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Ecological relationship between the physico-chemical variables and the dynamics of ciliated protozoa in a tropical aquatic-system (Cameroon)

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Key words: Eco-dynamics, ciliated protozoa, abiotic variable ,hydrosystem.

Abstract

The eco-dynamical relationship has been established between the environmental variables and the distribution of ciliated protozoa in an aquatic ecosystem in Yaounde, Cameroon that is being subjected to anthropogenic pollution. These biological indicators for polysaprobic and mesosaprobic lotic and lentic systems were more exigent for biotopes with a high level of biodegradable organic and mineral content. Ammonia, Dissolved Carbon Dioxide and the presence of water hardness indicators were more determinant in the proliferation of ciliates such as *Caenomorpha medusula* and *Metopus ovatus* which are confirmed biological indicators of very high pollution. The quantitative and qualitative dispersion of the infusorian community was more related to the physico-chemical parameters of the medium that have been considered in our investigation. The stalk and the contractile axis in *Vorticella* impose a structural resistance of varied pollution load. The spinning movement envisaged in *Urocentrum turbo* contribute in the search for proper habitat, food and also in absconding the prey-predator relationship, which is very rampant in streams and rivers. The presence of a food vacuole, a contractile vacuole, a cytopharynx and pellicles can influence the stability of the ciliate population in water, while the cilia play a primordial role in the displacement of these protozoans in their media as they trophically articulate between the micro-zooplankton and the macro-zooplankton.

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Introduction

Organisms respond positively or negatively to the physico-chemical conditions of most water bodies (Malmqvist *et al.*, 2008). These conditions can be modified by allochthonous inputs or autochthonous regeneration of mineral or organic matter(Roberts *et al.*, 2004). This mobilisation of nutritious elements in lotic or lentic ecosystems intervene in the metabolical processes responsible for the survival and development of the organisms present (Takehito *et al.*, 2001). Among the various groups of organisms are ciliated protozoa which play a very prominent positions in most aquatic trophic associations as presented by Summerer *et al.*, 2009, Kodama and Fujishima,2010. They are considerable grazers on bacteria and also micro-zooplancton as stipulated by Veljo and Priit, 2004. They are an important algal consumers and contribute in the functioning of rivers by their ability to fix carbon and in the recycling of nutrients (Summerer *et al.*,2009). Ciliated protozoa are very good biological indicators of pollution as they respond numerically to the pollution pressure of any medium in which they occur.

They are being subjected to predation by meta-zooplancton , invertebrates and vertebrates (Wiackowski *et al*, 2001). Despite this biological regulation, the environmental, ionic and anionic variables constantly influence the repartition of this protozoan plankton (Andruschyschyn *et al*, 2003). This diversity of interaction between the ciliates and the various components of the biotope is pre-occupying. Our objective is to assess the level of relationship between some biological indicators of saprobity and the abiotic components of the medium in question.

Materials and methods

The tropical aquatic ecosystem assessed in this study is the lotic watershed in Yaounde. Analyses were carried out from upstream to downstream, with statistical calculations and diagrammatical representations effected in 2011. The water quality depreciated from Oligosaprobic, mesosaprobic and polysaprobic along the stream courses considered in our studies. The physico-chemical parameters studied were temperature by mercury thermometer, pH by the pH meter ,suspended solids by spectrophotometer, Oxydability and Oxygen by the Winkler method, Carbon Dioxide by titration, Orthophosphate by the amino-acid method, Total hardness by volumetry. The ciliates were sampled by polyurethane foams. They were identified live by the application of the silver ammoniacal carbonate staining methods of Galiano-Fernandez, 1986. They were counted in the laboratory of general biology of the University of Yaounde 1, under the binocular optical microscope of mark wild. The identification key applied is that proposed by Dragesco and Dragesco , 1986 for the determination of African ciliates.

