximal distribution in autumn. os and bms (61, 79), bms (61).

Observed at (88):

Temperature	8,7 – 10,5 °C.
O_2	9,7 – 13,9 mg/l.
O_2-saturation	86 – 117 %
CO_2 (free)	0 – 2 mg/l.

Oxytricha fallax STEIN

In stagnant water, particularly in small pools, in activated sludge, in Imhoff tanks, trickling filters, also in thalassogenic brackish water. Polyphagous nutrition: algae, bacteria, detritus, flagellates. ams (61,79), ams - ps (28). For saprobic valency see table 1.

Environmental spectrum:

Temperature	2 – 56 °C.	(1, 20, 52, 99, 130)
pH	6,8 – 7,5	(79)
O_2	3 – 5 mg/l.	(79)
CO_2 (free)	0 – 24,5 mg/l.	(99, 130)
NH_4	0,3 – 0,5 mg/l.	(1, 130)

salinity: th: up to 3.0 % (97)

Opisthotricha similis ENGELMANN

In stagnant water, particularly in small pools, in waste water fish-ponds, also in athalassogenic brackish water. Polyphagous nutrition: bacteria, diatoms, flagellates. Increased occurrence in spring and autumn.

Observed at (18): (365)

pH	8,0 – 9,8
O_2	0 – 6,3 mg/l.
NH_4	0 – 16 mg/l.

salinity: ath: up to 3.7 %

Preferred environment: in alkaline medium with relatively high number of bacteria.

Oxytricha ferruginea STILLER

In stagnant and running waters, also in thalassogenic brackish water and in sea water. Polyphagous nutrition: mainly algae, bacteria. Associated with Tachysoma pellionella. os (86).

Observed at (88):

Temperature	4,5 — 28,5 °C.
O_2	4,1 — 9,9 mg/l.
O_2-saturation	53 — 173%
CO_2 (free)	0 — 7,3 mg/l.

Paramecium aurelia EHR. & DUJ.

In stagnant and running waters, particularly in small pools, in sapropel, in settling ponds (135), also in athalassogenic and thalassogenic brackish water. Bacteriophage. bms and ams (121).

Observed at (23, 52, 54, 99):

Temperature	1 — 42 °C.
pH	6 — 9
O_2	0,1 — 22,5 mg/l.
CO_2 (free)	0 — 68,4 mg/l.

Paramecium bursaria (EHR.) FOCKE

In stagnant water, particularly in small pools and bogs, in moss, in aeration tanks and trickling filters. Feeds on algae, flagellates, bacteria, detritus. Associated with Colpidium campylum, Glaucoma scintillans, Paramecium trichium. Enemies: Didinium nasutum, Asplanchna seiboldi (42). Increased occurrence in spring (12). bms (61, 79), ams and ps (18). For saprobic valency see table 1.

Environmental spectrum (18):

Temperature	0 — 26 °C.	(+ 1, 23, 40, 88, 99)
pH	6 — 9,2	(+ 23, 49)
O_2	0,1 — 17,8 mg/l.	(+ 1, 23, 88, 99)
CO_2 (free)	0 — 48 mg/l.	(+ 1, 23, 40, 88)
NH_4	0 — 60 mg/l.	
NH_3 (free)	0 — 3 mg/l.	
H_2S	0 — 1,1 mg/l.	

salinity: ath: up to 0.2 %

number of bacteria per ml.: 3×10^6 to 14×10^7

Paramecium caudatum EHR.

In all types of stagnant and running water with bacterial decomposition processes, in waste water fish-ponds, activated sludge, Imhoff tanks, trickling filters, Emscher tanks. Feeds on algae, bacteria, detritus. Often associated with Colpidium colpoda, Spirostomum teres and Urocentrum turbo. Increased occurrence in autumn. ps(61), ams to ps (121). For saprobic valency see table 1. (366)

Environmental spectrum:

Temperature	1— 40 °C. (18, 52, 65, 88, 130)	(30 °C) (142)
pH	4— 9,4 (18, 49, 119)	(6,5—7,5) (18)
O_2	0— 14,4 mg/l. (1, 18, 82, 88, 130)	
O_2-saturation	0—150 % (88, 130)	
BSB_5	2—165 mg/l. (88, 130)	
CO_2 (free)	0—200 (18, 82, 130)	
NH_4	0—100 mg/l. (18, 132, 138)	(0—2 mg/l) (18)
NH_3 (free)	0— 2 mg/l. (18, 122)	(0—0,05 mg/l) (18)

salinity: th: up to 4.0 % (2, 18, 38, 50) (fresh water)

ath: up to 0.4 %

number of bacteria per ml.: PM 600 to 32 x 10^6

Special ecological literature: BICK (1966a).

Paramecium trichium STOKES, WENRICH

In stagnant and running waters with bacterial degradation of organic matter, in small pools, waste water fish-ponds, settling ponds, aeration tanks. Feeds on algae and bacteria as well as detritus. ams (118), ams to ps (18). For saprobic valency, see table 1.

