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Review Paper

The Cladoceran as live Feed in Fish Culture: A Brief Review

Budhin Gogoi[1*], Vivekanand Safi[1,2] and Debangshu Narayan Das[1]
[1]Fishery and Aquatic Ecology Laboratory, Department of Zoology, Rajiv Gandhi University, Itanagar, India
[2]Krishi Vigyan Kendra, Papumpare, Arunachal Pradesh, India
gogoi_budhin@yahoo.in

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Abstract

Over the years aquaculture farms have gained a rapid interest due to increasing demand of fish as cheap protein source in human nutrition. However, intensive farm management with fish feed supplement and high input cost stands as key barrier against fish productivity optimization. So, development of low-cost feed input for enhancement of farmed fish production becomes an important researchable issue in intensive aquaculture. In that context, mass propagation and supplementing live fish feed have received worldwide attention and have been playing a vital role as larval diet of fin and shell fishes in general. The Cladoceran like Moina spp, Daphnia spp. etc. have already been explored as living capsule of nutrition for many cultivable fishes. Being in second trophic level in aquatic ecosystem, this group of animal transfer energy both primary producers and detrital masses to the fin and shell fish supporting their growth and development. On this backdrop, an endeavor has been made in this article to appraise the past and present research on cladocera highlighting its future scope in sustainable aqua-resource utilization through fish feed economy in commercial aquaculture.

Keywords: Cladocera, Live Feed, Fish Nutrition, Growth, Survival.

Introduction

Proper feeding constitutes a major management aspect in farmed fin fish and shell fish. In aquaculture system, successful rearing of larvae is a requisite step to ensure better production that greatly depends on supplementation of live feed organisms enriched with essential nutrients. The availability of appropriate quantities of lipids, proteins, carbohydrates, vitamins, and minerals via their diet is essential for rearing success of fish larvae[1,2]. Poor growth, low feed efficiency, anemia and high mortality are associated with deficiency of any required nutrient[3,4]. The frequently applied live feed organisms in farmed fin and shell fishes are *Artemia salina,* rotifer *Brachionus plicalitis* and the freshwater cladoceran *Moina mongolica, Moina micrura, Daphnia carinata* etc[5]. The larval fishes are often fed with rotifers and cladocera at first followed by artificial pelleted feeds later. The fry and spawn prefer live feed though formulated feeds are sufficiently rich in protein. The requirements of the minerals and micronutrient for spawn and fry are still little understood to be incorporated judiciously in formulated feeds[6].

The rotifer (*Brachionus plicatilis*) and cladocera (*Moina*) has been widely accepted as a starter food for many larval fishes[7,8]. Rotifers are preferred live feed to the fries and fingerlings having small mouth size because of their size and slow movement[9,10]. As larval fish grows their feeding preferences changes gradually for cladoceran, brine shrimp and copepoda keeping priority with increasing mouth gap of growing larvae. It has been observed that most fish larvae prefers cladocera because their jerky movement, that make them more visible to fish[11]. The studies also revealed that the larvae of fish *Clarius batrachus, Ompok bimaculatus, Lates calcarifer* and *Channa striatus,* show better growth and survivability on cladoceran as live feed[7,12-15]. In freshwater aquaculture, *Daphnia* and *Moina* have been successfully used as larval live feed in pond[16]. The application of cladocera as larval live feed in marine aquaculture has rarely been explored but the rapid reproduction of *Moina mongolica* and its adaptability to marine environment open up the scope of using it for marine finfish larviculture[17.]

The choice of zooplankton as live feed in larviculture are considered on the qualities of following aspects- i. Purity, availability, acceptance of the organisms for the purpose of economic viability. ii. Nutritional needs of the cultured fish/ prawn larvae. iii. Mouth gape size of larval fish. iv. Nutritional value and suitability for mass scale production[1]. The mass culture offers the possibility of obtaining a large quantities cladocera within short periods of time under optimum conditions of temperature, food, and water quality[18-23]. The cladoceran generally thrive on microscopic organic particles (bacteria, phytoplankton, fungi and protozoan) suspended in to water[24-26]. Cow dung, chicken dropping, fish faces, horse manure, rice bran and mineral fertilizer were found to support mass culture of cladocera very successfull[27-30]. The cladocera as most common live feeds has great values to aquaculture industries, this review paper therefore intended to provide a comprehensive outline of the available information on the subject. The review seems very much necessary because of i. Scanty scientific knowledge on cladoceran diversity as compared to other aquatic life forms. ii. Feasibility of using cladocera as live feed for larval rearing of fishes, prawns, mussels in farms. Despite the world wide efforts to introduce artificial feed supplement totally or partially, it has been observed that live feed organisms are enriched with essential nutrients (protein, fats, minerals etc.) that are essential for development of larval stages of many fin and shell fish. So, species specific mass culture is needed to assured supplementation in farmed fishes since the collection from wild is a game of chance and seasonal[30].