The Spearman's correlation coefficient was applied in the determination of the impact of some physico-chemical variables on some selected ciliates protozoa. The Spearman's rank correlation coefficient which is often denoted by the letter *p* (rho) or *r*s, is a non-variable assessment of the analytical dependence between two parameters that are present in an ecosystem (Spearman ,1904). It assesses how well the relationship between two variables can be described using a monotonic function. If there are no repeated data values, a perfect Spearman correlation of +1 or −1 occurs when each of the variables is a perfect monotone function of the other. The Spearman correlation coefficient is defined as the Pearson correlation coefficient between the ranked variables. For a sample of size *n*, the *n* raw scores X_i, Y_i are converted to ranks x_i, y_i, and ρ is computed from these:

$$\rho = \frac{\sum_i (x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\sum_i (x_i - \bar{x})^2 \sum_i (y_i - \bar{y})^2}}.$$

Tied values are assigned a rank equal to the average of their positions in the ascending order of the values. In applications where ties are known to be absent, a simpler procedure can be used to calculate ρ. Differences $d_i = x_i - y_i$ between the ranks of each observation on the two variables are calculated, and ρ is given by:

$$\rho = 1 - \frac{6 \sum d_i^2}{n(n^2 - 1)}.$$

There are several other numerical measures that quantify the extent of statistical dependence between the pairs of observations. The most common of these is the Pearson product-moment correlation coefficient, which is a similar correlation method to Spearman's rank, that measures the "linear" relationships between the raw numbers rather than between their ranks (Myers and Well , 2003).In continuous distributions, the grade of an observation is, by convention, always one half less than the rank, and hence the grade and rank correlations are the same in this case. More generally, the "grade" of an observation is proportional to an estimate of the fraction of a population less than a given value, with the half-observation adjustment at observed values. This corresponds to one possible treatment of tied ranks. A negative Spearman correlation coefficient corresponds to a decreasing monotonic trend between *X* and *Y* (Choi, 1977). The sign of the Spearman correlation indicates the direction of association between *X* (the independent variable) and *Y* (the dependent variable). If *Y* tends to increase when *X* increases, the Spearman correlation coefficient is positive. If *Y* tends to decrease when *X* increases, the Spearman correlation coefficient is negative. A Spearman correlation of zero indicates that there is no tendency for *Y* to either increase or decrease when *X* increases. The Spearman correlation increases in magnitude as *X* and *Y* become closer to being perfect monotone functions of each other. When *X* and *Y* are perfectly monotonically related, the Spearman correlation coefficient becomes 1. A perfect monotone increasing relationship implies that for any two pairs of data values X_i, Y_i and X_j, Y_j, that $X_i - X_j$ and $Y_i - Y_j$ always have the same sign. A perfect monotone decreasing relationship implies that these differences always have opposite signs. The Spearman correlation coefficient is often described as being nonparametric (Corder and Foreman, 2009). This can have two meanings. First, the fact that a perfect Spearman correlation results when *X* and *Y* are related by any monotonic function can be contrasted with the Pearson correlation, which only gives a perfect value when *X* and *Y* are related by a linear function. The other sense in which the Spearman correlation is non-parametric in that its exact sampling distribution can be obtained without requiring knowledge of the joint probability distribution of *X* and *Y*

Results and discussion

The spearman's correlation coefficient for ciliates (*Chilodonella uncinata, Caenomorpha medusula, Loxodes kahli, Metopus ovatus, Paramecium africanum,Telotroche de Vorticellidae,Urocentrum turbo,Vorticella*) and the data for temperature, pH, Suspended solids, orthophosphates, Oxygen, Carbondioxide, Total hardness and ammonia are represented in the figures 1-10.The structural particularities of the ciliates assessed in our investigations are presented in figures 11-17 .There is a positive relationship between most indicators of polysaprobity and mesosaprobity and the values obtained for dissolved carbondioxide, ammonia and orthophosphates. *Paramecium africanum* is highly correlated with dissolved oxygen downstream, *Chilodonella uncinta* and *Caenomorpha medusula* with orthophosphate upstream.

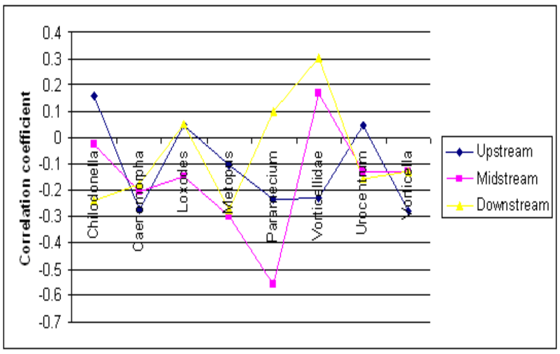

Fig. 1. Correlation coefficient of some ciliates bio-indicators of pollution with temperature.