Environmental spectrum (18):

Temperature	2 —30 °C.	(+ 1, 130, 142)
pH	6,4— 8,3	
O_2	0 —14,4 mg/l.	(+ 1, 130)
BSB_5	7 —24,5 mg/l.	(130)
CO_2 (free)	0 —93 mg/l.	(+ 130)
NH_4	0 —60 mg/l.	
NH_3 (free)	0 — 3 mg/l.	
H_2S	0 — 1 mg/l.	

salinity: th: up to 1.4 %

number of bacteria per ml.: D: 10^6 to 165 x 10^6

Phascolon vorticella STEIN

In stagnant and slow-flowing waters, particularly in small pools, in waste water fish-ponds. Phytophagous nutrition: feeds mainly on algae. Associated with Disematostoma colpidioides, Cyclogramma viridis, Spirofilopsis tubicola. Increased occurrence in summer (31). bms (83). For saprobic (367) valency see table 1.

Plagiopyla nasuta STEIN

In stagnant and running waters, particularly in small pools, in sapropel, also in athalassogenic brackish water and in sea water. Polyphagous nutrition: mainly algae, bacteria, detritus. Associated with Caenomorpha, Discomorphella, Epalxella, Metopus (77, 78). Increased occurrence in summer. ps(79), For saprobic valency see table 1.

Observed at:

Temperature	2 —20,5 °C	(1, 99, 136)
O_2	0,1—16	(1, 99)
CO_2	0 —68,4 mg/l.	(99)
salinity:	th: up to 2.5 %	(55)

Not in raw sewage (79).

Platycola truncata FROMENTEL

In stagnant and running waters. Polyphagous nutrition: algae, bacteria, detritus. Enemies: Trachelophyllum chilense. Increased occurrence in summer. In bms and ams ranges (63). For saprobic valency see table 1.

Environmental spectrum:

Temperature	0 —23 °C.	(20, 63, 90)
pH	6,3— 8	(20, 63, 90)
O_2	1 —12 mg/l.	(90, 137)
BSB_5	4 —12 mg/l.	(63)
CO_2 (free)	2 —12 mg/l.	(90)
NH_4	0 —16 mg/l.	(62a, 63)

number of bacteria per ml.: MF: 10^6 – 9 x 10^6 (90)

Special ecological literature: KRALIK (1961).

Platynematum sociale (PENARD) KAHL

In stagnant and running waters, in waste water fish-ponds, sludge activation basins, trickling filters. Bacteriophage, Association with Cinetochilum margaritaceum. For saprobic valency see table 1.

salinity: th: up to 1.5 % (56).

Avoids H_2S (84). ams (79).

Podophrya fixa O.F.M.

In stagnant and running waters, particularly in small pools, in activated sludge, in trickling filters, also in thalassogenic brackish water. Predator: feeds on Cyclidium, Paramecium, Stylonychia. ams (61,79), ps to bms (93). For saprobic valency see table 1.

Observed at:

Temperature 4 – 19 °C. (40)

Prorodon teres EHR.

In stagnant and running waters, particularly in small pools, in waste water fish-ponds, also in athalassogenic brackish water and in sea water. Polyphagous nutrition: algae, bacteria, detritus. Associated with (368) Loxodes striatus. Increased occurrence in autumn. ams (79), bms (121).

Observed at:

Temperature	1 —25,5 °C.	(1, 40, 99)
pH	6,4— 7,2	(66)
O_2	0,1—14,2 mg/l.	(1, 99)
CO_2 (free)	3,5—57,6 mg/l.	(99)

salinity: : th: up to 4.0 % (2, 55, 85)

Scyphidia hyalina BIEGEL

In stagnant and running waters. Increased occurrence from spring to autumn.

Environmental spectrum (90):

Temperature	5 —20	°C.
pH	7,2— 8	
O_2	9 —12	mg/l.
CO_2 (free)	about 3	mg/l.
NH_4	about 0,5	mg/l.

Spirostomum ambiguum (O.F.M.) EHR.

In stagnant and slow-flowing waters, particularly in small pools, in trickling filters, also in athalassogenic brackish water and in sea water. Polyphagous nutrition: algae, bacteria, flagellates, detritus. Associated with Cyclidium citrullus Halteria grandinella, Loxodes rostrum, Tachysoma pellionella. Increased occurrence in autumn (10). ams (61, 79), ps and ams (119). For saprobic valency see table 1.

Environmental spectrum (18):

Temperature	0 —32	°C.	(+ 1, 40, 99, 129)
pH	6 — 7,8		
O_2	0,1— 7,4	mg/l.	
BSB_5	15 —42	mg/l.	(82)
CO_2 (free)	0 — 9,8	mg/l.	(88)
NH_4	0 —17	mg/l.	
H_2S	0 — 1,3	mg/l.	

salinity: th: up to 0.4 % (+2)

number of bacteria per ml.: PM: 2×10^3 to 10^5

Special ecological literature: BICK (1957).

Spirostomum teres CLAP. & LACH.

