A Seminar paper on

Application of Live Food during Fish Larvae Rearing in Fish Hatchery

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Application of Live Food during Fish Larvae Rearing in Fish Hatchery[1]

By

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ABSTRACT

The larvae of fish are usually very small, extremely fragile, and generally not physiologically fully developed. Their small mouth size, under developed of their sensory organs and poor digestive system, are limiting factors in proper feed selection and use during the early first-feeding or start-feeding period. It is observed from the study that, fish larvae fed on different live foods like, *Artemia*, rotifer, copepods, cladocerans etc. have more significant survivality, specific growth rate (SGR) and less cannibalism than fed on artificially produced starter feeds or egg yolk. Almost 40-50% more survivality was observed during feeding the live foods to the larvae in hatchery. To compare within the live feeds rotifers show best positive result in both survivality and SGR. Besides this feeding on live foods, bio encapsulated live foods can be the improved feeding technique for the future. So, the live food is ideal for the first few days' culture of most fish larvae because of its numerous characteristics; rich in nutrients, small size, slow morbidity and easy digestibility by the larvae.

Key words: Survivality, Specific Groth Rate (SGR), Bio encapsulation, live food

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CHAPTER I

Introduction

Food scarcity is one of biggest problem in many countries its bad impact falls on their economy. Food security is becoming serious issue with rapidly increasing world population in recent years. Conventional agriculture has not the ability to supply enough food therefore, new alternative and unconventional food sources have to be explored to feed this much crowded world. The 2030 Agenda for Sustainable Development (2030 Agenda for short) offers a forethought of a fairer, more lenient world in which no one is left behind. The 2030 Agenda sets aims for the contribution and conduct of fisheries and aquaculture towards food security and nutrition, and the sector's use of natural resources, in a way that secures sustainable development in terms of economic, social and environmental, within the context of the FAO Code of Conduct for Responsible Fisheries (FAO, 1995). For achieving the goal, world need to expand current aquaculture practice and utilize every bit of its resources. Aquaculture is one of the fastest-growing animal food-producing sectors, and in the last three decades world food fish production of aquaculture has expanded by almost 12 times, at an average annual rate of 8.8 percent (Yoshimatsu, T. and Hossain, M.A. 2013). Aquaculture has expanded from being almost negligible to fully comparable with capture production in terms of suppling protein and feeding people in the world in the course of half a century. Moreover, aquaculture has also evolved in terms of technological innovation and adaptation to meet changing requirements. The global population has increasing and in order to maintain current level of per capita consumption of aquatic foods, the world will require an additional 23 million tons by 2020. This additional supply will have to come from aquaculture practice (FAO, 2012).

In 1970s the production of farmed marine fin fish and shrimp depended almost exclusively on the capture of wild fry for subsequent stocking and on-growing in ponds, tanks or cages, the complete domestication of many marine and brackish water aquaculture species was only achieved during the last two decades. However, since then the controlled production of larvae from captive broodstock, or in other words the hatchery production of billions of fish and shellfish larvae (i.e. bivalve molluscs, penaeid shrimp, salmonids, European seabass, Gilthead seabream etc.) currently being produced within hatcheries all over the world. It has now become a routine operation for most cultivated fish and shellfish species.

Larval rearing is one of the toughest phases of aquaculture faced by those interested in promoting industrial production of emerging marine and fresh water species. The cultivation of larvae is

generally carried out under controlled hatchery conditions and usually needs specific culture techniques which are normally different from conventional nursery and grow-out practice, and especially with respect to husbandry and feeding strategies, and microbial control. There are few limiting factors in proper feed selection and use during the early first-feeding or start-feeding period. It is perhaps not surprising therefore that larval nutrition, and in particular that of the sensitive first-feeding larvae, has become one of the major bottlenecks preventing the full commercialization of many farmed fish and shellfish species. In spite of huge efforts to use artificial feeds, the culture of fish larvae during the primary nursing phase still depends heavily on natural live food.

Live food organisms include all plants (phytoplankton) and animals (zooplankton) grazed upon by economically important fishes. Live Food is the best food can possibly feed to fish. It's natural. It's healthy. Live fish foods make a tremendous supplement to the diet of fish and some of these can be cultivated quite easily therefore providing a free food as well. (Claus *et al.*, 2010). Artificial larval feeds has no match to live food organisms in terms of acceptance, nutritional value and other factors. Feeding habit of fishes in natural water bodies is vary from one species another but all the fishes need protein rich live food for their better growth, efficient breeding and survival (Mandal *et al.*, 2009). The success in the hatchery production of fish larvae for stocking in the grow-out production is largely dependent on the availability of suitable live food for feeding fish larvae, fry and fingerlings (Lim *et al*., 2003). The availability of large quantities of live foods organisms such as rotifer (*Brachionus plicatilis and Brachionus rotundiformis*), *Artemia* nauplii and green water to meet the different stages of fry production has contributed to the successful fry production of at least 60 marine finfish species and 18 species of crustaceans (Dhert, 1996). A common procedure during the culture of both larvae of fish and prawns in hatchery is to add microalgae (i.e. “green water”) to intensive culture systems together with the zooplankton prey (Tamaru *et al*., 1994), has become common practice these days.

Success of aquaculture depends on healthy cultured stock. A disease free healthy stock can be maintained by feeding live food to the larvae of fish in hatchery. For getting good output from rearing of larvae of fish and shellfish in hatchery they should be fed with nutrient rich live food.

The study has undertaken to accomplish the following objectives:

- To identify the importance of live foods for fish larvae
- To identify the best live foods for fish larvae in hatchery
- To improve larval rearing techniques by using live foods

CHAPTER II

Materials and Method

This is exclusively a review paper for seminar so all of the data, information has been collected from the indirect sources. During the preparation of the review paper, I went through various relevant books, journals, proceedings, reports, publications, internet etc. Findings related to my topic have been reviewed with the help of the library facilities of Bangabandhu Sheikh Mujibur Rahman Agricultural University. I got suggestion and valuable information from my major professor and my course instructors. After collecting all the available information, I myself complied the collected information and prepared this seminar paper.