Aquatic food chain and cladocera

The Cladocerans are most commonly available and abundant zooplankton in fresh water lakes and ponds occupying primary consumer level in aquatic trophic system. Being filter feeding organisms, the cladocera ingest particles of varied sizes, including nanoplankton, detritus, bacteria and phytoplankton[25,26,31] and finally devoured as an important naturally available diet for fishes[16,19,22,32]. These organisms thereby play a crucial role in recycling of nutrients and transfer of energy to higher trophic level through aquatic food webs[32-35]. The cladoceran are therefore considered as being the integral component in energy transfer and nutrient cycling in aquatic ecosystem[36-38].

Nutrient composition

The nutritional quality of *Daphnia*, *Moina* varies considerably depending on their age and the type of food they are receiving from their habitat. Although variable, the protein content usually averaged 50% of the dry weight. The total fat as per dry weight is 20-27% for adult and 4-6% for juveniles[28]. Lehman and Naumoski[39] reported phosphorus (P) content in individual *Daphnia pulex* was the functions of the P contents in algal cells fed to them. *Chlamydomonas* and *Ankistrodesmus* were grown in semi-continuous cultures containing 2 µM and 10 µM PO_4 to produce differences in algal cellular P content. *D. pulex* fed with algae having higher P contained 60 percent more phosphate than *D. pulex* of equal size that were fed with algae having low P content. It is also evident that, *Daphnia magna* fed with algae *Scenedesmus acuminatus* contain 46.2% PUFA while *D. magna* feed with yeast contained 53.5% MUFA[40].

Walve and Larsson[41] studied the percent dry weight of Carbon, Nitrogen and Phosphate contents from two species of cladocera (i.e *Bosmina longispina* and *Evadne nordmanni)* and reported the ranges of carbon, nitrogen and phosphate respectively as (42.5- 49.9%,9.3-10.8% and 1.2 -1.4%). Cauchie *et al.*[43] determined the biochemical composition of *Daphnia magna* and reported average composition of protein was 271 ± 64 mg/ dry weight, lipid was 100 ± 28 mg/ dry weight, 96 ± 58 carotenoids/ dry weight, 49 ± 14 mg chitin/dry weight and 125 ± 78 mg ash/ dry weight. Ovie and Ovie[42] estimated amino acids profile, moisture contents and crude protein level in *Moina micrura, Diaphanosoma excisum* and *Brachionus calyciflorus*. They have reported a total of 17 amino acids (nine essential and eight non-essential amino acids). The dominant essential amino acids (per 16 g N) in *M. micrura* were lysine (10.73 g), arginine (8.17 g), leucine (8.0 g), and histidine (5.09 g); in *D. excisum,* lysine (9.95 g), leucine (8.0 g), valine (6.23 g), and arginine (4.78 g), and in *B. calyciflorus,* leucine (8.95 g), lysine (8.64 g), arginine (6.37 g), phenylalanine (5.20 g), and valine (4.83 g). The moisture contents in *M. micrura* (89%), *D. excisum* (89.3%) and in *B. calyciflorus* (91.6%) and crude protein levels were and 52.4%, and 57.3%, and 50.3%, respectively.

Tong *et al.*[44] compared the essential amino acids in *M. mongolica* with other commonly used live food organisms (*Artemia* napulii and *B. plicatilis*). They found that the content of most essential amino acids in *M. mongolica* was lower than that in *Artemia* or in *B. plicatilis*, but the content of methionine in *M. mongolica* was 1.5% of the total amino acids, which was higher than that in *Artemia* (0.9%) and *B. plicatilis* (0.8%). *Moina mongolica*, therefore, can be a good source of methionine for fish larvae. Wen *et al.*[45] measured the nutrient contents of *Daphniopsis tibetana* and found eighteen amino acids occupied 69.68% of total protein. The theonine, methionine and histidine were obviously higher while the content of methionine was up to 3.64%.