In stagnant and running waters, particularly in small pools, in trickling filters, activated sludge. Polyphagous nutrition: algae, bacteria, detritus, flagellates. Increased occurrence in autumn. bms (61), ams (121). For saprobic valency see table 1.

Environmental spectrum:

(369)

Temperature	0 —25 °C.	(1, 40, 88)
pH	6,7— 8,1	
O_2	0 —11 mg/l.	(18, 88, 133, 138)
CO_2 (free)	0 —50 mg/l.	(88)
NH_4	0 — 7,5 mg/l.	(18, 138)
H_2S	0 — 1 mg/l.	

salinity: ath: up to 0.2 %

th: up to 0.7% (30, 55, 38, 85)

number of bacteria per ml.: PM: $13 \times 10^3 - 16 \times 10^6$ (18, 138)

Stentor coeruleus EHR.

In stagnant and slow-flowing waters, particularly in small pools and bogs, in trickling filters, also in thalassogenic brackish water. Polyphagous nutrition: bacteria, ciliates, detritus, diatoms. Increased occurrence in autumn. ams (61, 79), bms (119). For saprobic valency see table 1.

Environmental spectrum:

Temperature	0 — 26 °C.	(10—20 °C)
	(1, 40, 80, 89, 138)	(1, 66, 101)
pH	6,4— 8,4	(6,4—7,2)
	(80, 66)	(66, 131)
O_2	0 — 20,7 mg/l.	(1, 66, 82, 99,)
O_2-saturation	0 —206 %	
CO_2 (free)	3 — 52 mg/l.	(80, 99, 115)
NH_4	0,1— 7,3 mg/l.	(138)
H_2S	0 — 7,5 mg/l.	(80)

Stentor igneus EHR.

In stagnant waters. Polyphagous nutrition: algae, bacteria, ciliates, flagellates. Increased occurrence in summer. bms (61).

Environmental spectrum (40, 66, 80, 88):

Temperature	1 — 19,9 °C.
pH	7,4— 9,2
O_2	0,3— 22,9 mg/l.
O_2-saturation	1 —234 %
CO_2 (free)	0,6— 24,8 mg/l.
NH_4	0 — 4 mg/l.
H_2S	0 —0,1 mg/l.

Stentor polymorphus (O.F.M.)

In stagnant and slow-flowing waters, particularly in small pools, in waste water fish-ponds and trickling filters, also in athalassogenic brackish water and in sea water. Polyphagous nutrition: algae, detritus, ciliates, flagellates, rotatorians. Increased occurrence in spring (133). bms (61, 79), bms to ams (20), os to bms (8). For saprobic valency see table 1.

Environmental spectrum:

Temperature	3 — 25,5 °C.	(1, 23, 40, 80, 99)
pH	6,8— 8,8	(79, 80)
O_2	0 — 22,5 mg/l.	(1, 23, 40, 80, 99)
O_2-saturation	0 —200 %	
CO_2 (free)	0 — 44 mg/l.	(23, 80, 138)
NH_4	0,1— 6,2 mg/l.	(80, 138)
H_2S	0 — 1,2 mg/l.	(80)

(370)

salinity: th: up to 0.2 % (2)

number of bacteria per ml.: PM: 4,700 up to 97,000 (138)

Stentor roeseli EHR.

In stagnant and slow-flowing waters, particularly in small pools, also in thalassogenic brackish water. Polyphagous nutrition: algae, bacteria, ciliates, flagellates. Associated with Epistylis rotans, Vorticella monilata, Zoothamnium limneticum. Increased occurrence in autumn. ams (61), bms (121). For saprobic valency see table 1.

Environmental spectrum (20):

Temperature	0 — 25 °C.	(+ 1, 40, 88, 90)
pH	5,9— 9,4	
O_2	0 — 22,4 mg/l.	(+ 40, 88, 99, 130)
O_2-saturation	0 —207 %	(80)
CO_2 (free)	0 — 52 mg/l.	
NH_4	0 — 5 mg/l.	
H_2S	0 — 1,2 mg/l.	

number of bacteria per ml.: OM: 10^3 to 54 x 10^5

Stichotricha secunda PERTY

In all types of water, also in thalassogenic brackish water. Above all, frequent in summer.

Observed at (88):

Temperature	4,5— 28 °C.
O_2	5,5— 15,3 mg/l
O_2-saturation	67 —174 %
CO_2 (free)	0 — 2,1 mg/l

Strobilidium gyrans (STOKES)

In stagnant and slow-flowing waters, often in the open water, in waste water fish-ponds. Feeds on algae, bacteria, detritus. Numerous in autumn (133). os (61, 79).

Observed at (1, 40, 81, 88, 99):

Temperature	1 — 22 °C.
pH	6,4— 7,2
O_2	1,8— 17,2 mg/l.
O_2-saturation	18 —169 %
CO_2 (free)	0 — 18 mg/l.
NH_4	0 — 1 mg/l.

Stylonychia mytilus EHR.

