

Rohu *Labeo rohita* (Hamilton, 1822) changes feeding strategy throughout its ontogeny: An explanation from feeding ecology

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Abstract- *Labeo rohita* is a popular Indian major carp species in carp polyculture practice. It is known as water column feeder which feeds on plankton. In the juvenile and adult stages rohu is essentially an herbivorous column feeder, preferring algae and submerged vegetation. Under natural condition, in fingerling stage, it prefers zooplankton, with phytoplankton as subsidiary food. At this stage it exhibited a strong positive selection for all zooplanktonic organisms and smaller phytoplankton. Adults show a strong negative selection for all zooplanktonic organisms and positive selection for most phytoplanktonic organisms. However, in periphytic environment, it ingests sub-periphytic organisms present in proximity to substrate. In conclusion, it is agreed that *L. rohita* exhibits different feeding strategy during its growth from fingerling to adult and also from planktonic to periphytic environment. Adoption of a fish culture strategy according to its differential feeding strategy would maximize in converting naturally available resources to fish biomass especially in polyculture practice.

Keywords: Indian Major Carp, feed selectivity, resource-partitioning, polyculture, periphyton, phytoplankton

I. INTRODUCTION

Understanding the utilization pattern of aquatic resources is an important area of research in fish culture. Keeping in view the resource utilization as essential criteria, food and feeding habits of fish provide important information in selection of species to cultivate in poly-species fish culture.

Labeo rohita (rohu) is one of the most important Indian major carps (IMC) in carp polyculture practice. This Indo-Gangetic riverine species is distributed throughout South Asia, South-East Asia, Sri Lanka, the former USSR, Japan, China, Philippines, Malaysia, Nepal and some countries of Africa. Information on its culture is available only from the early part of the 20th century. In India, it was introduced into almost all riverine systems and now occupies a central position in polyculture of fish in ponds.

Its compatibility for resource utilization with other freshwater carps, mainly catla (*Catla catla*) and mrigal (*Cirrhinus mrigala*) made it an ideal candidate for carp polyculture practice [1]. High growth potential and compatibility coupled with high consumer preference, have established rohu as one of the most popular and delicious

freshwater fish cultured in India, Bangladesh and other adjacent countries in the region. It serves as an important nutritional source of protein and n-3 PUFA fatty acids [2]. Among all IMCs rohu supplies the highest percentage of protein [3]. In little fraction, it also acts as a source of Calcium and Vitamin-A [4].

II. FOOD AND FEEDING HABIT OF ROHU

However, no confirmatory study is available on food and feeding habit of rohu on natural resources. From the older reports so far available, describes its basic food as plankton [5, 6, 7, 8], zooplankton [9] or both zoo and phytoplankton [8]. Few studies on growth and behavior analysis concluded it as periphyton feeder [10, 11, 12]. Muhammad et al. (2006) [13] found differential size dependent diet composition and divergent dietary preference between *L. rohita* and *C. carpio* in semi intensive ponds. Study on food selection and feeding relationship of *L. rohita* polycultured with *C. catla* and *C. mrigala* suggested it as zooplankton feeder in fingerling and phytoplankton feeder in adult stage [14]. Majumder et al. (2016) [15] confirmed it as phytoplankton feeder with enhanced feeding in periphytic environment.

Most of these studies unanimously agree that under natural conditions, in its early life stages, rohu partly prefers zooplankton, composed mainly of rotifers and cladocera, with phytoplankton forming the essential food. In the fingerling stage, it has strong positive selection for zooplanktonic organisms as well as some smaller phytoplankton like desmids, phytoflagellates and algal spores. It exhibits its zooplanktivorous stage up to 150 mm in total length [16]. However, this stage may be extended up to a total length of 20.6 cm [17]. On the other hand, adults show strong positive selection for phytoplankton. At this stage, rohu is a herbivorous column feeder, commonly preferring algae and submerged micro-vegetation. In adult rohu, Alam et al. (2011) [16] accounted 84.76% of its diet from plant origin with Chlorophyceae contributing the major part (45.8%) of total food component. Further, though the fish is believed to be a column feeder, the occurrence of decayed organic matter, sand and mud in its gut suggest its partial preference to bottom feeding habit. The nibbling type of mouth with soft fringed lips, sharp cutting edges and absence of teeth in the bucco-pharyngeal region help the fish to feed soft aquatic organisms which do not require seizure and crushing. The modified thin and hair-like gill rakers also suggest that the fish feeds minute planktonic organisms sieving from water. In ponds, the fry and fingerlings exhibit schooling behavior mainly for feeding, however, this habit was not observed in adults [18].