CHAPTER III

Review of Findings

3.1 Types of live food

Aquatic live foods are mainly two major types- phytoplankton and zooplankton. Among the different types of live foods available for use in fish hatchery for aquaculture, some important are discussed below:

3.1.1 Micro algae

Algae are chlorophyll bearing unicellular or multi-cellular plants and use of micro algae as a possible source of protein food was recognized by the researchers in mid-20th century. In recent years, mass culture of unicellular algae such as diatoms (viz. *Chaetoceros* and *Skeletonema*) and phytoplankters (viz. *Isochrysis, Tetraselmis and Chlorella*) is becoming quite popular for feeding larvae of fishes, prawns, shrimps and molluscs in fish hatcheries.

3.1.2 Infusoria

Nutritionally very rich Infusoria are soft bodied microscopic single celled animalcules and therefore, serve ideally as starter diet for early stages of fish larvae. Infusoria or small live organisms are indispensable in the early development stages of fish larvae (Zableckis, 1998). The most common forms of freshwater infusoria are *Paramoecium* and *Stylonychia Fabrea* and *Euplotes* are of marine ones.

3.1.3 Rotifers

Rotifers popularly called as wheel animalcules 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 marine and freshwater fish and prawn species. Among different rotifer, genus *Brachionus* (Brachionidae: Rotifera) are well represented in different water bodies worldwide (Pejler, 1977). 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.

3.1.4 *Artemia*

Of the live food used in commercial fish hatcheries, *Artemia,* constitute the most widely used organism. It is an organism closely related to shrimp belonging to the class Crustacea and phylum Arthropoda and popularly known as brine shrimp. *Artemia* has thebiggest advantage of using live form on demand from dry and storable powder. Immersion in seawater dormant *Artemia* cysts regain their metabolic activity within 18-24 hours and release free swimming larvae (nauplii) of

about 0.4 mm length. Normally 2to 3 lac nauplii are hatched from each gram of high quality cysts (Treece, 2000).

3.1.5 Copepods

Copepods are common zooplankton and serve as natural feeds for larvae and juveniles of many finfish. It is believed that copepods can meet the nutritional requirements of fish larvae (Evjem *et al.,* 2003).

3.1.6 Cladocerans

Two cladocerans, namely Daphnia and Moina are important live food in aqua hatcheries and generally called 'water fleas'. *Moina* has been extensively utilized as live food in many hatcheries and in the maintenance and culture of aquarium fishes of commercial importance (Martin *et al*., 2006).

3.2 Nutritional value of live foods

Live food organisms contain essential nutrients such as proteins, lipids, carbohydrates, vitamins, minerals, amino acids and fatty acids (New, 1998) and hence are commonly known as "living capsules of nutrition". Providing appropriate live food at proper time play a great role in achieving maximum growth and survival of the early stages of finfish and shellfish. For maximum production and profitability, the nutritional components of natural foods must be identified and quantified. Nutritional status of live food organisms can boost up through various techniques of enrichment and bioencapsulation.

In aqua hatcheries micro algae are indispensable not only owes its nutritional attributes but more so for its microscopic size ranging from 5 to 25 microns meeting the feeding requirements ideally well for early stages of various aquatic animals. Microalgae typically contain 30 to 40% protein, 10 to 20% lipid and 5 to 15% carbohydrate (Brown *et al.,* 1997). Although the proximate composition of microalgae can change significantly (Harrison, 1990). PUFAs derived from microalgae, i.e. docosahexaenoic acid (DHA), eicosapentaenoic acid (EPA) and arachidonic acid (AA) are known to be positive effects on various larvae (Sargeant *et al.,* 1997). Rotifer contain highly unsaturated fatty acids (HUFA) which are essential for the survival and growth of fish larvae (Whyte and Nagata, 1990). Rotifer feeds containing DHA and EPA) can be valuable for marine fish larvae. Rotifers are composed of about 52 to 59% protein, up to 13% fat and 3.1% n-3 HUFA depending upon their food source (Awais, 1992; Oie and Olsen, 1997). High nutritional value of rotifers is of major importance for survival and growth of the fish larvae in fish hatchery. Other important live food species *Artemia* is commonly used in shrimp hatcheries, because its size is suitable for larvae, it has high nutritional value, and it is easy to be digested. According to John

et al. (2004), the newly hatched *Artemia* nauplii contains 50.6% protein, 25.7% carbohydrate, 14.2% fat, 9.4% ash and the energy value of 18.97 KJg^{-1}. Using of *Moina* is the most common live food organism for feeding young fish larvae of ornamental fish culture. The predominant fatty acids of all copepods were DHA constituted 26- 42%, EPA 15-24% and 16:0 8-12% of total fatty acids (Evjem *et al.*, 2003).

3.3 Feeding application and results

3.3.1 Survivality

Samiran, P. and Ghosh, T.K. (2015) conducted an experiment on larval rearing of freshwater Angelfish (*Pterophyllum scalare*) fed on different diets. Survival rate (%) of angelfish larvae fed on different diets like *Artemia*, rotifer, Moina, Ceriodaphnia, egg custard and green water were counted. The mean survival rate (%) after 20 days observation were 74.67% for rotifer, 68.33% for *Artemia*, 70.89% for *Moina*, 31.19% for egg custard and 23.72% for green water (Figure 1). It was found that there was no significant difference in length (mm) between *Artemia* and *Moina* and incase of rotifer and Moina at 5% level ($p<0.05$, $n=5$).

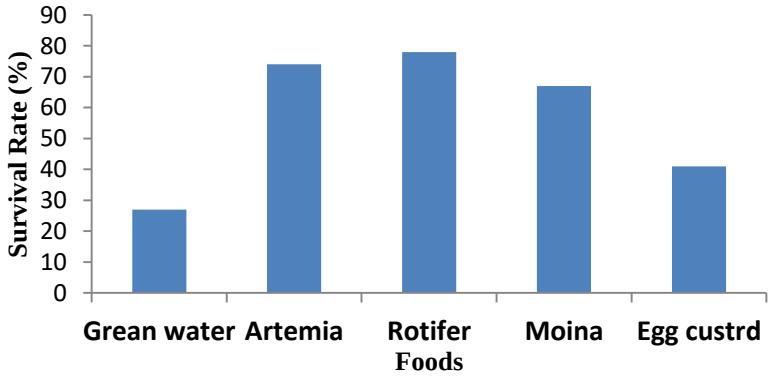

Figure 1: Survival rate (%) of fresh water angelfish larvae fed on different diets (Samiran, P. and Ghosh, T.K., 2015).