In all types of water, particularly in small pools and eutrophic ponds, also in bogs. Polyphage: feeds on algae, bacteria, flagellates. Increased occurrence in spring and autumn. ams to bms (61), or (65). For saprobic valency see table 1.

Environmental spectrum (18): (371)

Temperature	2— 25 °C. (+ 1, 88, 89, 130)	(16—20 °C) (66)
pH	4— 8,4	(6,4—7,2) (66, 73)
O_2	0— 22,5 mg/l (+ 1, 81, 88, 89)	
BSB_5	2— 24,5 mg/l. (82, 130)	
CO_2 (free)	0—205 mg/l.	
NH_4	0— 26 mg/l.	
NH_3 (free)	0— 3 mg/l.	

salinity: th: up to 1.5 % (+ 2, 38, 55, 97)

number of bacteria per ml.: PM 6,000 up to 5×10^6

Stylonchia pustulata EHR.

In stagnant and running waters, particularly in small pools, in trickling filters, activated sludge, also in athalassogenic brackish water and in sea water. Polyphagous nutrition: algae, bacteria, ciliates, detritus, flagellates. Associated with Stylonychia mytilus. os (61).

Observed at:

Temperature	1 —22,5 °C. (1, 40, 88)	
O_2	0,1—11,8 mg/l.	(1, 88)
CO_2 (free)	0 —22 mg/l.	(88, 99)
NH_4	0,2— 0,5 mg/l.	(1)

salinity: th: up to 3.09 % (38, 97)

Stylonychia putrina STOKES

In stagnant and running waters. Polyphagous nutrition: algae, bacteria, ciliates. ams to bms (61), os (65). For saprobic valency see table 1.

Environmental spectrum (18):

Temperature	2 —25 °C.	
pH	5,8— 9,4	
pH	5,8— 9,4	(6,5—7)
O_2	0 —12,6 mg/l.	(0,1—1 mg/l)
CO_2 (free)	0 —56 mg/l.	(10—30 mg/l)
NH_4	0 —22 mg/l.	
NH_3 (free)	0 — 2 mg/l.	

salinity: th: up to 1.4 % (fresh water)

ath: up to 0.2 % (13)

number of bacteria per ml.: PM: 1,000 to 2 x 10^7

Tachysoma pellionella (O.F.M.) (= Oxytricha pellionella O.F.M.)

In stagnant and running waters, particularly in small pools, in moss, in waste water fish-ponds, activated sludge, trickling filters. Polyphagous nutrition: algae, bacteria, ciliates, detritus, flagellates. Associated with Cyclidium glaucoma, Litonotus folium, Pleuronema chrysalis, Paramecium bursaria. (372) ams (61), bms (121), os (65). For saprobic valency, see table 1.

Environmental spectrum:

Temperature	0 —43 °C.	(1, 20, 40, 80, 88, 104, 130)
pH	6,4— 9,1	(20)
O_2	0 —22,5 mg/l.	(1, 20, 80, 88, 130)
BSB_5	10,9—24,5 mg/l.	(130)
CO_2 (free)	0 —22,9 mg/l.	(1, 20, 80, 88, 130)
NH_4	0 — 5 mg/l.	(18, 80)
H_2S	0 — 0,5 mg/l.	(18)

salinity: th: up to 1.2 % (38)

Tetrahymena pyriformis (EHR.) LWOFF

In stagnant and running waters, particularly in small pools and bogs, in waste water fish-ponds, activated sludge, Emscher tanks, trickling filters. Polyphagous nutrition: algae, bacteria, detritus. Associated with Colpidium

colpoda. ps (79), bms and ams (121). For saprobic valency see table 1.

Environmental spectrum:

Temperature	1— 41,2 °C.	(20, 33, 93)
pH	7— 8,9	
O_2	0— 10,4 mg/l.	(81)
CO_2 (free)	0—200 mg/l.	
NH_4	0—250 mg/l.	
NH_3 (free)	0— .5 mg/l.	
H_2S	0— 2 mg/l.	

Thuricola folliculata (O.F.M.) KENT

In stagnant and running waters, in bogs. Polaphagous nutrition: algae, bacteria. os (79), bms (60). For saprobic valency see table 1.

Enviromental spectrum (90):

Temperature	4 —22 °C.
pH	7,1— 7,9
O_2	6 —12 mg/l.
CO_2 (free)	2 —12 mg/l.
NH_4	0 — 2,5 mg/l.

number of bacteria per ml.: MF: 10^6 - 9 x 10^6

Thuricola kellicottiana (STOKES)

(= Cothurnia kellikottiana PENARD)

In stagnant and slow-flowing waters.

Observed at (90):

Temperature	3 —10 °C.
pH	7,1— 7,2
O_2	10 —12 mg/l.
CO_2 (free)	2 — 8 mg/l.
NH_4	0 — 0,1 mg/l.

number of bacteria per ml.: MF: 7 x 10^5 to 10^5

Tintinnidium fluviatile (STEIN)

(including T. fluviatile f. cylindrica GAJEWSKAJA) (373)

Planktonic form of stagnant or gently flowing water. Feeds on algae, bacteria, detritus. os (79), bms (61), ams (83). For saprobic valency see table 1.