III. PATTERN OF FEED SELECTIVITY

Planktonic environment

Ontogenic shift is very prominent from the point of feed selectivity by rohu. Fingerlings of rohu show strong positive selection for zooplankton like crustaceans (*Cyclops*, *Daphnia*), rotifers (*Keratella*) etc. as well as some smaller phytoplankton like phytoflagellates (*Euglena*, *Volvox*), desmids (*Cosmarium*, *Closterium*) etc. [14]. Phytoplanktonic macro algae from Chlorophyceae, Bacillariophyceae and Cyanophyceae are totally avoided at this stage. Reversibly, adults were reported with strong negative selection for zooplanktonic and positive selection for most phytoplanktonic organisms [14]. On evaluation of Ivlev's (1961) [19] electivity index, Khan and Siddique (1973) [14] found high and positive electivity index for Chlorophyceae and Bacillariophyceae. Except large filamentous algae *Oedogonium*, most of the Chlorophyceae like *Pediastrum*, *Selenastrum*, *Ankistrodesmus*, *Scenedesmus*, *Zygnema*, *Ulothrix* and *Tetraspora* were highly preferred. However, small sized unicellular or colonial Chlorophyceae like *Selenastrum*, *Pediastrum* and *Scenedesmus* were exclusively preferred over others. Bacillariophyceae were preferred next to Chlorophyceae. Among Bacillariophyceae *Cyclotella*, *Naviculla*, *Nitzschia* and *Synedra* were selected fairly well in comparison to others. The electivity index was negative for all blue green

algae. Phytoflagellates preferred in fingerling stage were totally avoided. Zooplankton, like Protozoa, rotifers and crustaceans appeared in small quantities in the gut contents as compared to their abundances in the environment (Figure 1).

Rahman et al. (2006) [20] also studied growth, production and food preference of rohu in two culture environments i.e. monoculture and polyculture with common carp (*C. carpio* L.) using artificial and natural feeds in ponds. They observed three distinct types of feeding patterns of rohu based on availability of resources in the environment. **First**, rohu ingested more phytoplankton and zooplankton in culture environment with artificial feed. Such preference was above the preference of supplied artificial feed. The quantity of phytoplankton and zooplankton ingested in ponds with artificial feed are, respectively, 1.3 and 3.2 times higher than treatments with natural feed. The shifting of rohu towards naturally available food resources was interesting as it avoids direct feeding on artificial feeds and availed natural feed resulted through fertilizing benefits by artificial feed in the environment. **Second**, it ingested twice as much as phytoplankton than zooplankton in environments with natural feed. **Third**, in the presence of artificial feed, rohu ingested 1.3 times more zooplankton than phytoplankton. Interestingly last two cases represented totally opposite feeding behaviors of rohu. Earlier, Miah et al. (1984) [9] reported zooplankton as a preferable food of rohu fry over phytoplankton. Further studies on ingestion rate of food organisms by rohu describe changes in ontogenic behavior in natural ponds. Rahman et al. (2008) [17] focused that ingestion rate of phytoplankton by rohu increases with fish size. Above 20.6 cm total length, its ingestion rate on zooplankton gradually decreases and phytoplankton increases. They concluded with a significant positive relationship between rohu's gut phytoplankton biovolume and total length. Rotifers were found the most important food items for rohu under 20.6 cm total length (32-45% of total diet) followed by Cladocera (25-28% of total diet) and Copepoda (14-16% of total diet). Up to a total length of 20.6 cm, these three groups together contributed 74-88% of the total diet of rohu. Above these length, Chlorophyceae were recorded as the most important food items for rohu (28-41% of the total diet) followed by Bacillariophyceae (15-27% of the total diet). Around 43-68% of the total diet of rohu was contributed by these two groups only.

Periphytic environment

Periphytic organisms live attached to submerged surfaces in aquatic environment attain high biomass in short time and contribute up to 80% of the aquatic primary production [21]. It has significant role in providing food for fish and other fauna in natural and controlled environment [22]. As a food in aquaculture, periphyton may provide 75% metabolic energy to fish [23] and this helps in increasing

the fish productivity. Traditionally, periphyton is being used as rich source of naturally available aquatic food resource for fishes in countries like Cambodia, West Africa, Srilanka, India and Bangladesh.