Ouraji *et al.* (2010) observed that survivality of kutum fish larvae *(Rutilus frisii kutum*) rearing in five feeding treatments (A, B, C, D and E where, A: zooplankton alone 21 days; B: 12 days zooplankton followed by 9 days artificial feed; C: 8 days zooplankton followed by 13 days artificial feed; D: 4 days zooplankton followed by 17 days artificial feed; E: artificial feed alone for 21 days) and found that survivality was highest in A(91.60%), and lowest in E(69.16%).

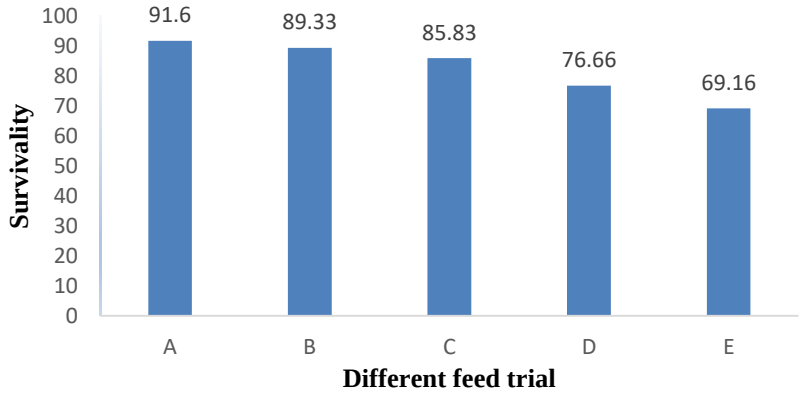

Figure 2: Survival rate (%) of kutum fish larvae fed on different diets (Ouraji *et al.*, 2010).

According to Ananthan, J. and Kareem, A. (2014), Koi carp larvae fed on*(B. plicatilis)*, (*A. dengizicus)*, mixed zooplankton feed and *C. reticulata* showed significantly high survival rate (75%), (70%), (65%) and (60%), respectively and least survival rate (35%) was recorded in pelletized feed fed larvae during 35 days rearing period (Figure 3).

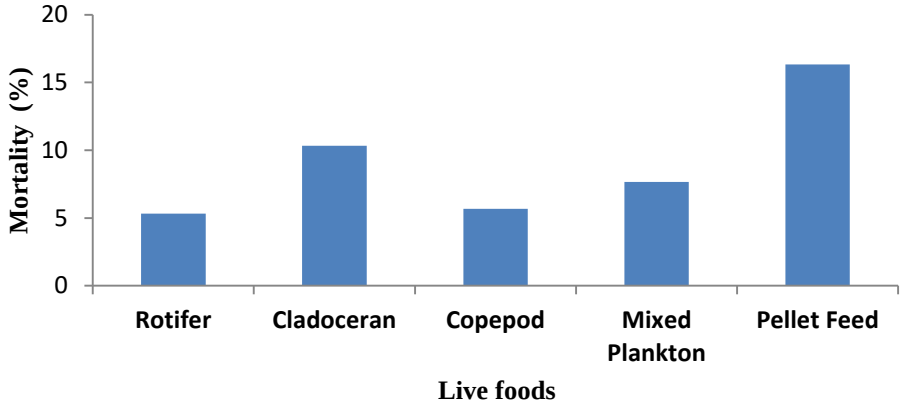

Figure 3: Mortality Rate (%) of koi carp (*Cyprinus carpio*) larvae fed with different feeds (Ananthan, J. and Kareem, A. 2014).

According to Sumithra *et al.* (2014), the survival rate of 93.33% was recorded in fishes fed with rotifer, followed by fishes fed with cladocerans, and then by fishes fed with control feed. The fishes fed with pellet feed showed the lowest survival rate (6.67%). Mortality rate was maximum in fishes fed with pellet feed and minimum in fishes fed with rotifer (Figure 4).

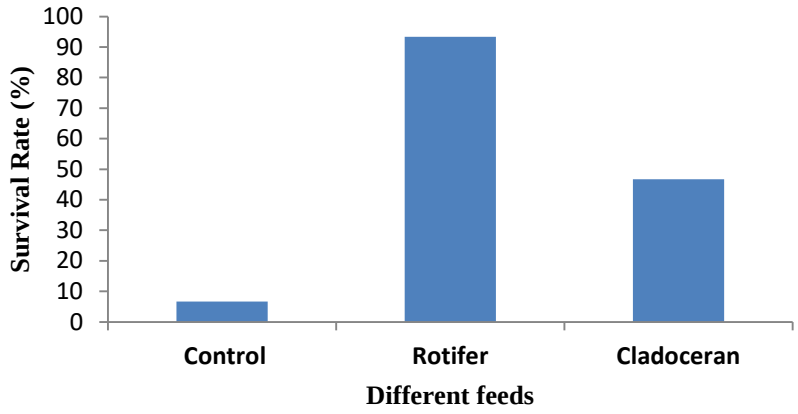

Figure 4: Survival rate of mollies fed with different feeds (Sumithra *et al.*, 2014).

According to Ananthan, J. and Kareem, A. 2015, results of feeding experiment with four different live feeds and a commercial pelletized feed showed that from the first week of their exogenous feeding, gold fish larvae grew and survived significantly better on rotifer, mixed zooplankton and cyclopoid copepod food than the cladoceran and pelletized food tested. With regard to survival rate, of the five feeds experimented, live feeds (rotifer 95%, copepod 90%, cladoceran 85%) provided the best survival of early of gold fish indicating the larvae utilized live feeds more efficiently than the pelletized commercial feed (Figure 5).