Tintinnidium fluviatile var. emarginatum MASKEL

In stagnant waters (90, 109). Polyphagous nutrition: algae, bacteria, detritus. Associated with Campanella umbellaria, Carchesium polypinum. Increased occurrence in spring and autumn. bms (112). For saprobic valency see table 1.

Environmental spectrum (according to NUSCH, private communication):

Temperature	2 —15	°C.
pH	6,9— 7,7	
O_2	12 —14	mg/l
CO_2 (free)	2 — 5	mg/l.
NH_4	up to 0,1	mg/l.

number of bacteria per ml.: MF: $3 \times 10^5 - 25 \times 10^6$

Trachelius ovum EHR.

In stagnant and running waters, particularly in small pools, in moss. Predator, feeds on ciliates, flagellates. bms (61), ams (20). For saprobic valency see table 1.

Observed at (1, 40, 99):

Temperature	3 —16	°C.
O_2	6,2—10	mg/l.
CO_2 (free)	5,7—13,2	mg/l.

Trachelius pusillum CLAP. & LACH.

In stagnant waters, in activated sludge. Polyphagous nutrition: bacteria, detritus. bms (61).

Observed at (88, 99):

Temperature	4,5—14.	°C.
O_2	0,2—10,9	mg/l.
CO_2 (free)	0,1—25	mg/l.

Trimyema compressum LACKEY

In stagnant and slow-flowing waters, particularly in small pools, in purification plants, Emscher tanks (74), sapropel. Bacteriophagous nutrition. Associated with Caenomorpha, Epalxella, Metopus, Saprodinium. ps (79). For saprobic valency see table 1.

Environmental spectrum (18):

Temperature	0 —25	°C.
pH	6,8— 8,5	
O_2	0 — 3	mg/l.
CO_2 (free)	0 —30	mg/l.
NH_4	0 — 3	mg/l.
H_2S	0 — 6	mg/l.

salinity: ath: up to 0.2 % (374)

Only occurs in ps-zones with low NH_4-content (18).

Trochilia minuta (ROUX)

In stagnant and running waters, in waste water fish-ponds, activated sludge, Imhoff tanks. Polyphagous nutrition: algae, bacteria, detritus. bms (61), ams (83).

Environmental spectrum (1, 80, 88, 99):

Temperature	1 — 20,5	°C.
pH	7,5— 9,1	
O_2	0,5— 22,4	mg/l.
O_2-saturation	4 —207	%
CO_2 (free)	1,4— 26,5	mg/l.
NH_4	0 — 4	mg/l.
H_2S	0 — 1,1	mg/l.

Tropidoatractus acuminatus LEV.

In stagnant waters, particularly in small pools and in bogs. Polyphagous nutrition: mainly bacteria, detritus. Increased occurrence in summer.

Observed at (6, 9, 99):

Temperature	1 —36	°C.
pH	6,1— 7,4	
O_2	0 — 7,3	mg/l.
CO_2 (free)	4,4—58	mg/l.
NH_4	0 — 2,4	mg/l.
H_2S	0 — 2,2	mg/l.

Urocentrum turbo (O.F.M.)

In all stagnant and slow-flowing waters where degradation of plant and animal waste products takes place. Small pools; waste water fish-ponds , trickling filters. ams (79), bms (61). For saprobic valency see table 1.

Environmental spectrum (1, 18, 66, 80, 81, 88, 99, 129, 133):

Temperature	0 — 28,5 °C.
pH	5,8— 9,2
O_2	0 — 22,5 mg/l.
O_2-saturation	0 —198 %
CO_2 (free)	0 — 58 mg/l.
NH_4	0 — 18 mg/l.
H_2S	0 — 1,2 mg/l.

number of bacteria per ml.: PM: 2,000 to 5×10^5

Uroleptus piscis (O.F.M.) STEIN

In stagnant and slow-flowing waters, particularly in small pools; in trickling filters, also in thalassogenic brackish water and in the sea. Polyphagous nutrition: algae, bacteria, detritus. Increased occurrence in autumn. bms (61).

Observed at (66,88,99):

Temperature	1 — 22,5 °C.
pH	6,4— 7,2
O_2	6,7—169 mg/l.
CO_2 (free)	4,3— 36 mg/l.

(375)

Uronema marinum DUJ.

In stagnant and running waters, particularly in small pools and in moss, in trickling filters, activated sludge. Bacteriophage. Associated with Cyclidium caudatum. Increased occurrence in autumn. ams (79), bms (61). For saprobic valency see table 1.

Environmental spectrum:

Temperature	1,5—17,1 °C.
O_2	0,3— 7,8 mg/l.
BSB_5	13,5—24,5 mg/l.
CO_2 (free)	0,3 —57,2 mg/l.

salinity: th: up to 0.5 % (13)

ath: up to 6.0 %

number of bacteria per ml.: PM: $2 \times 10^3 - 16 \times 10^6$ (18, 138)

Urostyla weissei STEIN

In stagnant and slow-flowing waters, particularly in small pools and bogs, in trickling filters. Polyphagous nutrition: algae, bacteria, detritus, flagellates. Associated with Urostyla grandis. ams (61, 79), bms (61).

