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Role of zooplankton in aquaculture

Sunil Ram Vaidya
Ph.D. Associate Professor, Department of Zoology, Patan Multiple Campus, Tribhuvan University, Kathmandu, Nepal

Abstract
Zooplankton are small animals that float freely in the water column of lakes, reservoirs, ponds and oceans and whose distribution is determined by water currents and mixing. The zooplankton community of most lakes ranges in a size from a few tens of microns (Protozoa) to more than 2 mm (Macrozoo plankton). In terms of productivity, the dominant groups of zooplankton in most lakes are Crustacea and Rotifera. Zooplankton plays an important role in aquatic food webs because they are important food for fish and invertebrate predators and they graze heavily on algae, bacteria, protozoa and other invertebrates. Zooplankton communities are typically diverse (more than 20 species) and occur in almost all lakes and ponds. Zooplanktons are rarely important in rivers and streams because they cannot maintain positive net growth rates in the face of downstream losses. Zooplanktons are small floating or weakly swimming organisms. They are very important as primary consumers. They are important food base for secondary consumers including fish. Rotifers are an important part of the freshwater zooplankton, being a major food source. They are filter-feeding with corona. Most of them are littoral, sessile, but some are completely planktonic. They are too small to be important as food for most fish. They may be important in diets of some larval fish. Most rotifers are around 0.1 - 0.5 mm long. Cladocerans are small crustaceans (0.2-3.0 mm) with head and body. Body is covered by bivalve carapace. They swim by using large 2nd antennae. Cladocerans are large species favored by many fish (visual and filter-feeders). More energy returns from bigger species. Zooplanktons are preferred natural food for larval stage of fish and prawn.

Keywords: zooplankton, rotifer, cladocera, copepods, fish, prawn, aquaculture

1. Introduction
Zooplankton are small animals that float freely in the water column of lakes and its distribution is primarily determined by water currents [1]. The zooplankton community of most lakes ranges in size from a few tens of microns (Protozoa) to >2 mm (macrozooplankton). In terms of biomass and productivity, the dominant groups of zooplankton in most lakes are Crustacea and Rotifera and these protocols emphasize these groups. Zooplankton play a pivotal role in aquatic food webs because they are important food for fish and invertebrate predators and they graze heavily on algae, bacteria, protozoa, and other invertebrates [2]. Zooplankton communities are typically diverse (>20 species) and occur in almost all lakes and ponds.

Zooplankton communities are highly sensitive to environmental variation. As a result, changes in their abundance, species diversity, or community composition can provide important indications of environmental change or disturbance [3]. Zooplankton communities often respond quickly to environmental change because most species have short generation times (usually days to weeks in length). Zooplankton communities respond to a wide variety of disturbances including nutrient loading [4], acidification [5], contaminants [6], fish densities [7], and sediment inputs [8]. Zooplanktons are minute aquatic organisms size ranging from a few microns to a millimeter or more. They include representatives of almost every taxon of the animal kingdom [9] that live all (holoplankton) or part (meroplankton) of their life as plankton [10] plays an important role in the aquatic ecosystem.

2. Advantages of Using Zooplankton
Zooplankton are regarded as an important source of carotene. Fish fed on copepods and krill were found to be more pigmented than those fed on commercial feed [11], which is important for marketing of salmonids. The flavor and texture of fish were also found to have improved with feeding zooplankton [12]. Live zooplankton contain enzymes (amylase, proteases and esterase) which play an important role in larval digestion [13]. Zooplankton enhances metamorphosis of larvae [14], and are nutritious, tastier and easily digestible. In addition, the chilled and frozen zooplankters float making it easier for the fish to catch [15]. The high content of amino acids [16], enzymes [16] and water [17] in zooplankton are all positive qualities for start feeding [17]. Free amino acids are present in the frozen fluid that surround the zooplankton and these form a powerful attractant and appetite stimulant for fish [18].

3. Some Important Zooplanktons
3.1 Rotifers
Rotifers are popularly called as wheel animalcules. They are an important group of live food organisms for use in aqua hatcheries. *Brachionus*, which is the most known form of all rotifers, serve as an ideal starter diet for early larval stages of many fish and prawn species in marine as well as freshwater. Species of the genus *Brachionus* (Brachionidae: Rotifera) are well represented in different water bodies worldwide [19]. Depending on the mouth size of the cultured organisms, small (50 to 110 micron length) or large (100 to 200 micron length) rotifers are used. There are about 2,500 species of rotifers

have been known from global freshwater, brackish water, and seawater. *B. plicatilis* is the species used most commonly to feed fish larvae in hatcheries around the world. It is a euryhaline species, small and slow swimming, with good nutritional value. It is well suited to mass culture because it is prolific and tolerates a wide variety of environmental conditions. The rotifer, *B. plicatilis* and *B. rotundiformis*, have been indispensable as a live food for mass larval rearing of many aquatic organisms [20]. By way of significant developments in larval rearing technology of fishes, demand for the rotifer is further increasing. The nutritional value of rotifers for larval fish depends on the rotifers' food source. Highly unsaturated fatty acids (HUFA) are essential for the survival and growth of fish larvae [21]. Rotifer feeds containing DHA (docosahexaenoic acid, 22:6n-3), and EPA (eicosapentaenoic acid, 20:5n-3) can be valuable for marine fish larvae.