Several experiments have been performed in periphyton based polyculture environment with species *L. rohita*, *Oreochromis niloticus*, *Catla catla*, *Cirrhinus mrigala* and *Labeo calbasu* to understand and evaluate synergizing production level [24, 11, 25]. In these experiments, *L. rohita* showed best growth and productivity. Azim et al. (2001) [12] found 77% higher production of *L. rohita* when stocked with *L. gonius* using bamboo as substrate than substrate free pond. Experimenting with *C. catla* and *C. calbasu*, Azim et al. (2002) [26] reported 2.6 times higher production of *L. rohita* under substrate (bamboo) fed condition. Evaluation on its ability to access periphytic food resources was attempted through periphyton-based aquaculture experiments in ponds [27]. Although, these studies did not attempt feeding ecology of rohu in periphyton-based experiments, the biomass based outcome confirms that the fish intelligently explores naturally available resources in periphytic than planktonic environment. NFEP (1997) [10] also reported higher total weight gain of rohu in the substrate treatment experiments and concluded that it could be due to its periphyton grazing habit. Montchowui et al. (2009) [28] indicated that *Labeo* species are specialized feeders on colonized algae and detritus from the substratum.

Though these experiments were performed in periphytic environment, the feeding ecology of stocked fish species has been overlooked. Among the carp group only *Cyprinus carpio* has got wider attention as suitable candidate for Periphyton Based Aquaculture [29]. Recently Saikia et al. (2013) [30] observed that all sizes of rohu feed extensively on algae under periphytic environment in natural pond. Their study comprised of rohu in two different environments viz. planktonic and periphytic. Their study which was based on the gut content of fish from these environments, confirmed that rohu exhibits enhanced feeding (with wider Smith's diet breadth) in periphyton based area. Further, they analyzed resource selectivity and confirmed that rohu at a later stage of growth explores both plankton and periphyton in substrate based area. However, they assumed that rohu may not be truly feeding on periphyton, since its mouth morphology doesn't support a grazing behavior of the fish, but explores periphytic food in a very lucid manner. A step further, they proposed that the fish cleverly utilizes a sub-periphytic zone rich in algal communities in proximity to substrate. Such enhanced feed accessibility in natural environment can be adopted for micronutrient enrichment of rohu directly through algal feed resources.

IV. OPTIMIZATION OF FEEDING OF ROHU ON NATURAL RESOURCES

The available studies on food and feeding habit of rohu in substrate free or substrate based environments explained a kind of niche apportionment by rohu towards different food types along with its ontogenic progression. These food types are (1) selective zooplanktonic communities at early stage of growth, (2) phytoplankton communities at a later stage of growth and (3) extensive utilization of algal communities irrespective of age class under periphytic condition (Figure 3). The last option might be an outcome of synergistic relationship of availability of resources to the active planktivorous behavior of rohu. Ivlev (1961) [19] suggested that the tendency of a particular animal to consume certain food items selectively in comparison to others is determined by its inherent properties. Allen (1941) [31] pointed out that though feeding behavior of fish plays an important role in the selection mechanism, but besides it, the production of any food item by nature of the environment and their availability also influence it. Thus the fishes select their food from those food items which are accessible to them in the environment. From a periphytic or periphytic-planktonic interface, if rohu can access optimum food organisms, it would definitely contribute to the increase in fish biomass as well as micronutrients in its body. Introduction of natural substrates like bamboo poles for the colonization of periphytic organisms in pond environment could minimize inter-specific feeding competition of rohu with other stocked fishes in polyculture environment. Earlier studies reported better fish yield in substrate treatments, which could be due to niche partitioning through addition of foods in the form of periphyton [32] and bacterial biofilm [11]. Significant gains in weight of rohu and catla in substrate environments over substrate free environments were reported [33, 34]. In monoculture, its feeding ecology also strongly supports the increased selection on natural resources in substrate based environments than substrate free environments [15, 30]. Periphyton feeding habit of rohu might have benefited catla through reducing inter-specific competition in polyculture condition. In ponds without substrates, rohu and catla tend to compete with each other for planktons [26].