Observed at (20, 99, 130):

Temperature	0 — 25,5 °C.	(1, 18)
pH	4,1— 7,8	(7—7,5) (18)
O_2	0,1— 14,5 mg/l.	(0,1—6 mg/l) (1, 18, 102, 138)
CO_2 (free)	5 —200 mg/l.	(10—20 mg/l) (18, 99)
NH_4	0 — 22 mg/l.	(18, 138)
H_2S	0 — 1,2 mg/l.	(18)

Urotricha farcta CLAP. & LACH.

In stagnant and slow-flowing waters, particularly in small pools, in waste water fish-ponds. Polyphagous nutrition: algae, bacteria, detritus. ams (61, 79), For saprobic valency see table 1.

Environmental spectrum (1, 18, 88, 99):

Temperature	0 —25 °C.
pH	6,4— 8,2
O_2	0 —14,7 mg/l.
CO_2 (free)	0 —75 mg/l.
NH_4	0 —15 mg/l.

number of bacteria per ml.: D: 1×10^6 - 170×10^6

Urozona bütschli SCHEW. (376)

In stagnant and running waters, particularly in small pools, in Emscher tanks, trickling filters, sapropel. Bacteriophage. Associated with Dexiotrichides centralis, Enchelyomorpha vermicularis, Trimyema compressum. Increased occurrence in spring and autumn. ps (79). For saprobic valency see table 1.

Environmental spectrum (1, 9, 80, 99):

Temperature	1 — 16 °C.
pH	6,0— 8,6
O_2	0 — 11,1 mg/l.
O_2-saturation	0 —110 %
CO_2 (free)	3 — 57,6 mg/l.
NH_4	0,1— 4,8 mg/l.
H_2S	0 — 1,2 mg/l.

Vaginicola ingenita (O.F.M.)

In all types of water. Bacteriophage. For saprobic valency see table 1.

Observed (90) in the following ranges:

Temperature	12 —20	°C.
pH	7,5	
O_2	8 —10	mg/l.
CO_2 (free)	2 — 6	mg/l.
NH_4	0 — 0,2	mg/l.

number of bacteria per ml.: MF: 10^6 to 2 x 10^6

Vorticella campanula EHR.

In all waters, also in small pools, bogs, also in athalassogenic salt waters. feeds on algae, bacteria, flagellates. Associated with Aspidisca costata, A. lynceus, Euplotes affinis. Enemies: Trachelius ovum, Podophrya epozoica. Increased occurrence in spring and autumn. bms (61, 79), bms to os (28). For saprobic valency see table 1.

Environmental spectrum (90):

Temperature	0 —25 °C.	(+ 23, 88, 89, 92)
pH	6,9-- 9,5	(+ 47, 88, 89)
O_2	2,3—22,6 mg/l.	(+ 47, 88, 89)
CO_2 (free)	0 —20 mg/l.	(+ 23, 88)
NH_4	0 — 7,5 mg/l.	

number of bacteria per ml.: MF: 0.5 x 10^6 - 9 x 10^6

Vorticella convallaria (LINNE)

In stagnant and running waters, in waste water fish ponds, activated sludge, aeration chambers, trickling filters, also in athalassogenic brackish water. Polyphagous nutrition: mainly algae, bacteria, detritus. Associated with Aspidisca costata, Euplotes campanula, Vorticella citrina. Maximum distribution in spring and autumn. In ams zones (61, 79), in bms ranges (127). For saprobic valency see table 1.

Environmental spectrum (90):

Temperature	2 —23 °C.	(+ 40)
pH	5,5— 9	
O_2	1 —13 mg/l.	(+ 130)
BSB_5	7 —13,5 mg/l.	(130)
CO_2 (free)	0 —15 mg/l.	
NH_4	0 —17,5 mg/l.	

salinity: th: up to 2.7 % (85) (377)

number of bacteria per ml.: MF 10^6 - 9 x 10^6

Vorticella margarita FROMENTEL

In stagnant and running waters. Polyphagous nutrition: algae, bacteria, detritus. Increased occurrence in summer and autumn (90).

Environmental spectrum (90):

Temperature	5 —12 °C.
pH	7,1— 7,8
O_2	8,5—11 mg/l.
CO_2 (free)	0 — 6 mg/l.
NH_4	um 0,1 mg/l.

number of bacteria per ml.: MF: 10^6 - 3 x 10^6

Vorticella microstoma EHR.

In stagnant and running waters, particularly in small pools, in waste water fish-ponds, activated sludge, Imhoff taks, aeration tanks trickling filters, also in thalassogenic and athalassogenic brackish water. Polyphagous nutrition: mainly algae, bacteria. Associated with Colpoda cucullus, Paramecium caudatum, Stylonychia putrina. Enemies: Amphileptus claparedei, Prorodon microstoma. Increased occurrence in summer (133). ps (61, 79), ams (124), os (65). For saprobic valency see table 1.