Depending upon their food source, rotifers are composed of about 52 to 59% protein, up to 13% fat and 3.1% n-3 HUFA [22]. High nutritional value of rotifers is of major importance for survival and growth of the fish larvae, and several cultivation techniques, including feeding with different algae, baker's yeast and artificial diets, are used to improve their nutritional quality. Maintaining large cultures of rotifers and their production on a predictable basis is a major problem. The food of rotifers appears to the key element in their mass production. Presently, fresh baker's yeast is mostly used as the main diet ingredient for rotifers. However, its freshness, a criterion that is difficult to evaluate, can greatly influence the dietary value of the yeast for the rotifers and as a consequence, determine success of rotifer culture. Several measures are taken to deal with the problem such as supplementation of baker's yeast with micro algae, improving the nutritional quality of rotifers through vitamin C supplementation, treatment with antibiotics to prevent bacterial contamination and use of probiotics, i.e. the addition of beneficial bacteria in rotifer culture.

3.2 Artemia

Artemia commonly known as brine shrimp are zooplankton, like copepods and Daphnia, which are used as live food in the aquarium trade and for marine finfish and crustacean larval culture. There are more than 50 geographical strains of Artemia has been identified. Many commercial harvesters and distributors sell brands of various qualities. Approximately 90% of the world's commercial harvest of brine shrimp cysts (the dormant stage) comes from the Great Salt Lake in Utah. Normally 2, 00, 000 to 3, 00, 000 nauplii are hatched from each gram of high quality cysts [23]. Of the live food used in aqua hatcheries, Artemia, constitute the most widely used organism. It is an organism closely related to shrimp belonging to the order - Anostraca of the class - Crustacea and phylum - Arthropoda. The biggest advantage of using Artemia is that one can produce live food on demand from dry and storable powder i.e. dormant Artemia cysts which upon immersion in seawater regain their metabolic activity and within 24 hours, release free swimming larvae (nauplii) of about 0.4 mm length. Artemia has high nutritive value and high conversion efficiency. All the life stages of Artemia, i.e. cysts (after decapsulation), nauplii, juveniles, sub-adults are used as feed. Today, in majority of the commercial aqua hatcheries, Artemia nauplii is virtually used as a sole diet. Frozen adult Artemia, are widely used by aquarists, fish breeders and aquaculturists. Artemia biomass is also used as food additive for domestic livestock or extraction of pharmaceutical products as also in making protein rich food products. It is even used for human consumption in some countries. Owing to its great utility, Artemia trading is a growing business in several parts of the world.

An important characteristic that influences the suitability of Artemia in aqua hatcheries is the size of nauplii, which can vary greatly from one geographical source to another. This is one of the reasons why the local strains of Artemia in India are not performing so well in qua hatcheries and, therefore, hatchery operators have to depend on imported Artemia cysts. In comparison to Moina, the Artemia nauplii provides better growth and survival performance to fry and adults of guppy. With combined feeding using B. calyciflorus and Artemia nauplii, feeding of discus larvae becomes less tedious and more practical for use in commercial breeding of discus, and this would also eliminate the risk of larvae being eaten up and shorten the breeding interval, thereby leading to higher yield of fry [24].

3.3 Copepods

Copepods are common zooplankton of freshwater and brackishwater. They are natural feeds for larvae and juveniles of many finfish and crustaceans and it is generally believed that copepods can meet the nutritional requirements of fish larvae [25]. In the wild, most marine fish larvae feed on copepod eggs and nauplii during the first few weeks of life. Because some species of copepods have very small size larvae (a necessity for some species of fish larvae) and can have very high levels of HUFAs and other essential nutrients, they are an excellent food source for first-feeding larvae. In fact, a number of marine larval fish cannot be reared using rotifers as the first feed but have been reared on either laboratory reared or wild caught copepod nauplii.

