GSJ: Volume 8, Issue 9, September 2020, Online: ISSN 2320-9186
www.globalscientificjournal.com

Importance of Living Diversity: A Way Towards a Less-expensive Aquaculture

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ABSTRACT

Aquaculture is a very progressing field of science. It solely accounts for development and welfare of a country and its people. The expenses on aquaculture are a hindering its progress. Prepared fish-meal or other feeds are not affordable for small scale farmers. Therefore, the dire need is to provide the farmers with less expensive, nutrient-rich and balanced diet for their farming practices. Live-feed is the best option in this regard. If live-feed organisms get their due importance in aquaculture farming, the expenses can be reduced to half of their recent values. There is a immense diversity of live-food organisms, which can be used. Due to their highly nutritious contents of fats and proteins, they can take place of high priced meals and ingredients. Copepods are considered best in this regard.

INTRODUCTION

Aquaculture is mostly regarded as the farming or cultivation of aquatic organisms including fish, crustaceans, mollusks, aquatic plants, algae and many other aquatic organisms. In aquaculture freshwater and saltwater populations are reared under perfectly controlled conditions to assure better possibilities for future food production. Aquaculture is very different from commercial fishing in respect that it covers a broad range of aquatic organisms. Commercial fishing on the other hand is the rearing of wild fish for food. Aquaculture is rarely spelled aquiculture but is more commonly called as aqua-farming (the farming of aquatic organisms). In aquaculture farming the rearing processes are somehow changed and modified to increase the production. There are many different kinds of aquaculture. Fish farming, oyster farming, shrimp farming, mariculture, algaculture i.e. Seaweed farming, and cultivation of ornamental fish but most of the time the ornamental fish cultivation is not consider in aquaculture (Jhingran, 1987).

The foods that are given as a whole to carnivorous animals and are not gone through certain levels of processing are called live foods. The live foods are given as a whole or may be broken into small pieces even chopped, cooked or frozen. Live food organisms are commonly called “living capsules of nutrition” because they contain all the essential nutrients like protein, lipids, carbohydrates, vitamins, minerals and fatty acids. For intensification of aquaculture the production of live food organisms is very important step. The live feed is added to fish tank in which larvae are cultured. It is thought that live feed is indispensable in inducing certain fish behaviors. The movement of live feed stimulates feeding behavior in larvae and various live feeds are with high water content. This high water content cause the food to be easily digested in digestive tract of marine fish larvae. In wild environment live food like the zooplankton can be directly taken in by fish larvae the same is done in aquaculture. To achieve maximum growth and maximum survival rate live food is provided at proper time. The fabrication of high quality fish is very often limited by poor quality fingerlings at commercial level. Deformities and low survival rates are the ultimate consequences of poor quality or inadequate food supply (Qin, 2013).

Healthy cultured stock is the main requirement of aquaculture. In order to get a disease free culture, live food supplemented with artificial food is used. Live food is important because artificial food cannot fulfill all the nutritional requirements. Special planning and perfect strategies are important in overcoming the risk of high mortality rate in the larval phase of culturing. Some larval species require zooplanktons as first live feed organisms but the others require zooplanktons in addition to other live feeds. Larvae cannot feed on artificial feed. Hence, they require live feed for their proper growth. Live foods are protein rich and can be purchased from market but one disadvantage is that they vary with different seasons. But live feeds can be cultured easily (Hamre *et al.,* 2002).

The live food organisms includes all types of phytoplankton and zooplanktons which are present in water bodies and are preyed upon by other fishes, crustaceans etc. There is an ability of live food to swim in water column. Thus, they are constantly available to fish and shellfish species. These live food organisms are the most valuable resource of aquaculture. Most of fish and shellfish larvae feed on planktonic bodies in water. Fish are not abundant in clear ponds but are abundant in greenish water. The green color of pond is due to high concentration of phytoplankton and other organisms in water (Vasudevan *et al*. 2012).

Planktons are the main source of energy and start the food chain in aquatic environment. They provide food to other consumers. Health as well as fertility of aquatic environment depends all on productivity of its plankton. In nature, mostly zooplankton and phytoplankton are used as food by larvae of many fish, shellfish species and other marine animals. The plankton diet provides the larvae with important nutrients needed for growth and metabolism. This diet also facilitates the nutrient uptake by larvae and has diverse composition to provide larvae with all essential nutrients (Delbare *et al.,* 2006).