Environmental spectrum (11, 20, 40, 81, 90, 142):

Temperature	0 —50 °C.
pH	5,8— 9,5
O_2	0 —12 mg/l.
CO_2 (free)	0 —60 mg/l.
NH_4	0 —65 mg/l.
H_2S	0 — 4 mg/l.

number of bacteria per ml.: MF 5 x 10^6 to 85 x 10^6

Vorticella monilata TATEM

In all types of water, including athalassogenic and thalassogenic brackish water. Polyphage: feeds on algae, bacteria, detritus, and flagellates.

Maximum distribution in spring and autumn (90). ams to bms (62a), os (65).

Environmental spectrum (40, 90, 129, 136):

Temperature	8,6—25,4 °C.
pH	7,2—10,5
O_2	5,4—13,3 mg/l.
CO_2 (free)	0 — 8 mg/l.
NH_4	0,5— 2,5 mg/l.

(378)

number of bacteria per ml.: MF: 2×10^6 to 9×10^6

Special ecological literature: NUSCH (1970).

Vorticella striata DUJ. var. octava (STOKES) NOLAND & FINLEY (= V. octava STOKES).

In stagnant and running waters, particularly in small pools, in aeration chambers, activated sludge. Polyphagous nutrition: bacteria, detritus. Increased occurrence in summer. For saprobic valency see table 1.

Environmental spectrum (90):

Temperature	0—26,5 °C.	(+ 130)
pH	5— 8	
O_2	3—14 mg/l.	(+ 130)
CO_2 (free)	0—12 mg/l.	(130)
NH_4	0—15 mg/l.	

number of bacteria per ml.: MF: $10^6 - 9 \times 10^6$

Vorticella picta EHR.

In stagnant and running waters. Polyphagous nutrition: mainly algae, bacteria. Associated with V. campanula. Increased occurrence from spring to autumn. bms (63).

Environmental spectrum (90):

Temperature	3—20 °C.
pH	7— 8
O_2	9—16 mg/l.
CO_2 (free)	0— 6 mg/l.
NH_4	0— 0,2 mg/l.

number of bacteria per ml.: $2 \times 10^5 - 6 \times 10^6$

Vorticella vestita STOKES

In stagnant and running waters. Polyphagous nutrition: mainly algae, bacteria. Increased occurrence in summer.

Environmental spectrum (90):

Temperature	5 —15 °C.
pH	7,2— 7,6
O_2	8 —13 mg/l.
CO_2 (free)	0 — 8 mg/l.
NH_4	0,1— 2 mg/l.

Number of bacteria per ml.: MF: $10^6 - 6 \times 10^6$

Summary

Ecological data on 132 species of ciliated Protozoa are summarized in tables showing the ecological valencies (or limits of tolerance) with regard to temperature, pH, O_2 (D.O.), percentage of oxygen saturation, BOD_5, free CO_2, NH_4, free NH_3, H_2S, salinity and number of bacteria.

As far as available additional informations about the range of optimal environmental conditions are presented.

The saprobiological valencies (the so-called „Indicator value") of 72 ciliates are listed in table 1 (page 339) using the 10-points-method of ZELINKA & MARVAN.

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Addendum:

(141) Noland, L. E., and Gojdics, M., 1967: Ecology of free-living Protozoa. — In: Research in Protozoology Vol. 2, 216—266.
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Translation of Bibliography Items

1. Ecology of the free-living ciliates of the river Schwabach with special consideration of the various distribution factors.

2. Experimental studies of the salt tolerance of ciliates from brackish water and freshwater

3. Studies of the role of ciliates as bacteriophages in the biological treatement of sewage waste

5. Detection of a chemotactically effective substance in Spathidium stammeri

6. The infusorian Tropidoatractus acuminatus LEVANDER

7. Organisms as indicators of water quality and the saprobiont system

9. Contributions to the ecology of some ciliates of the saprobiont system

10. Ecological studies of ciliates of small bodies of water with a high content of fallen leaves

11. Ecological investigations of ciliates and other organisms from various types of polluted water

12. Ecological studies of settling ponds

13. The succession of organisms in the self-purification of organically polluted water given a variety of environmental conditions

14. The population dynamics of freshwater ciliates in tests with marine brackish waters and soda lakes

15. Ecological studies of ciliates in the saprobiont system I. Contribution to the knowledge on Cyclidium citrullus, Glaucoma scintillans, Litonotus lamella and Paramecium caudatum

16. Ecological studies of ciliates in the saprobiont system II

(17) Comparative investigations of the ciliate succession during the degradation of cellulose in marine brackish and in athalassogenic brackish water of the type corresponding to waste water from potash plants.

(18) Autecological and saprobiological research on freshwater ciliates.