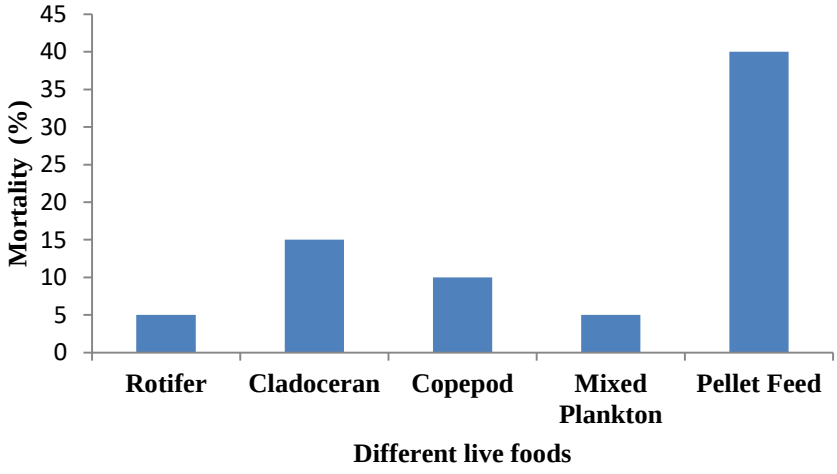

Figure 5: Mortality Rate (%) of gold fish (*Carassius auratus*) larvae fed with different feeds (Ananthan, J. and Kareem, A., 2015).

According to Hung *et al.* (1999), growth performances and survival rates for a 9-d nursing time on Mekong catfish larvae (*Pangasius bocourti).* Survival rate (%) was observed 91.7, 93.7, 92.7

and 67.5 for *Artemia* nauplii, *Moina sp.*, *Tubifex* worms and Trout starter feeding treatments, respectively (Figure 6).

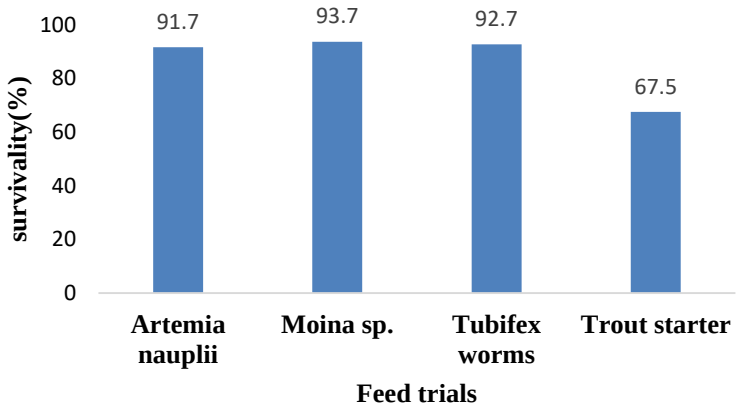

Figure 6: Survivality Rate (%) of Mekong fish (*Pangasius bocourti*) larvae fed with different feeds (Hung *et al.*,1999).

3.3.2 Growth performance

According to Ananthan, J. and Kareem, A. (2014), Koi carp larvae showed efficacy to all the five different feeds used in a study conducted and these feeds supported the development of larvae from exogenous feeding stage to juvenile stage. But there is a significant difference pertaining to length, specific growth etc.

[Length gain of larvae (mm) =Average final length of larvae – Average initial length of larvae

Survival rate (%) = (No. of fish larvae survived *100) / No. of fish larvae introduced

Cannibalism rate (%) = 100 – (Survival rate% + Observed mortality %)

Specific growth rate (% day^{-1}) = [(Final weight of fish larvae – Initial weight of fish larvae)* 100) / Experimental period].

Maximum length gain was recorded in Koi carp larvae fed with rotifer (10.02±1.6 mm) followed by copepod (9.48±1.46 mm), mixed zooplankton (8.31±1.33 mm) and cladoceran (7.03±1.09 mm) feeds. Minimum length gain was recorded in the larvae fed with pelletized feed (5.76±0.94 mm). Specific growth rate of copepod, mixed zooplankton, rotifer, cladoceran, and pelletized fed larvae is 0.20%, 0.20%, 0.17%, 0.14% and 0.08 % , respectively (Figure 7).

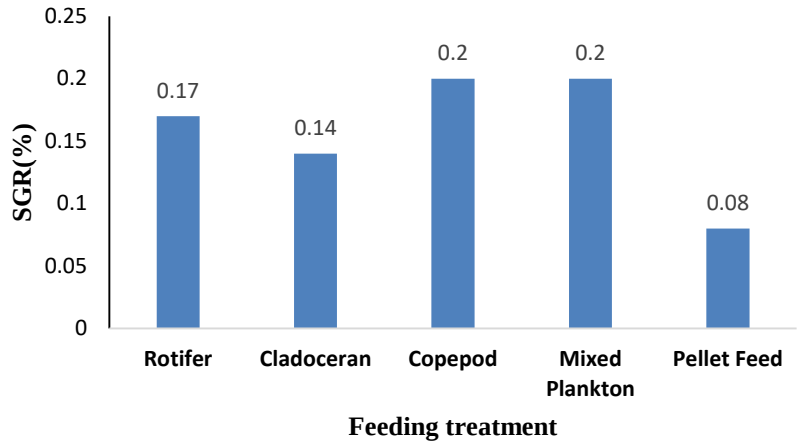

Figure 7: SGR (%) of koi carp in different feeding treatment (Ananthan, J. and Kareem, A., 2014).

According to Sumithra *et al.* (2014), the growth and survival of mollies with different feeds Showed different results. Mollies showed the highest gain in length of about 1.02 cm when fed with rotifer, followed by fishes fed with cladocerans, and then by pelletized feeds (Figure 8).