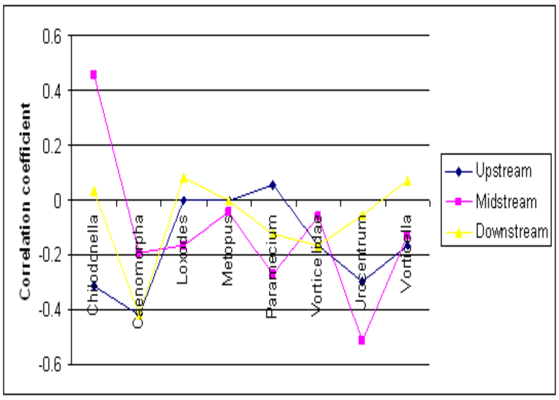

Fig. 2. Correlation coefficient of some ciliates bio-indicators of pollution with pH.

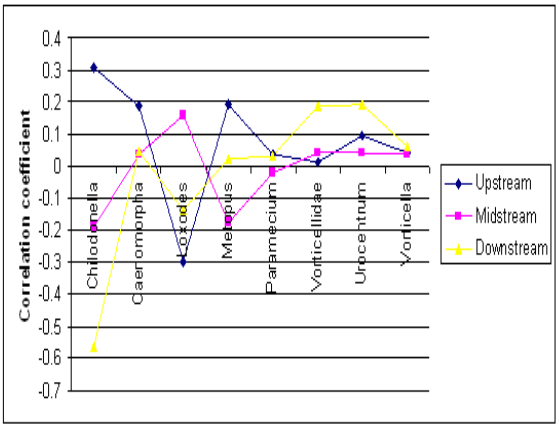

Fig. 3. Correlation coefficient of some ciliates bio-indicators of pollution with Suspended solids.

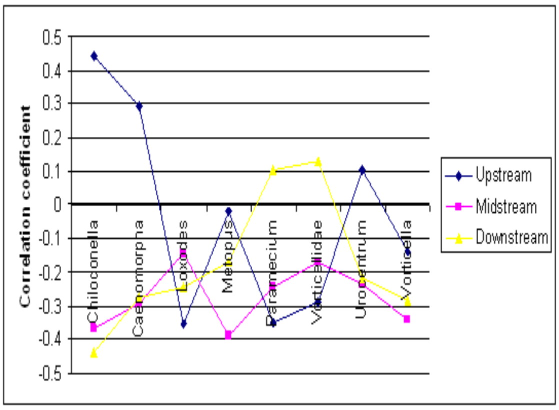

Fig. 4. Correlation coefficient of some ciliates bio-indicators of pollution with orthophosphates

There was a positive value for *Urocentrum turbo* and *Paramecium africanum*, with the values of temperature, while the value was negative for other ciliates enrolled in our investigation (Figure 1).This same trend was remarkable for the acidic, neutral basic, inorganic and organic composition of the watershed (Figures 2-10).There was a high negativity in the relationship between orthophsphates and Dissolved oxygen in some of the samples assessed. Carbon dioxide was highly correlated with *Chilodonella uncinata* (0,5136), *Caenomorpha* (0,8004), *Metopus*(0,8256), *Urocentrum turbo* (0,6612) and *Vorticella* (0,6645) as presented in figures 6. Calcium, Magnesium and total hardness was more exigent for ciliates indicators of polysaprobity downstream of the ecosystems analysed as presented in figures 7-10. Apart from *Paramecium* which was negatively linked to ammonia, downstream, all other ciliates presented a remarkable positive value in all the biotopes considered.

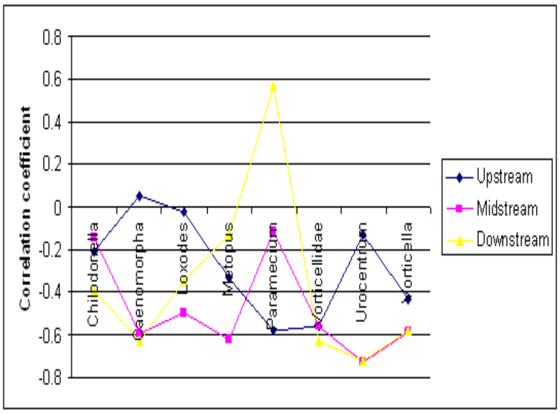

Fig. 5. Correlation coefficient of some ciliates bio-indicators of pollution with Dissolved Oxygen.