Research with several species, such as the turbot and red snapper, has shown that when offered mixed plankton diets, young larvae consume more copepod nauplii than rotifers and prefer copepod nauplii because of the differences in size and swimming patterns of the two prey types. Consequently, there is considerable interest in the use of copepods as feed sources for small marine larval fish. Copepods are cylindrical with a trunk comprised of 10 segments, consisting of head, thorax and abdomen. Adult copepods size range from 0.5 to 5.0 mm. The larval stages consist of six naupliar and six copepodite stages. Main suborders of copepods found in brackishwater are calanoids (*Acartia, Calanus* and *Pseudocalanus* spp.), harpacticoids (*Tisbe* and *Tigriopus spp*.), and cyclopoids. Herbivorous copepods are primarily filter feeders and typically feed on very small particles. But they can feed on larger particles, which give them an advantage over the rotifers. Copepods can also eat detritus. They differ from Artemia and rotifers in that they do not reproduce asexually. Copepods mate after maturing and female produces 250 to 750 fertilized eggs (rotifers produce 15 to 25 per female).

The copepod lifespan is 40 to 50 days (5 to 12 days for rotifers), and it has a longer generation time (1 to 3 days for the rotifer and 7 to 12 days for the copepod). In contrast to rotifers, copepods are more difficult to culture on a commercial basis. Only a few species of copepods, such as *Tigriopus japonicus*, have been mass cultured successfully. Even this technique employs the combination of rotifer culture and the use of baker's yeast or omega-3 yeast as feed. Unfortunately, the amount of yeast used to produce the copepod and rotifer combination outdoors is fairly high. There are outdoor production systems that can produce large numbers of copepods; however, these systems are very inefficient in terms of number of copepods per litre of culture water.

Considerable work needs to be done on culture and harvest techniques before copepods become as widely used as rotifers. One interesting advantage of copepods is that under appropriate conditions some species will produce a resting egg similar to that of Artemia. So once commercial techniques are developed, copepod eggs could be collected in large numbers and stored for months, like Artemia (brine shrimp) and rotifer cysts. Photoperiod and temperature largely determine the production of copepod resting eggs. Laboratory production of these eggs is possible, but has not yet proved to be economically feasible. It is hoped that using copepods as a food source can improve the culture of a variety of species, such as the red drum, by reducing the size variability and mortality.

The use of copepods, especially the harpacticoids, is well documented in marine fish culture. The Japanese have routinely cultured the copepods Tigriopus and Acartia for rearing fish larvae approximately 7mm in length. The growth and biochemical composition of Coryphaena hippurus larvae that were fed with copepod (Euterpina acutifrons) survived well under stressful conditions. A system for the mass culture of a benthic marine harpacticoid copepod, described by Sun and Fleeger [26], should be useful for aquaculture. Other species of copepods considered to be promising for mass culture are *Acartia clausi, A. longiremis, Eurytemora pacifica, Euterpina acutifrons, Oithona brevicornis, O. similis, Pseudodiaptomus inopinus, P. marinus, Microsetella norvegica and Sinocalanus tenellus*. Evjem *et al*. [25] reported that copepodid and adult stages of the marine copepods *Temora longicornis* and *Eurytemora* sp. had a total lipid content varying between 7% and 14% of dry weight (DW).

4. Conclusion

Zooplanktons are one of the major primary consumer in most of the aquatic ecosystem and are the best indicator of water quality. Any undesirable change in the physical, chemical and biological properties of the water leads to the changes in zooplankton diversity and abundance. So that regular monitoring of zooplankton gives information about the proper management of aquatic ecosystem. Normally polluted water contain very low count of zooplankton, Some species of zooplankton especially species of Rotifer (eg: *Brachionus calyciflorus*) show dominance in polluted water.Diets deficient in essential nutrients, especially lipids are thought to be the main reason for the high mortality rate of young fish. Zooplankton are rich in essential amino and fatty acids (EPA and DHA) and should be sufficient as a first source of nutrients required by fish for growth. Zooplankton have been widely used for rearing larvae and fry, and most studies indicated that the fry performed better when fed with live zooplankton than with dry artificial diets. Further research is needed for the development of zooplankton-based dry diets in the form of pellets in order to avoid the possible leaching of nutrients from frozen zooplankton. The availability of on-grown live food would not only offer farmers and exporters a better alternative option for feeding to their fish, but more importantly, the possibility of enhancing the fish performance and quality through bioencapsulation.