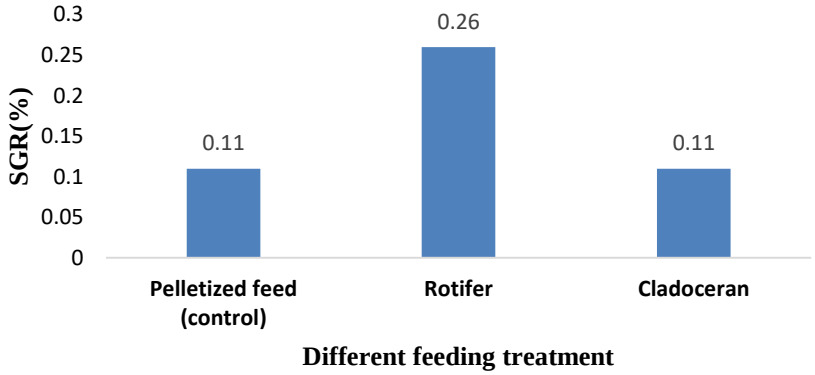

Figure 8: SGR (%) of mollies in different feeding treatment (Sumithra *et al.*, 2014).

According to Ananthan, J. and Kareem, A. (2015), results of feeding experiment with four different live feeds and a commercial pelletized feed showed that from the first week of their exogenous feeding, gold fish larvae grew and survived significantly better on rotifer, mixed zooplankton and cyclopoid copepod food than the cladoceran and pelletized food tested. At the end of 35 days feeding experiment specific growth rate of gold fish fed with rotifer, mixed zooplankton, copepod, pelletized and cladoceran fed larvae were 0.85, 0.51, 0.45, 0.31, and 0.14, respectively (Figure 9).

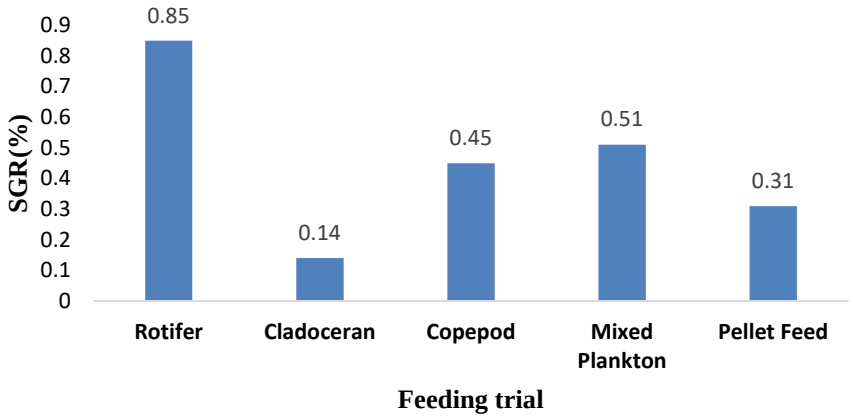

Figure 9: SGR (%) of gold fish in different feeding treatment (Ananthan, J. and Kareem, A., 2015).

According to Ouraji *et al.* (2010), SGR of kutum fish larvae *(Rutilus frisii kutum)* was dependent on the feeds provided in the larval rearing period. It was observed in the larvae rearing in five feeding treatments (A, B, C, D and E where, A: zooplankton alone 21 days; B: 12 days zooplankton followed by 9 days artificial feed; C: 8 days zooplankton followed by 13 days artificial feed; D: 4 days zooplankton followed by 17 days artificial feed; E: artificial feed alone for 21 days) in this experiment that SGR was highest in A(13.18 %day^{-1}), and lowest in E(8.01 day^{-1}).

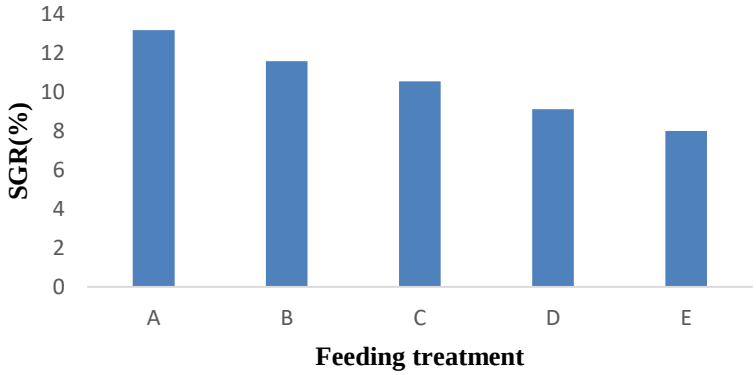

Figure 10: SGR (%) of kutum fish larvae in different feeding treatment (Ouraji *et al.*, 2010).

3.3.3 Cannibalism

According to Ananthan, J. and Kareem, A. (2014), with regard to cannibalism of koi carp (*Cyprinus carpio*) high variation was recorded between live feed and pelletized feed. Sibling cannibalism were minimum when larvae fed with *B. plicatilis* 19.67%, followed by *A. dengizicus*

24.33%, mixed zooplankton feed 27.33%, *C. reticulata* 29.67% and maximum cannibalism were recorded when larvae fed pelletized feed 48.66% (Figure 11).

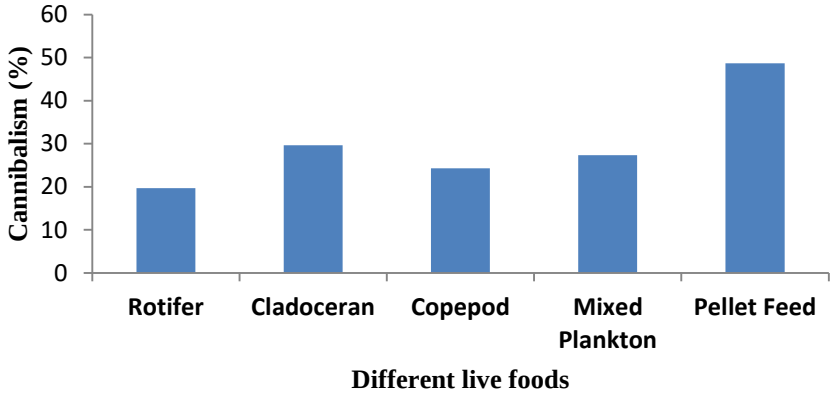

Figure 11: Cannibalism (%) of koi carp (*Cyprinus carpio*) larvae fed with different feeds (Ananthan, J. and Kareem, A., 2014).