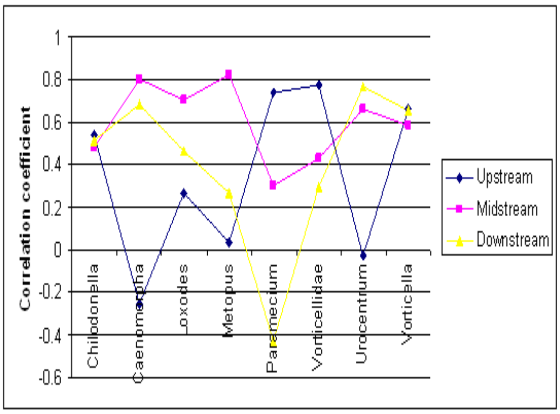

Fig. 6. Correlation coefficient of some ciliates bio-indicators of pollution with carbondioxide.

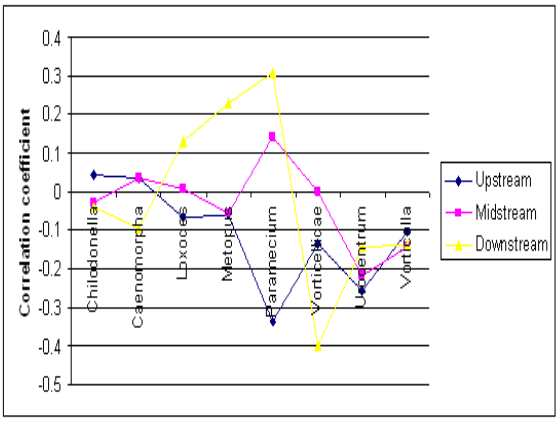

Fig. 7. Correlation coefficient of some ciliates bio-indicators of pollution with total hardness.

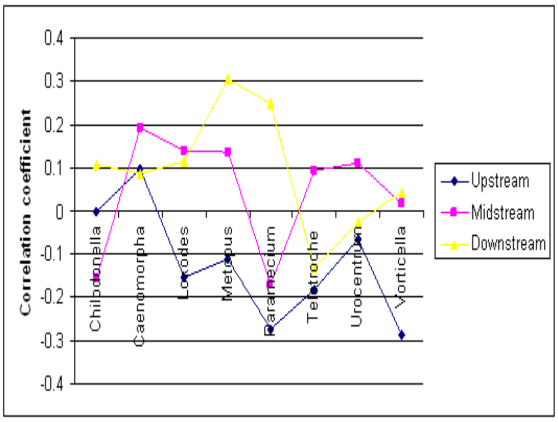

Fig. 9. Correlation coefficient of some ciliates bio-indicators of pollution with Magnesium ion.

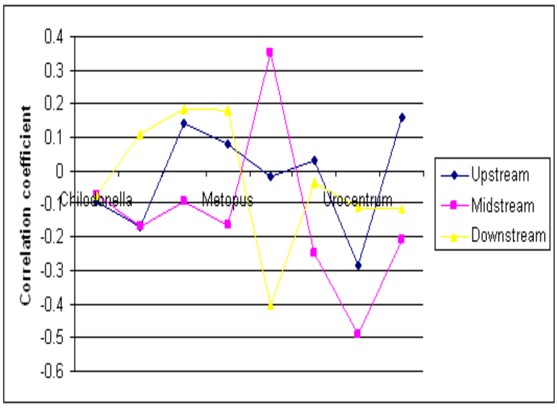

Fig.10. Correlation coefficient of some ciliates bio-indicators of pollution with the calcium ion.

According to Sonntag *et al,* 2011, the presence of some assimilable components such as ammonia and phosphorus are necessary for the functioning of ciliates because they play a crucial role in their catabolic and anabolic processes. The inorganic and organic variables that are present in ecosystems constitute a primordial component in the architectural framework of micro-zooplankton that is present in soil and water. A high concentration of ammonia has been known to activate the multiplication of *Euplotes vannus* (Henglong, 2004).The direct discharge of industrial and domestic waste in the Yaounde watershed can be very important for polysaprobic ciliates such as *Metopus* and *Caenomorpha* and mesosaprobic ciliates such as *Paramecium, Urocentrum* and *Vorticella* (figures 11-17) as revealed in our findings.