Tong *et al.*[44] compared the contents of highly unsaturated fatty acids (ω3, ω6 and ω9) in *M. mongolica* with other live food zooplankton such as *Artemia* nauplii and *B. plicatilis*. The content of 20:5ω3 (eicosapentaenoic acid) in *M. Mongolica*was higher (12.7%) while it was only 2.1% and 1.9% of the total fatty acid in *Artemia* and *B. plicatilis* respectively. Macedo *et al*[46] reported that fat contents in *Daphnia laevis* related to the fat contents of diet. *D. laevis* fed on *Scenedesmus quadicauda* and *Ankistrodemsus gracilis* having fats content of 11.1% and 22.1% respectively of their dry weight attain 6.2 to 11% of triacylglycerol level. Wen *et al.*[45] quantified fat contents of *Daphniopsis tibetana* where primary fatty acids were C_(16:0), C_(16:3), C_(18:1ω9), C_(18:2ω6) and C_(18:3ω3) and the content of UFA was 71.58%, the contents of C_(18:2ω6) and C_(18:3ω3) was 9.97% and 26.52%, respectively. Bogut *et al.*[46] analysed the protein and fat contents of *Daphnia magna* and reported protein contents accounted to 1.18% and 39.24% of fresh and dry mass, respectively. These amounts of proteins completely meet nutritional requirements of both carp fry and its older categories and other omnivorous fishes. Raw fat and fibre contents in dry weight were 4.98 and 4.32%, respectively, which is suitable for the commercial carp breeding. The proportions of saturated and unsaturated fatty acids in lipids of *Daphnia magna* were 18.70% and 66.20%, respectively. Among the unsaturated fatty acids, the omega–3 group was present with 27.30%. The omega–3: omega–6 fatty acids ratio was 5.68:1, which fully meets the carp nutrition requirements. Farhadian *et al.*[47] reported protein and lipid contents of *C. quadrangula* were 54% and 12.3% of dry weight respectively. The amount of saturated fatty acids was 27.3% and unsaturated fatty acid was 63.7%. Monounsaturated fatty acids (MUFAs) constituted the major part of the fatty acids (36.91 %) followed by saturated fatty acids (SFAs) (27.03 %) and polyunsaturated fatty acids (PUFAs) (26.74 %).

Fish growth and survival record

The feeding sequence during larval development in most of the fishes passes through endogenous to exoendogenous and ultimately to exogenous transition[21,48], so the rate of survival of the larvae is dependent on supplementation of suitable live fish feed for successful larval rearing mostly due to their non preference to artificial feed[49,50]. Govoni *et al.*[51] clarified that this is probably due to underdeveloped stomach in larvae.

He *et al.*[52] studied the feasibility of using *M. mongolica* as a live food for two species of marine fish larvae: red seabream *Pagrosomus major* and sea perch *Lateolabrax japonicas*. After 10 days fish survival rate is 100% and weight gain averages 101.5 mg d−1 when fed with *Moina*, and 92.5 mg d−1 when fed with *Artemia*. He opined that if rotifer is a suitable starter food for fish larvae then juvenile *M. mongolica* may serve as live food for fish post larvae and adult *M. Mongolica* can be a transitional food for fish fingerlings between live food and formulated feed. The growth and survival of sea bass larvae *Lates calcarifer* fed with live or frozen, *Moina macrocopa* was studied by Fermin and Boliver[53]. They have observed the fish with a mean initial SL of 3.6 mm had the highest specific growth rate (SGR18.82% daily) after 15 days of rearing. The mean number of ingested *Moina* correspondingly increased with the fish body size and with the length of the feeding period. The results affirmed that *Moina* can be alternative effective feed supplement to expensive *Artemia* for hatchery rearing of sea bass. The prey selectivity and capture success of larval *Allotoca dugesi* on *Brachionus calyciflorus, Moina macrocopa* and *Daphnia pulex was studied* by Dominguez *et al.*[54]. They have reported capture success (capture/attack) ranged from 0.80 to 0.98 with *Brachionus*, 0.72–0.94 with *Moina* and 0.17–0.46 with *Daphnia*. Prey preference experiments were conducted using *B. calyciflorus, M. macrocopa* and *D. pulex* at a fixed ratio of 5:2:2 ind/mL^{-1}, respectively, and revealed a positive selection for rotifers and *Moina*, but avoidance of *Daphnia*. Fermin[13] studied larval rearing of sea bass *Lates calcarifer* using *Moina macrocopa* as live fish feed. Fifteen day old sea bass larvae were fed with *Moina* + *Artemia* (at 1:1 ratio). After 20 days, survival rates of fish fed *Artemia* and *Moina*+*Artemia* (7.7 ± 2.8%) were similar and higher than the *Moina*-fed group (2.6 ± 1.4%). Thirty-day-old sea bass fry ingested the highest number of *Moina* with (17.19 ± 1.96). There was a low feeding incidence of *Moina* by 15-day-old sea brass because of larger size of *Moina* than the *Artemia.* The number of ingested *Moina* was positively correlated to the fish body length.