3.4 Best performance live food

Among the all live food rotifers are the most widely used live feed in intensive aquaculture (Srivastava *et al*., 2011). Its body size makes this organism an appropriate prey at start feeding. It also has high population growth rate at high densities and it feeds by filtrating particles in suspension which makes it easy to enrich with potentially lacking nutrients.

Table 1.Requirements of Fish Larvae

Requirements of a Fish Larvae	Characteristics of Rotifer
Mouth gape is very small (3-15 mm), need micro food particles.	Size 100-300 µm; easily taken by fish larvae
Poorly developed digestive tract	highly digestible live food
Need balance nutrition for primary body formation	High level of protein, fat, HUFA, favorable amino acid profile
Low prey ability	The swimming behavior of rotifer encourages aggressive feeding activity by the larval fish.

(FAO, 2012)

Rotifers are used in aquaculture because they are so easy to raise, they can be grown in almost any container that will hold water, a couple of 5 gallon glass tanks with simple aeration would be ample to culture enough to raise small broods of fish at home. It provides the larvae with essential enzymes to digest food, since at this stage, the digestive system of the fish larvae are still under-developed. Live feeds are, therefore, an important food source in the early larval stages.

An experiment was conducted by Dhaneesh *et al.*, (2011) performed under four different feeding conditions in a way of three times per day (8.00, 12.00, and 16.00 h). Clear water rearing conditions with rotifers (*B. calyciflorus*) fed at a density of 8–10 rotifer/ml for 10 days (R), green water conditions (*Chlorella sp*., 1.1–2.6×10^5) with rotifers (8–10 /ml) offered for 10 days (C+R), green water (C sp., 1.1–2.6×10^5) conditions for 3 days followed by clear water in combination with rotifers (8–10 /ml) for 7 days (3C+7R), and Artemia nauplii (4–6 /ml) offered for 10 days (Art). Artemia and rotifers remain to be available in culture tanks about 2 h after each administration of feeding. After 10 days of feeding with rotifers, all groups were given solely *Artemia* nauplii up to 35 days post-hatching.

Only data are collected on day 10 (switching of food items) and day 35 (the end of experiment).

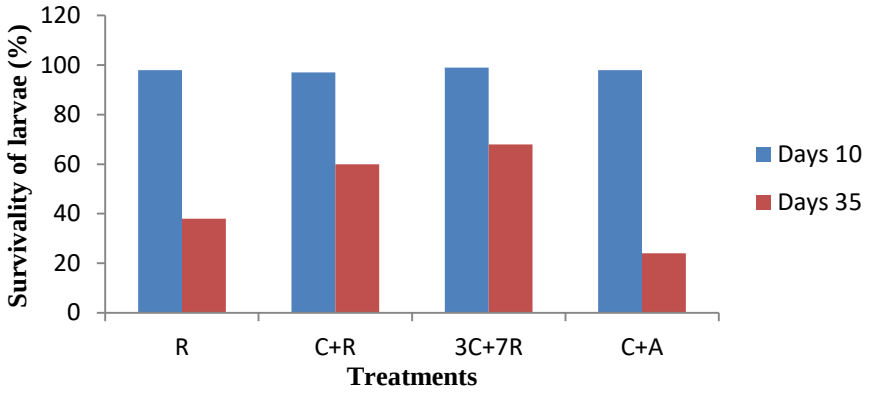

Figure 12: Survival rate of Clownfish larvae counted on day 10 and at the end of the experiment (R =clear water + rotifer; C+R=green water + rotifer; 3C+7R=3 days green water + 7 rotifer; C+A= clear water + Artemia) [Source: Dhaneesh *et al.*, 2011].

Larval survival was counted at day 10 and at the end of the 35th day rearing experiment. The highest survival rate (68.2±2.3%) was obtained with the larvae receiving only algae (3C+7R) in the first 3 days of feeding (Figure 12). Average survival rate of the larvae cultured in green water (C+R) condition for 10th day was 60.2±13.2%. Growth parameters (length and wet weight) were measured on days 0, 7, 10, 21, and 35 post-hatching.

The survival rate of the larvae receiving rotifers in clear water (R) condition was lower (38.2±6.6%) compared with the other two groups receiving rotifers. Lowest survival rate (23.9±10.3%) was obtained with the larvae receiving only *Artemia* (Art) during 35 days (Figure 12).

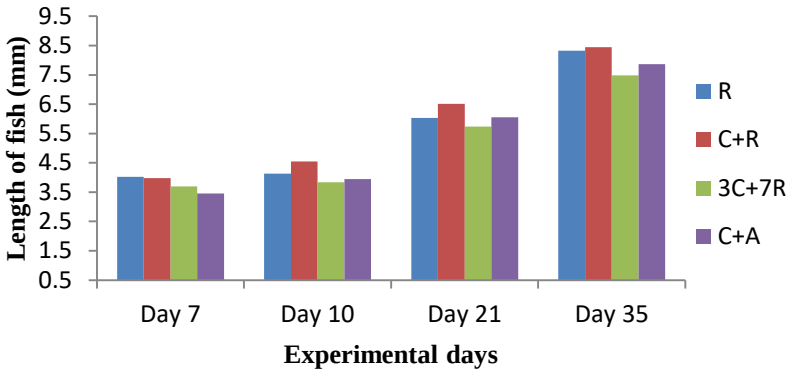

Figure 13: Length (mm) of Clownfish larvae measured on days 7, 10, 21, and 35 of the experimental course (Dhaneesh *et al.*,2011).

The larvae cultured in green water conditions for 10 days had the largest size (8.45 mm total length) after 35 days of culture (Figure 13). On day 10, the mean weight of the rotifer fed larvae for 10 days (R and C+R) was not significantly different. On the 10th day, average wet weight of larvae receiving rotifers supplemented with algae was significantly higher than in the group fed on *Artemia* (Art) (Table 2). A significantly higher mean length and wet weight of the larvae cultured in green water condition in comparison with larvae fed on *Artemia* was detected on the 10th day, indicating that feeding rotifers (8-10 /ml) along with algae accelerated fish larval growth (97.8%).