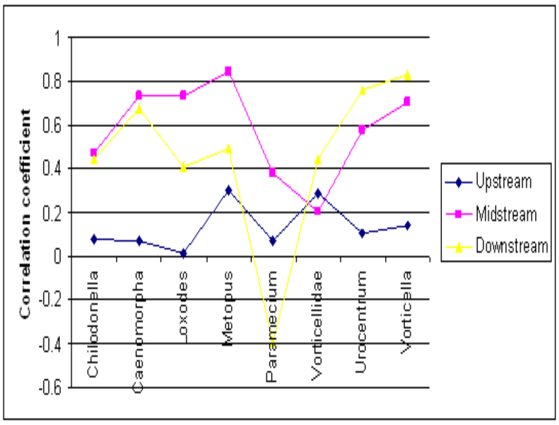

Fig. 8. Correlation coefficient of some ciliates bio-indicators of pollution with ammonium ion.

The low correlation observed for the pH could be due to the fact that , most streams do not have a high variability of their acidic and basic status in this hydrosystem. The concentration of Chloride and conductivity have been known to decrease the abundance of ciliates in an Austrian lake that is exposed to a high salt discharge(Sonntag *et al.,* 2002). The negative correlation observed for *Urocentrum turbo* and *Vorticella campanula* with the values of water hardness could be due to the pollution sensitive character of these organisms which are more linked to hydrosystems exposed to decomposing organic matter (Traian *et al,* 2008).The presence of a spine for movement in *Urocentrum turbo* and a stalk for fixation in *Vorticella* are morphological constraints which impose the ecological survival of these pollution indicators in tropical water bodies. This organic matter leads to a multiplication of bacteria which serves as nutrients for most bactivorous ciliates (Pritt and Ingmar, 2000). The presence of a food vacuole, a contractile vacuole, a cytopharynx and pellicule can influence the stability of the ciliate population in water, while the cilia play a primordial role in the locomotion of these protozoans in their media (figures 11-17).

The low correlation calculated between most of the ciliates and dissolved oxygen could be explained by the fact that, this parameter does not play a limiting role in some aquatic ecosystems subjected to intense present a high load of asimilable particulate substances; this substantiates a high relationship for ammonia, orthophosphate and dissolved carbon dioxide as presented in figures 1-10.

Conclusion

The assessment carried out on the qualitative and quantitative dispersal of the ciliates with respect to environmental variables, reveal a high relationship between surface water which are rich in Ammonia, Orthophosphate, Carbon Dioxide and a low correlation between pH, Temperature and Oxygen. The polysaprobic ciliates such as *Caenomorpha medusula* and *Metopus ovatus* are functionally and pollution, thus functioning in an anaerobic regime as evocated by Sonntag *et al,* 2011; Traian *et al*., 2008. Heterotrophic ciliates could depend more on the availability of the prey-predator relationship for survival, than on the direct abiotic conditions of the aquatic medium. A thermal gradient of 20-25'C is an adaptation of protozoan to tropical environmental conditions (Woodward *et al,,* 2010). *Paramecium africanum* could develop both in the mesosaprobic upstream or the polysaprobic downstream, due probably to it's ecological ubiquity (Summerer, 2009). The ciliates which indicate a high pollution are more correlated, to hydrological conditions that structurally adapted to water resources with a high content in decomposing nutritive resources. The mesosaprobic ciliated protozoa re-enforce their food and contractile vacuole as well as the cytopharynx for trophic and eco-operational survival in the medium. The catabolic, anabolic and architectural particularities of the ciliates influence their adaptation in tropical freshwater. This is a valuable contribution to the understanding of the structural and functional mechanisms underlining the eco-dynamical monitoring and the sustainable management of aquatic resources in tropical water bodies.