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6. References

1. Alden RW, Dahiya RC, Young RJ. A method for the enumeration of zooplankton subsamples. Journal of Experimental Marine Biology and Ecology. 1982; 59:185-206.
2. Arnott SE, Magnuson JJ, Yan ND. Crustacean zooplankton species richness: single- and multiple-year estimates. Canadian Journal of Fisheries and Aquatic Sciences. 1998; 55:1573-1582.
3. DeVries DR, Stein R. Comparison of three zooplankton samplers: a taxon-specific assessment. Journal of Plankton Research. 1991; 13:53-59.
4. Dodson S. Predicting crustacean zooplankton species richness. Limnology and Oceanography. 1992; 37:848-856.
5. Keller W, Yan ND. Recovery of crustacean zooplankton species richness in Sudbury area lakes following water quality improvements. Canadian Journal of Fisheries and Aquatic Sciences. 1991; 48:1635-1644.
6. Yan ND, Keller W, Somers KM, Pawson TW, Girard RE. Recovery of crustacean zooplankton communities from acid and metal contamination: comparing manipulated and reference lakes. Canadian Journal of Fisheries and Aquatic Sciences. 1996; 53:1301-1327.
7. Carpenter SR, Kitchell JF. The trophic cascade in lakes. Cambridge University Press. Cambridge, U.K, 1993.
8. Cuker BE. Field experiment on the influence of suspended clay and P on the plankton of a small lake. Limnology and Oceanography. 1997; 32:840-847.
9. Hall RI, Yan ND. Comparing annual population growth estimates of the exotic invader *Bythotrephes* by using sediment and plankton records. Limnology and Oceanography. 1997; 42:112-120.
10. Lindeque PK, Parry HE, Harmer RA, Somerfield PJ, Atkinson A. Next generation sequencing reveals the hidden diversity of zooplankton assemblages. Plos One, 2013; 8:e81327. doi:10.1371/ journal.pone.0081327.
11. Cushing CE. A plankton sub-sampler. Limnology and Oceanography. 1961; 6:489-490. de Bernardi R. Methods for the assessment of zooplankton abundance, 1984, 59-86.

12. James MR. Sampling and preservation methods for the quantitative enumeration of microzooplankton. New Zealand Journal of Marine and Freshwater Research. 1991; 25:305-310.
13. Lind OT. Handbook of Common Methods in Limnology. C.V. Mosby Company, Saint Louis, Missouri, 1974, 154.
14. Omori M, Ikeda T. Methods in marine zooplankton ecology. John Wiley and Sons, New York. 1984, 332.
15. Das P, Mandal SC, Bhagabati SK, Akhtar MS, Singh SK. Important live food organisms and their role in aquaculture. Frontiers in Aquaculture. Ed. J. K. Sundaray, M. Sukham, R.K. Mohanty, S.K. Otta, Narendra Publishing House, New Delhi, 2012, 69-86.
16. Kostopoulou V, Divanach P. The rotifer Brachionus plicatilis: an emerging bio-tool for numerous applications. Journal of Biological Research-Thessaloniki. 2012; 17:97-112.
17. Lubzens E, Tandler A, Minkoff G. Rotifer as food in aquaculture. Hydrobiologia. 1989; 186-187(1):387-400.
18. Tyagi VK, Chopra AK, Durgapal NC, Kumar A. Evaluation of Daphnia magna as an indicator of Toxicity and Treatment efficacy of Municipal Sewage Treatment Plant. J Appl. Sci. Environ. Mgt. 2007; 11(1):61-67
19. Pejler B. On the global distribution of the family Brachionidae (Rotifera). *Arch. Hydrobiol.Suppl*. 1977; 53:255-307.
20. Maruyama I, Nakao T, Shigeno I, Ando Y, Hirayama K. Application of unicellular algae *Chlorella vulgaris* for the mass culture of marine rotifer Brachionus. Hydrobiologia. 1997; 358:133-138.
21. Whyte JMC, Nagata WD. Carbohydrate and fatty acid composition of rotifer, *Brachionus plicatilis*, fed monospecific diets of yeast or phytoplankton. Aquaculture. 1990; 89:263-272.
22. Oie G, Olsen Y. Protein and lipid content of the rotifer *Brachionus plicatilis* during variable growth and feeding conditions. Hydrobiologia. 1997; 358:251-258.
23. Treece GD. *Artemia* Production for Marine Larval Fish Culture, SRAC Publication No. 702, Texas A & M University, Sea Grant College Program, 2000.
24. Lim CL, Dhert P, Soregloos P. Recent developments in the application of live feeds in the freshwater ornamental fish culture. Aquaculture. 2003; 227:319-331.
25. Evjemo JO, Reitan KI, Olsen Y. Copepods as live food organisms in the larval rearing of halibut larvae (*Hippoglossus hippoglossus* L.) with special emphasis on the nutritional value. Aquaculture, 2003; 227(1, 4):191-210.
26. Sun B, Fleeger JW. Sustained mass culture of *Amphiascoides atopus*, a marine harpacticoid copepod, in a recirculating system. Aquaculture. 1995; 136:313-321.