In order to provide themselves with a complete and balanced diet, the larvae feed on a very broad range of zooplanktons. As zooplanktons vary in size from minute to large they provide suitable food source to larvae of all sizes whether small or large. Larvae feed on zooplanktons according to their size. The hatcheries which are located near some large water body, sea or ocean are at a great advantage regarding the use of zooplanktons as natural feed of larvae. Zooplanktons can be used as a sole source of food or a supplement diet for larvae. The zooplanktons can only be used as fresh diet because they cannot be stored for long time or short time. The survival value of zooplanktons is very low in artificial conditions. The most probable solution to this problem is deep freezing the food to prevent spoiling and decaying. Zooplanktons are not used widely as food source for culturing species because they can bring many kinds of parasites with themselves and cause the larval death. The parasites brought by zooplanktons include fish flea (*Argulus faliaceus*, the fresh water flea and *Livoneca* species, the marine water flea) and parasitic copepods (*Lernaea* species are the freshwater parasitic copepods and *Lernaeascus* species are the marine water copepods) (Agh and Sorgeloos, 2005).

Zooplanktons are primary and important source of food for larvae. Important zooplanktons are rotifers and copepods. These are the favored prey of shrimps and fish and also the most widely used live feeds in aquaculture. In food web of marine ecosystem zooplanktons form major portion of food to fish and shellfish larvae. Copepods are believed to fulfill all the nutritional requirements of larvae. The artificial feed resembles the live feed in its nutritional value in terms of acceptance and other factors. Feeding habit is not the same in all species of fish but the preference for protein rich food is common. All fishes need protein rich food in order to grow faster and develop in a better way. Enrichment technique has helped a lot in raising and boosting the standard of live feed for larvae. The success of hatchery production lies on the availability of perfect and suitable diet for larvae, fry and fingerlings (Mandal *et al*., 2009).

Microalgae are used as live feed for bivalves, abalone, crustaceans and some fish larvae. Several hundred species of microalgae have been tested but less than 20 are found useful as food. Microalgae have important role in aquaculture because they are used in enrichment of zooplanktons for feeding larvae. Microalgae provide nutrients as proteins with essential amino acids, PUFA, pigments and sterols. These nutrients are carried from one trophic level to other throughout the food chain. There existed a quite common procedure in culturing of larvae of fish and prawns. This was to add microalgae with zooplankton prey to the intensive culture system Zooplanktons are used as live feed for various species of crustaceans and fish. Microalgae are used as live feed for zooplanktons also. Some species rely on microalgae for food includes *Penaeus* spp. (prawns), *Pinctada maxima* (pearl oyster), edible oysters, abalone (*Haliotis* spp.) and barramundi. The algae upon which larvae feed are of nano-planktonic size (Alajmi and Zeng, 2013).

Microalgae are used in rearing of bivalves but from the beginning the microalgae used for rearing bivalves were of temperate origin. The bivalves were also of temperate region. The culturing of microalgae in tropical condition is the need of the hour to support growing tropical mariculture. There is a need to produce such strains of microalgae that can tolerate harsh tropical conditions. Regardless of the availability of tropical microalgae there is very little information about the nutritional requirements of bivalve larvae. To determine the nutritional quality of microalgae biochemical analysis is most important. For this, experiments are done with juvenile or adult bivalves. Microalgae contain HUFA, highly unsaturated fatty acids. According to some studies HUFA are advantageous for bivalve growth and development. But other studies do not support this idea and claim that there is negative influence of HUFA on bivalves and the saturated fatty acids play important role in growth (Becker, 2004).

Among rotifers *Brachionus plicatilis* is used as food source for marine fish and some shrimp species. *Brachionus plicatilis*is regarded as the starter diet in larviculture of marine fish. It is a brackish water zooplankton. It was first discovered by Japanese aquaculturists. If optimum conditions are provided *Brachionus plicatilis* reproduces by the process of parthenogenesis with female producing several eggs which hatch and reach the reproductive stage very fast. Microalgae or yeast is used as food for rotifer larvae. Rotifers contain 52-59% protein, more than 13% fat and about 3% HUFA (Arimoro, 2006).

First-feeding marine fish larvae are chiefly fed on rotifers *Brachionus* spp. in intensive culturing system. The larger sized *Artemia* is used as food in later developmental stages. Yet rotifers and *Artemia* cannot satisfy the nutritional requirement of larvae. Resultantly the larvae with poor growth and survival rate develop. Copepods can also be used as live feed in order to enhance the output. But for production of live feeds the biology of feed organisms should be known. For sustainable culturing of copepods one should know the nutritional requirements of copepods. Different algal diets can be used as copepods feed (John and Kamaruzzaman, 2012).