Table 2. Wet weight (mg) of Clownfish larvae measured on days 7, 10, 21, and 35 of the experimental course

Treatment group	Day 7	Day 10	Day 21	Day 35
R (clear water + rotifer)	12.53±0.04	22.54^{a} ±0.04	32.86±0.40	53.46^{a}±0.22
C+R (green water+ rotifer)	12.52±0.03	22.77^{a} ±0.10	40.20±0.30	54.86^{a} ±0.63
3C+7R (3 days green water + rotifer)	12.45±0.01	25.58^{b} ±0.05	34.62±0.16	54.08^{a} ±0.12
Art (clear water + Artemia)	12.42±0.02	20.56 ^{b} ±0.06	30.87±0.20	53.16^{a}±0.14

(Dhaneesh *et al.*,2011)

Egg is unquestionably one of the most nutritionally balanced foods known for man and animals. According to Fernando *et* al. (1994), Dwarf Gourami (*Colisa lalia*) larvae showed higher length and survival rate when larvae are fed to rotifer compare to egg yolk (Table 3).

Table 3.Comparison of the performance of Dwarf Gourami (*Colisa lalia*) larvae fed on rotifers with those fed on egg yolk particle

Feeding groups	Fed with rotifers	Fed with egg yolk
Total length (mm)		
Day 12	5.89	3. 9
Day 32	10.53	9.5
Survival (%)		
Stage 1 (Day 2 to 12)	92.3	95.4
Stage 2 (Day 13 to 32)	80.7	71.2
Overall (Day 2 to 32)	74.5	30.3

(Source: Fernando *et al.,* 1994)

3.5 Improving Larval Culture and Rearing Techniques

According to Sambhu *et al*. (2014), survival rate in the shrimp larvae fed with enriched rotifer in cod liver oil showed highest value when compared to the larvae fed with *Artemia* nauplii. This shows that shrimp larvae could capture Rotifer effortlessly than *Artemia* nauplii and thereby it could bring higher survival. Nutritional quality of prey is an important aspect to consider in shrimp larval rearing. Lipids represent the most important energy source during embryonic development and essential fatty acids, such as the highly unsaturated fatty acids (HUFA) EPA (20:5n-3, eicosapentaenoic acid) and DHA (22:6n-3, docosahexaenoic acid), are extremely important for larval development, especially in improving neural functions (Sargent *et al*., 2002). Although nutritional deficiencies in prey quality can be overcome through enrichment with essential fatty acids, high HUFA levels are difficult to accumulate in *Artemia* nauplii due to their inherent catabolism of DHA. In contrast, rotifers are not selective for the uptake or catabolism of HUFA and high levels of DHA are easily incorporated in these organisms (Dhert *et al*., 1993). The higher survival in larvae fed with Rotifer enriched with cod liver oil may be due to the presence of fatty acids in cod liver oil (Faleiro and Narciso, 2009). Better survival with cod liver oil enriched rotifer than non-enriched Artemia (Yahyavi and Takami, 2007). Regunathan (2005) researched on differential rotifer enrichment diets for *F. indicus* larval rearing and concluded that protein selco enriched rotifer could replace non-enriched artemia from Zoea 2 to Mysis 2 stage with similar survival and till Mysis 3 with non-significant survival compromise. Differences in digestibility and nutritional quality of *Brachionus* and *Artemia* nauplii may also be important besides prey ingestibility. Larvae fed with enriched Rotifer in Cod liver oil (Treatment T_1) showed higher survival when compared to control other treatments (Table 4). Lowest survival was observed in T_4 which was fed by a combination of *Artemia* nauplii and enriched Rotifer in HUFA. Larvae fed

with *Artemia* nauplii alone were found to be healthy and the survival was as good as Control. Combination of *Artemia* nauplii and enriched rotifer did not show high survival rate when compared to Control.

Table 4. Effects of enriched rotifer on shrimp larvae

Parameters	Control	T_1	T_2	T_3	T_4
	M ±SD	M ±SD	M ±SD	M ±SD	M ±SD
Initial Number	5000±12	5000±12	5000±12	5000±12	5000±12
Final Number	1908±74	2294±41	1106±59	1910±98	504±88
Survival (%)	38±08	46±11	22±09	30±05	10±04

(Sambhu *et al.*, 2014)

[Control= un-enriched rotifer; T_1= Rotifer + cod liver oil; T_2 = Rotifer + HUFA; T_3= *Artemia nauplii*; T_4= *Artemia* nauplii + enriched Rotifer in HUFA]

Common snook Larvae at the 75/25 (copepod/rotifer) and the 50/50 tanks had the average highest length (4.70 mm), followed by the 25/75 (copepod/rotifer) with an average length (SL) of 4.32 mm, which was very similar to the 100% rotifer diet (average length (SL) of 4.28 mm). No significant difference was found between the first two treatments ($p > 0.05$) or between the other two (25/75 and 100 rot), but a significant difference was found between the first two and the last two ($p < 0.005$).

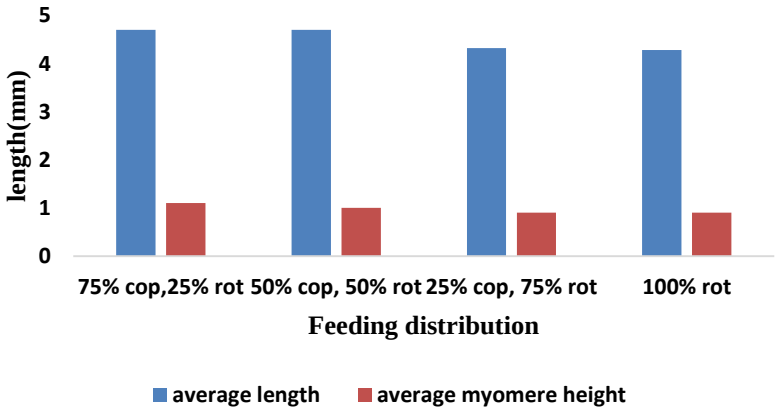

Figure 14: Average length (SL) and myomere height from larvae exposed to four diets (Carlos, Y. *et al.*, 2010).