(19) Research on the tolerance to seawater and brackish water of ciliates belonging to the saprobe system used for water quality evaluation

(21) Biological investigations, particularly of the ciliate fauna, in the sewage-laden water of the river Schlei

(24) The ciliates of activated sludge and their dependence on purification processes. Munich Contributions to the Biology of Sewage, Fischery, and Rivers, 5, 206-222.

(25) The protozoan fauna of the salt-lake lagoon near Odessa.

(26) On the limits of resistance of some freshwater infusorians to chloride solutions.

(30) Contributions to the knowledge of the ciliate fauna in some brackish-water pools on the Mediterranean coast of France.

(31) The ciliates of transient waters.

(32) Revision of the genus Dileptus (DUJ.) - Systematics, cytology, biology.

(36) A new free-living vorticel: Tetrochidium johanninae n.sp.

(37) Documents and ecological and practical observations on the culture of ciliated infusorians.

(40) On the ecology, morphology, and systematics of infusorians from Lake Baikal.

(41) On the biomass of some small pools in a mountain meadow in the Börzörny Mountains (Upper Hungary).

(42) On the food selection of infusorians, investigated in the case of Paramecium caudatum and Stentor coeruleus.

(46) Research on the ecology and variability of Aspidisca costata in activated sludge.

(47) Ecological and biological research on freshwater peritrichans.

(51) Biological research on the animal and plant fauna in the port of Hamburg. Report, Zoological Museum of Hamburg, 33, 1-172.

(51a) On suctorians in the river Elbe near Hamburg and on their living conditions.

(52) Monograph on mineral spring fauna. Acta of the Royal Academy of Science, Turin, 45, 53-98.

(54) New and little known forms of the holotrichous/heterotrichous ciliates.

(55) Infusorians (ciliates) of/the salt-water areas of Oldesloe.

(56) Ciliates (infusorians), in: DAHL, F.: Germany's Animal World, Parts 18, 21, 25, 30, Jena.

(57) Ecological research on Danube ciliates. Water & Sewage, 4, 1-24.

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(59) The sessile peritrichans and suctorians of Basle and surroundings.

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(69) Sapropelic life.

(70) Sapropelic life.

(72) Contributions to the knowledge of some ciliates.

(73) The influence of external factors and active substances on the vitality and fission rate of Stylonychia mytilus. (382)

(74) The ciliate fauna of Emscher (Imhoff) tanks.

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(84) The fauna of the Potamogeton zone of lakes in Eastern Holstein.

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(86) Information on the rheophilic microbenthos.

(87) The peritrichans of the Erlangen environs with special reference to host specificity.

(89) On the pollution of a small river in Moravia by waste waters from taweries, leather factories, glue factories, and other plants.

(90) Ecological and systematical investigations of the peritrichans (protozoa, ciliata) among the growth in valley and river reservoirs with different degrees of saprobity (with model tests).

(91) Research on Frontonia marina FRABE-DOM from an inland salt-spring, giving special consideration to the pulsating vacuole.

(95) Contributions to the fauna of the river Oker in the urban area of Brunswick. Acta, Brunswick Scientific Soc., 11, 62-66.

(96) Some faunistic and ecological observations on the ciliates of small pools in rocky terrain.

(98) Research on freshwater suctorians.

(99) Contributions to the faunistics, biology and ecology of the heliozoans and ciliates of Basle and environs. (383)

(100) Hollow trees filled with water and their population. A contribution to the fauna dendrolimnetica.

(101) Research on detritus fauna in the sewage area near Hamburg.

(102) Plankton studies of the German Limnological Sunda Expedition.

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(106) On the biological classification of higher degrees of saprobity

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(108) Remarks on Amphileptus trachelioides (ZACHARIAS).

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(117) The role of ciliate analysis in the biological control of river pollution.

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(123) Ecological-systematical research on free-living and parasitic ciliates by the Erlangen Zoological Institute. (384)

(124) Vorticella microstoma EHR. as bio-indicator of ecologically different waters.

(125) On the biology and distribution of the fauna of protozoans and crustaceans in a highland brook in Hungary.

(126) The modification of peritrichous ciliates resulting from the influence of environmental factors and its importance to the evaluation of water.

(127) On the limnology of the soda-lakes of Hungary. I. The Nagyszek soda-lake and its peritrichous fauna.

(128) Peritrichous ciliates of ecologically different biotopes in Rovinj and environs.

(130) Experiments on the autopurification of running water. Bull.Food Hygiene Berne.

(131) Developmental-physiological investigations of the morphogenesis of Stentor coeruleus EHR.

(132) Contribution to the saprobiology of some organisms.

(135) On the classification and dynamics of shallow waters.

(136) Sapropel and its ciliate indicator forms.

(137) Ecological research on sessile / and planktonic ciliates in a eutrophic pond.

(138) The biota of the river Swist in the course of autopurification.

(140) More precise biological classification of the purity of running waters.

Addendum:

(142) The influence of temperature on the degradation of organic matter and on the succession of organisms involved, giving special consideration to the population dynamics of ciliates. Dissertation, Faculty of Mathematics and Science, Bonn University.

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