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Use of zooplankton as bioindicators for the management of aquatic diversity: A review

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Abstract
This review tended to summarize some recent research on zooplankton as bioindicator. The science of aquatic ecology and hydrobiology has gained great significance these years. The freshwater systems lakes and riverine systems satisfy our domestic, industrial, transport, and sporting needs and the biotic community of these water bodies, both animals and plants, are intimately integrated associates in this process. Alternations in their relationship depend on changes in the physico-chemical properties of the environment, illustrating the dynamic and delicate balance of these systems. In most of the cases zooplankton population size was correlated with biotic and abiotic parameters (pH, alkalinity, temperature, dissolve oxygen, transparency, phosphate, chlorine). Species of Rotifers, Cladocerans, Copepods and Ostracods were found in all cases.

Keywords: zooplankton, bioindicator, biotic parameters, abiotic parameters

Introduction
The distribution of aquatic organisms, and particularly plankton, has long been known to be heterogeneous. Spatial heterogeneity is common feature in all ecosystems and is the result of many interacting physical and biological process [1]. The study of freshwater fauna especially zooplankton, even of a particular area is extensive and complicated due to environmental, physical, geographical and chemical variations involving ecological, extrinsic and intrinsic factors. Although the distribution of biodiversity across the earth can be described in terms of the relatively small number of spatial patterns such as latitude, altitude, or habitat size, understanding how these extrinsic drivers influence diversity remains one of the most significant intellectual challenges to ecologist and biogeographers [2]. The seasonal fluctuations of the zooplankton population are a well-known phenomenon and zooplankton exhibits a bimodal oscillation with a spring and autumn in the temperate lakes and reservoirs [3]. This fluctuation is greatly influenced by the variations in the temperature along with many other factors. Among several factors, temperature seems to exhibit the greatest influence on the periodicity of zooplanktons [4].

Zooplankton is valuable source of crude protein, amino acids, lipids, fatty acids, minerals and enzymes for fry [5]. Yurkowski and Tabachek [6] reported that zooplankton satisfy all food requirements of fish and supported fry growth. Lysine and methionine, which are known to be the most limiting amino acids in feeds, are present in appreciable quality in zooplankton [7]. High ratio of unsaturated fatty acids to saturated fatty acid of zooplankton shows that zooplankton is good quality food for rearing fish larva (Lokman, 1994). The polyunsaturated fatty acid (PUFA) contents showed high concentrations of eicosapentaenoic acid and docosahexaenoic acid with moderate amounts of linoleic acid in zooplankton therefore zooplankton is regarded as desirable food [8]. Live zooplankton is also reported to contain enzymes like amylase, protease, exonuclease, esterase that play important roles in larval digestion [9].

Use of Zooplankton in Aquaculture
Zooplankton are minute aquatic animals that are non-motile or are very weak swimmers and they drift in water column of ocean, seas or fresh water bodies to move any great distance. Usually they move in the sunlit zone where food resources are most abundant and they also found in deep ocean water [10]. They are heterotrophic in nature (sometimes detritivorous) and are the favorite food of a great many marine animals. Since zooplankton plays important role in food web by linking the primary producers (by consuming phytoplankton, mainly various bacterioplankton and sometimes zooplankton) and higher trophic levels [11]. The freshwater zooplankton comprise of Protozoa, Rotifers, Cladocerans, Copepods and Ostracods. Planktonic protozoans are group of unicellular ciliated or flagellated organisms that feed on either picoplankton or nanoflagellates and small nanophytoplanktons according to their size [12]. Most of the protozoans are usually not sampled due to their minute size. Heterotrophic nanoflagellates (about 1.0 to about 20 μm in size) are more abundant (105-108 L^{-1} in highly eutrophic lentic ecosystems) than ciliates (8-300 μm in size) in fresh water body. Only 102-104 L^{-1} ciliates are found in fresh water ecosystem Rotifers are the most important soft-bodied metazoans (invertebrates) having a very short life cycle among the plankton? Only 100 widely spread rotifer species are planktonic and their life cycles are influenced by temperature, food and photoperiod [13].

Biology of Freshwater Rotifer (*Brachionus Calyciflorus*)
A single rotifer can become thousands of rotifers in few days when environmental condition is favorable to them [14]. A female rotifer can reproduce up to 7 eggs simultaneously without any genetic input from male and these eggs hatch in 12 hours and by 18 hours from hatching time the new rotifer is ready to start reproduction [14]. Structurally, the organism is

small in size, with low morbidity and high in amino acid profile [14]. Rotifers are well known in the scientific world for their contribution in live food web in freshwater and marine water communities [15].

Biology of *Moina micrura*

M. micrura is a cosmopolitan, cyclic parthenogenetic Cladoceran with ample morphological and ecological plasticity [16]. It is a small omnivorous species that is common in eutrophic water bodies [17]. They are live food organisms belonging to the Cladoceran crustaceans, which are usually called water flea. They are found as different strains all over the world.

Biology of *Daphnia pulex*

Daphnia belongs to sub order cladocera which are crustaceans. It has close resemblance to real fleas (*Pulex iritans*) but real fleas are insects which share only an extremely distant common ancestry with Daphnia, since both crustaceans and insects are Arthropods [18]. It is frequently used as food in freshwater larviculture [19]. They are rich in amino acid profile although they can be as small as 800micron in size. They undergo sexual reproduction and asexual reproduction depends on prevailing environmental condition [18].

Zooplanktons are ecologically and economically important heterogeneous group of tiny aquatic organisms that are present at the mercy of water currents, as they have weak power of locomotion. Zooplanktons are either herbivorous, feeding on phytoplankton or carnivorous, feeding on other zooplankton. They themselves are fed upon by fish and thus the vital transition between primary production (phytoplankton) and fish. Without these primary consumers, herbivorous and other levels of food chain would collapse [20]. Among all the freshwater aquatic biota, zooplankton population is able to reflect the nature and potential of any aquatic systems [21].

Conclusion

In conclusion, zooplankton population size were correlated with biotic and abiotic parameters (pH, alkalinity, temperature, dissolve oxygen, transparency, phosphate, chlorine). Species of Rotifers, Cladocerans, Copepods and Ostracods were found in all cases. Species variation of these order deceased in polluted water. Some species were not found in some highly polluted area though these species have high tolerance level. All the results of the studies indicating that potentiality of zooplankton as bioindicator is very high. Other countries can develop these concepts to monitor water quality.

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