An experiment was carried out during March - April 2014 by Isabel María Fernández Artiles in the Experimental Station of the Aquaculture Research Group (GIA) at the Marine Scientist and Technological Park, belonging to the University of Las Palmas de Gran Canaria in Taliarte (Telde, Gran Canaria) to observe the effects of enriched rotifer on gildhead sea bream (*Sparus aurata*) larvae. The rotifers used in this experiment were enriched with the different treatments, always

the day before larval feeding. Tree complete microalgae enrichments were prepared with a mix of krill oil, vitamin E, vitamin C, antioxidants, one of the tested algae (*Isocrysis sp.*, *Tetraselmis sp.* or *Dunaliella sp.*) and baker's yeast.

It was also shown that the highest biomass was found in the tanks where larvae were fed with diet 3 (vitamin C) while the lowest were again in tanks whose larvae were fed with diets 1 (DHA Protein SELCO) and 4 (*Dunaliella sp.*), being the last one the diet with the lowest obtained biomass (Figure 15).

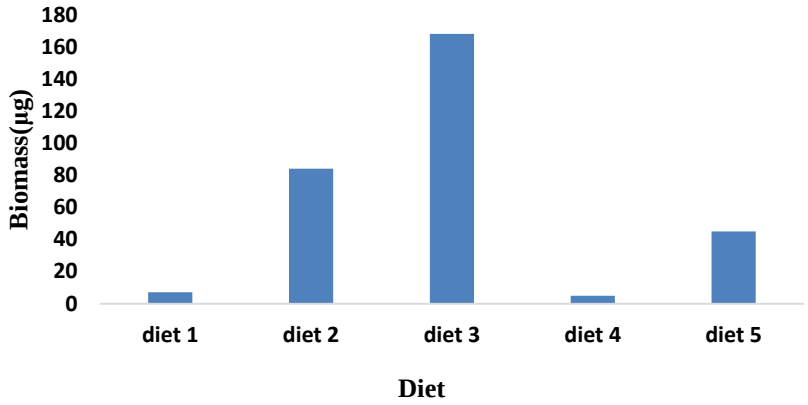

Figure 15: Biomass (µg) of sea bream larvae at the end of the experiment according to different diets (Isabel María Fernández Artiles., 2014).

It was moreover observed that larvae fed with diets 1 and 4 showed a decreasing survival rate after the applied stress, whereas larvae fed with diet 3 were the most are more resistant, with 86.67% of survival.

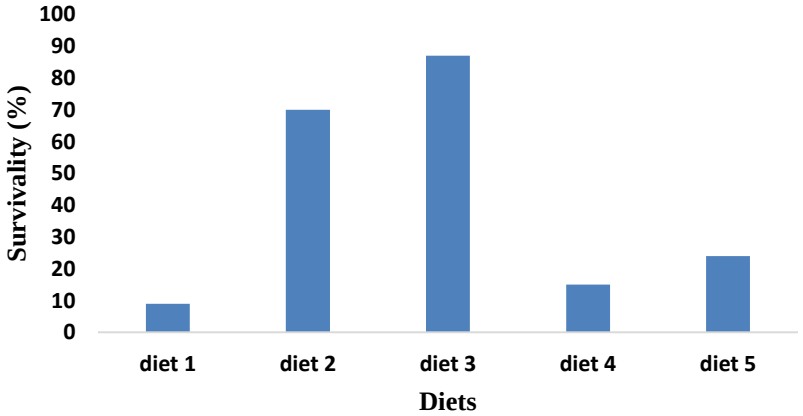

Figure 16: Larval survival rate after activity test at the end of the experiment according to different diets (Isabel María Fernández Artiles., 2014).

However, for the tanks fed with diet 3, high biomass was observed, which were also reported by Rudabeh *et al.* (2012). They stated that an increase biomass is associated with reduced growth of

the larvae. However, neither the survival rate nor the larvae resistances were not reduced by this high biomass due to the high PUFAs levels in the diet.

Table 5. Growth performance and feed utilization of juvenile *A. persicus* in different experimental groups live food for 8 days (initial weight=43.0±0.5 mg)

Growth Parameters	Control Group	Rotifer	Rotifer+ Vit-C
FBW (mg)	62.36±0.85	77.6±1.41	99.32 ±0.68
WG (%)	45.18±0.66	77.77±2.3	124.4±0.62
SGR (%/day)	4.65±0.06	7.38±0.18	10.47±0.4
FCR	4.48±0.07	2.47±0.08	1.51±0.01
Survival (%)	84.4±4.45	95.5±2.25	97.8±2.2

(Rudabeh *et al*., 2012)

Three experiment groups were studied; Group 1fed a mixed diet of decapsulated Artemia cysts, daphnia and rotifer as a control group, Group 2 fed rotifers as the starter diet and Group 3 fed a starter diet of rotifers enriched with vitamin C. Rotifer enriched with vitamin C showed promising weight gain than the control group (Table 5). Lowest FCR (1.51) with highest specific growth rate (10.47) and highest survival rate (97.8) was found in rotifer enriched with vitamin C (Table 5).

CHAPTER IV

CONCLUSION

- The larvae of fish are usually very small, extremely fragile, and generally not physiologically fully developed. For example, their small size (ie. small mouth size), the uncompleted development of their perception organs (ie. eyes, chemoreceptors) and digestive system, are limiting factors in proper feed selection and use during the early first-feeding or start-feeding period. Live food is ideal for the first few days culture of most fish larvae because of its numerous characteristics; small size, slow morbidity and easy digestibility by the larvae.

- Better growth and survival of fish larvae can be achieved using rotifer. Further, this live food reduced mortality in the critical larval stages and enhances their survival. Hence live feed of zooplankton (*B. plicatilis* and *B.rotundiformes* , *B.calyciflorus*) are recommended as initial larval feed and use of this indigenous live feed might have a positive impact on economy of the ornamental fish industry.

- Enriched rotifer showed better growth performance like length and weight gain, specific growth than un-enriched rotifer. It also showed high survival, low mortality and cannibalism in fishes and hence desirable for the rearing of most fish larvae in hatchery production. Therefore, larval rearing techniques can be improved by provision of enriched rotifer during different larval stages.

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