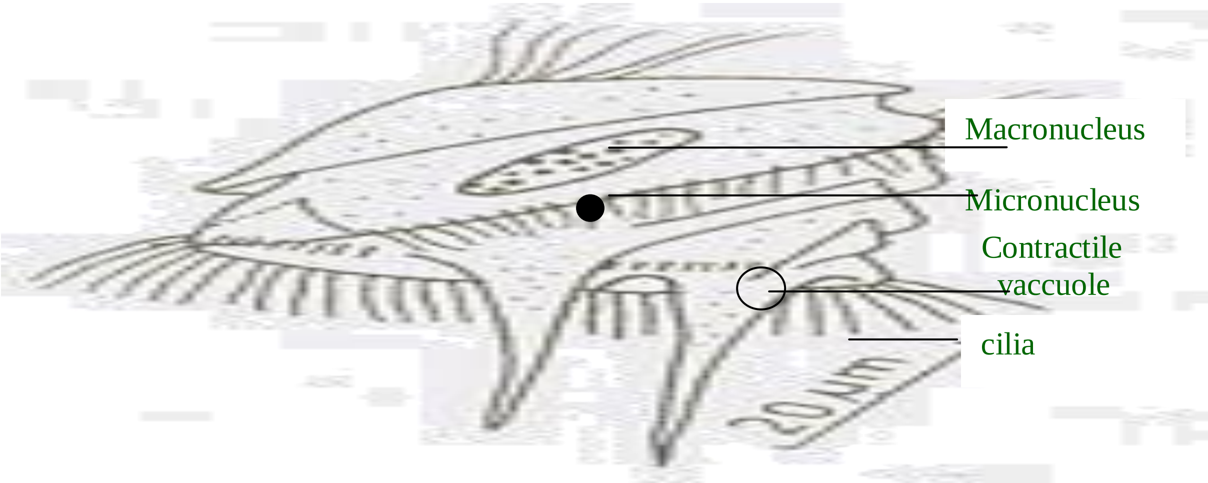

Fig. 11. Morphology of *Caenomorpha medsula*.

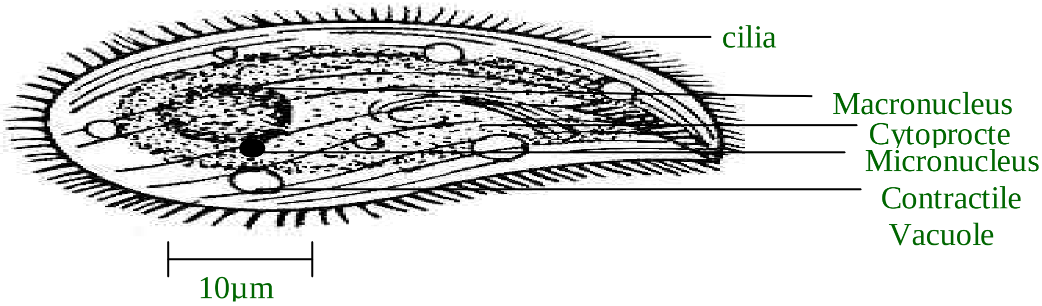

Fig. 12. Morphology of *Chilodonlla uncinata*.

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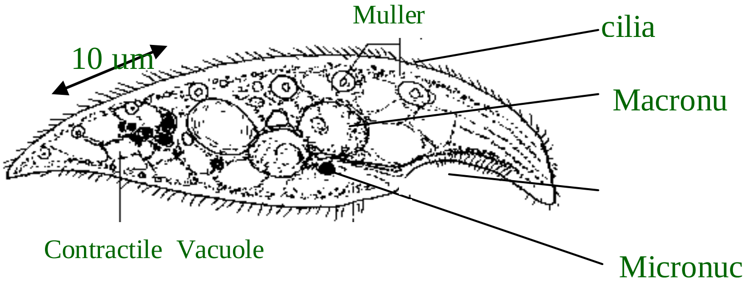

Fig. 13. Morphology of *Loxodes* sp.

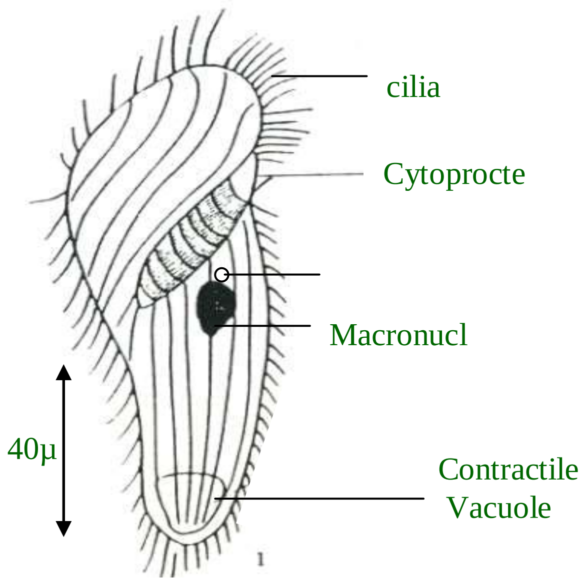

Fig. 14. Morphology of *Metopus ovatus*.