In an experiment conducted by Mehraj *et al.*[14], the larval snake head *Channa striatus* showed better survival and growth fed with cladocerans (*Ceriodaphnia cornuta, Moina micrura* and *Daphnia carinata)* and *Artemia* nauplii as individual and mixed cladoceran diet (*C. cornuta, M. micrura* and *D. carinata*) for four weeks. Fish fed with mixed cladoceran attained better weight gain and survivability. The larvae attained survival rate of (88±1.73%), (75.33±1.20%) and (77.33±1.45%) respectively and weight gain of (15.88±0.11 mg), (9.72±0.04 mg) and (10.0±0.06 mg) fed with *Artemia* nauplii, *C. cornuta* and mixed cladocerans in first seven days. Okunsebor and Ayuma[55] reported *Heteroclarias* fry fed live *M. micrura* had the highest percentage weight gain (496%), specific weight gain (3.09), percentage survival rate (88.83%) and condition factor (39.75). Okunserbor and Sotolu[56] studied growth performances and survival rate of *Clarias gariepinus* fry fed on live feeds *Brachionus calyciflorus,Ceriodaphnia reticulata* and shell free *Artemia*. The 25 fry each were placed in four aquaria in three replicates and were fed on four different treatment diets (‘a’: shell free Artemia; ‘ab’: Artemia shell free and mixture; ‘b’: *Brachionus calyciflorus*; and ‘c’ *Ceriodaphnia reticulata*. No significantly different (p>0.05) results were obtained in the total body length (1.60cm) of fry from all treatments but the values of specific growth rate (8.9), percentage weight gain (283%) and condition factor (69.17) in treatment with *Ceriodaphnia reticulata* were significantly higher (p<0.05) than other treatments. Larvae of Koi carp fed with *Ceriodaphnia reticulata* shows significantly higher survival rate (70%) then the larvae fed with pelletilsed diets[57]. Farhadian *et al.*[47] reported that the cichlid fish larvae consumed *C. quadrangula* at larval and in advanced stage. Early cichid larvae ingest *C. quadrangula* at 220–584 ind/day, advance cichlid fish larvae ingested *C. quadrangula* at 528–1956 ind/day.

Conclusion

The foregoing discussion clearly revealed that the live food is the essential requirement during the onset of exogenous feeding of many fish fry[58,59]. The success of fish hatchery linked to the readily available live feed, notably zooplankton in their habitat. Cladocerans have been selected as live feed sources in larval fish culture because of higher nutritional value and economic feasibility for their production in mass culture. The cladocera practically serves as essential energy sources particularly for larval nutrition towards optimal growth as well as maintenance of metabolism because of higher contents of proteins and fats[19,60]. In addition to nutrient composition, these organisms are preferred as live feed by early larval fish due to its smaller sizes and higher locomotive behavior. The jerky movement of cladoceran make them more visible to fish larvae[11,19,22,61,]. Moreover cladoceran can easily be raised through mass culture[18,20,62] and contains a broad spectrum of digestive enzymes such as proteinases, peptidases, amylases, lipases and even cellulose apart from having favourable protein sources for larval developments[46,63,64]. High level of proteins, free amino acids, fats and micronutrients were reported in most cladoceran species. Further, many studies affirmed better survivability and growth of fish larvae fed with cladocera. Therefore, cladocera can serve as good and cheap live food instead of expensive artificial feed.

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