V. CONCLUSION

It is clear that, despite enormous potentiality in polyculture, the food and feeding ecology of *L. rohita* on planktonic organisms as a whole and periphyton as particular has not been studied extensively. To determine trophic position of rohu and to justify it as potential candidate in converting maximum natural food resources to micronutrient rich nutritious fish biomass, a conclusive result on the part of its food and feeding ecology is required. In that context, periphyton is definitely a solution, especially for herbivorous fish species to adopt 'as and when need' type

of feeding strategy in polyculture pond. Report of Saikia et al. (2013) [30] may be incorporated for designing enhanced feeding module in enriching micronutrients along with protein in rohu. This will help, to some extent, to minimize size-dependent intra-specific and inter-specific competition among stocked species. As already reviewed, rohu is one of the most cultured freshwater fishes in Indian subcontinent and it shows enhanced feeding and significant growth under periphytic polyculture environment. But rohu-based polyculture in periphytic environment must be standardized with sufficient information on its feed sharing, resource partitioning and diet selectivity when stocked with other column feeders.

Though it shows satisfactory growth when stocked in polyculture pond under periphytic environment, such growth results do not confirm its resource utilization in the specified environment and hence needs further research before framing any effective strategy for maximum utilization of periphytic resources. The feeding ecology which showed its 'enhanced feeding in periphytic environment' was studied in monoculture practice, but a report on such feeding behavior in periphytic polyculture environment would be more applicable for its polyculture. Its ontogenic shift whether depends on size, monoculture or polyculture combinations are to be confirmed under the availability of periphytic resources.

Findings of Rahman et al. (2008) [17] confirms that rohu prefers diatom and green algae with increasing in size. Interestingly, in all experiments of periphyton based aquaculture, the implanted substrate in pond mostly favors the colonization of Bacillariophyceae and Chlorophyceae. Thus there exist every opportunity for rohu to select these two resources as its food under periphytic environment. Further research on its feeding ecology in periphytic environment under polyculture condition with variable combination of cultivable fish will definitely add new dimensions to rohu based polyculture in periphytic environment.

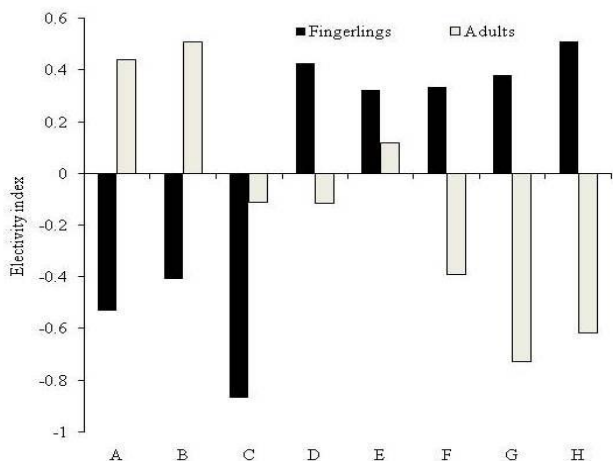


Figure 1: Electivity index (E) of *L. rohita* from pond. Data compiled from Khan and Siddique (1973); A: Chlorophyceae, B: Bacillariophyceae, C: Cyanophyceae, D: Phytoflagellates, E: Desmids, F: Protozoa, G: Rotifers, H: Crustaceans.

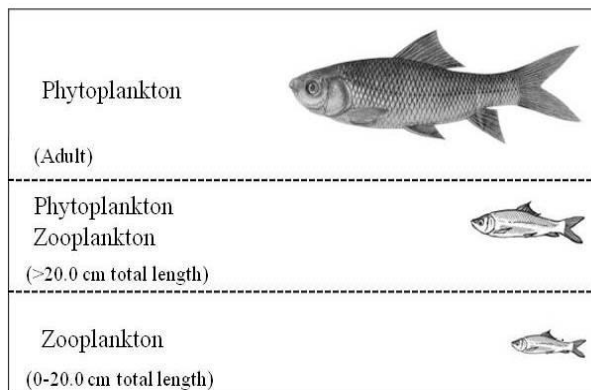


Figure 2: Niche apportionment by *L. rohita* for feeding during growth. At fingerlings stage of 0-20 cm in total length, rohu exclusively ingests zooplankton, at >20 cm in total it ingests both zooplankton and phytoplankton and in matured adult stage, the fish ingests exclusively on phytoplankton.

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