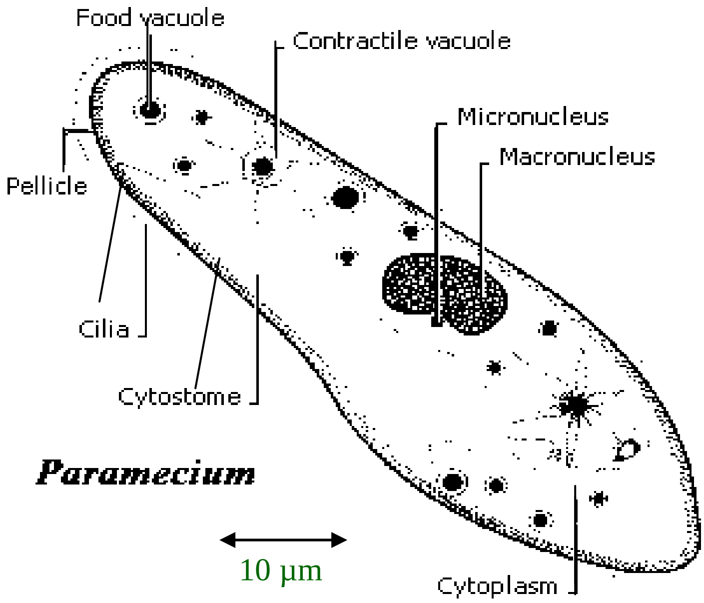

Fig. 15. Morphology of *Paramecium africanum*.

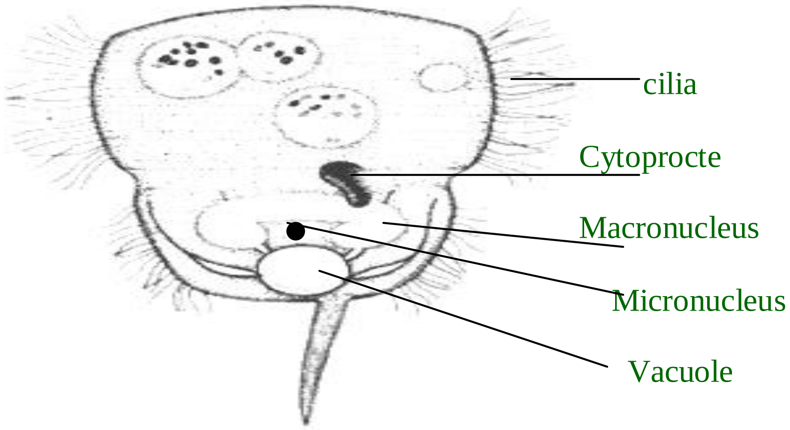

Fig. 16. Morphology of *Urocentrum turbo.*

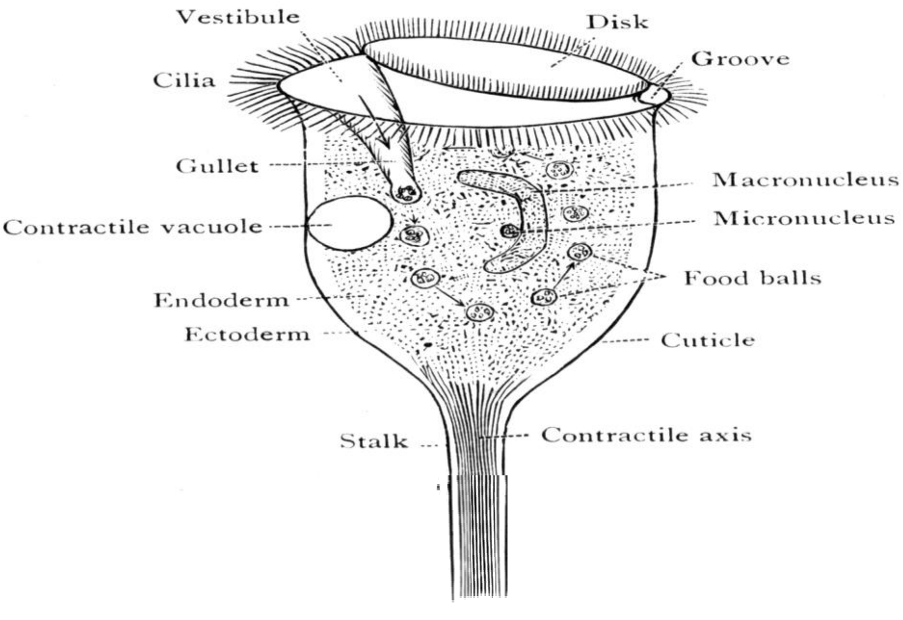

Fig. 17. Morphology of *Vorticella sp*.

References

Andruschyschyn O, Magnusson AK, Williams DD. 2003. Ciliate population in temporary freshwater ponds: seasonal dynamics and influential factors. Freshwater Biology **48(3),** 548-564.

Choi SC. 1977. Test of equality of dependent correlations. Biometrika **64(3),** 645–647

Corder GW, Foreman DI. 2009. "Nonparametric Statistics for Non-Statisticians: A Step-by-Step Approach", Wiley

Dragesco J, Dragesco Kerneis. 1986. Ciliés libres de l'Afrique intertropicale. Faune tropicale, *XXVI*, édition de l'Orstom 1- 559.

Galiano-Fernandez T, Serrano S, Galiano-Fernandez D. 1985. General morphology and stomatogenesis of two species of the genus *Entodinium* (Ciliophora, Entodiniomorphida). Acta Protozool **24**,181–186.

Henglong X, Weibo S, Warren A, 2004. An investigation of the tolerance to ammonia of the marine ciliate, *Euplotes vannus* (Protozoa ciliophora), Hydrobiologia **519,1-3,** 189-195.

Kodama Y, Fujishima M. 2010. Secondary symbiosis between *Paramecium* and *Chlorella* cells. International Review of Cell and Molecular Biology, **279**, 33-77.

Malmqvist B, Rundle SD, Covich AP, Hildrew AG, Robinson CT, Townsend CR. 2008. Prospects for streams and rivers: an ecological perspective. In Aquatic systems: trends and global perspectives (ed. Polunin N., editor), 19–29 Cambridge, UK: Cambridge University Press.

Myers JL, Well AD. 2003. Research Design and Statistical Analysis (2nd ed.), Lawrence Erlbaum. 508.p.

Packroff G. 2000. Protozooplankton, in acidic mining lakes with special, respect to ciliates. Hydrobiologia **433(1-3),** 157-166.

Priit Z, Ingmar O. 2000. Vertical distribution of planktonic ciliates in strongly stratified temperate lakes. Hydrobiologia **435(1-3),**19-26.

Roberts EC, Prisca JC, Laybourn-Parry J, 2004. Microplankton dynamics in a perennially ice-covered Antarttica, lake Hoare,Freshwater Biology **49(7),** 853-869.

Spearman C. 1904. The proof and measurement of association between two things. American Journal of Psychology **15**, 72–101.

Sonntag B, Posch T, Klammer S, Griebler C, Roland BR. 2002. Protozooplancton in the deep oligotrophic taunsel(Austria),influenced by discharges of soda and salt industries. Water, air and soil pollution:focus **2**(4), 211-226.

Sonntag Bettina, Summerer Monika Sommaruga Ruben, 2011.Factors involved in the distribution pattern of ciliates in the water column of a transparent alpine lake. Journal of Plankton Research **33(3),** 535–540.

Summerer M, Sonntag B, Hörtnagl P, Sommaruga R. 2009. Symbiotic ciliates receive protection against UV damage from their algae: a test with Paramecium bursaria and Chlorella. Protist **160 (2),** 233-43.

Takehito Y, Maiko K, Tek BG, Joaro U. 2001. Seasonal succession of zooplankton. Aquatic ecosystem **35(1),**19-29.

Traian Brad, Martin Braster, Boris van Breukelen, Nico van Straalen , Wilfred Röling FM. 2008. Eukaryotic Diversity in an Anaerobic Aquifer Polluted with Landfill Leachate , Applied and Environmental microbiology **74(13),** 3959–3968.

Veljo K, Priit Z. 2004. Dominance of ciliate grazing on bacteria during spring in a shallow eutrophic lake, Aquatic Microbial Ecology **22**, 135-142.

Wiackowski K, Ventela AM, Moilanen M, Vesa S, Kristina VK, Sarvala T. 2001. What factors control planktonic ciliates during summer in a highly eutrophic lake? Hydrobiologia **443 (1-3),** 43-57.

Woodward G, Perkins D, Lee EB. 2010**.** Climate change and freshwater ecosystems: impacts across multiple levels of organization. Royal Society of London Biological Sciences **12,** 2093–2106.