Naturally, many copepods (except parasitic copepods) are also used as food for adult marine organisms as well as for larval stages. Mostly harpacticoid and calanoid copepods are used as food. The copepods are good source of many nutrients. They are rich in amino acids. They provide most free amino acid to animals except methionine and histidine. If taken from nutritional point of view, copepods are much better and superior to *Artemia nauplii*. They show a better proteolytic activity than *Artemia*. They also have good fatty acid composition having more DHA than *Artemia*. Thus, copepods are an excellent source of nutrients with high energy value. For the better growth, development, pigmentation and survival of fish copepods are always preferred in aquaculture. But in contrast to rotifers copepods are very difficult to culture. Copepods play multiple roles including role in ecology, management of fishes, flow of energy and nutrients and aquaculture (Ananth and Santhanam, 2011).

Cladocerans are known as water fleas in general. Two cladocerans called *Daphnia* and *Moina* are commonly used as live feed. Cladocerans are highly advantageous because they have high reproduction rate. They also have ability to tolerate wide range of temperature and can thrive on organic wastes and phytoplanktons. In case of freshwater aquaculture and ornamental fish culturing industry *daphnia* is one of the most important food sources. *Daphnia* are mostly use as replacement of live feed for *Artemia* in mariculture. Daphnia is more than 70% protein. It contains a broad range of digestive enzymes like lipase, amylase, protease, peptidase and even cellulase. Daphnia also plays an important role in treatment of waste water and also in ecotoxicology. As far as the nutritional value of *daphnia* is concerned, it greatly depends on the chemical composition of food source of *daphnia*. Culture of daphnia should be handled with great care. If daphnia lacks vitamins the culture will crash after 10-30 generations (Loh *et al.* 2012).

Miona is also replacement feed for Artemia in rearing of most fishes like rainbow trout, salmon, striped bass, *Lates calcarifer, Macrobrachium.* But *Artemia* provides better performance in terms of growth and survival when compared with *Moina* in case of fry and adults of guppy fish. *Moina* is also used as feed for culturing of ornamental fish. Nutrient composition of *Miona* also differs with the culture medium but in most case it can be improved in nutrition aspect by the help of emulsified lipids. The 50% of the dry weight of *Moina* contains protein. Adult *Moina* have elevated fat content as compared to juveniles. Fat content is 20-27% of dry weight in adults and 4-6% in juveniles (Martin *et al*., 2006).

Live foods for aquaculture also include nematodes. Mostly free-living nematodes are used as food for rearing organisms. Nematodes are reared under laboratory conditions at low cost. Two species of nematodes are farmed very cheaply in laboratory. These are *Panagrellus revives* and *Caenorhabditis elegans* (Dhert, 2007).

Tubifex is also used as live feed but is not used as live feed for larval and post larval stages of fish and shellfish species. It is best favored diet for many ornamental fish species. *Tubifex* belongs to worm class oligochaeta of the phylum annelida. The habitat of *Tubifex* is generally sewage drains. It jerks into the muddy bottom of water body when disturbance occurs. The best know worm as food is red worm *Tubifex tubifex*. It is well known as live feed for its particularly short generation time. *Tubifex* can be cultured on large scale in pond mud mixed decaying vegetable matter and bran-bread masses (Mahmut *et al.*, 2003).

Chironomids are the non-biting midges. They contain hemoglobin that is why they are known as blood worms. The soft tubes made of organic matter provide first shelter to larvae. Adult larvae are of dark red color. The chronomids larvae are believed to be important live feed for many fish species and cultured invertebrates. Chronomid larvae are a high source of protein. They are 56% protein. They are also a source of lipids, vitamins and minerals. Chronomid are copious group of benthos insects. They have a huge reproductive capacity. Each female has capacity to lay 2300 eggs in one batch (Basu *et al.*, 2010).

Microbes can also be used as live feed for larvae of many species. Yeast can be used directly as live feed for many larvae but it is mainly used in feeding of zooplanktons reared for using in larviculture. Yeast is an important constituent of artificial larval diets. Yeast is also used as supplement for algae preparation of artificial diets for post larval stage of penaeid shrimp. Most of the probiotics belong to genus bacillus. The probiotic bacteria can be consumed by several groups of phytoplanktons and zooplanktons, rotifers and copepods. Bacteria are good in their nutritional content with essential amino acids, proteins and polysaccharides. Bacteria are also a rich source of exogenous enzymes. Bacteria also play a role in digestion and absorption process in the gut of certain larvae. They breakdown larger particles into smaller ones thus, aiding in digestion (Soroy, 2012).

Earthworms are a good source of proteins. It speeds up growth, development and sexual performance. It also stimulates appetite, makes feed attractive so waste is avoided. The fairy shrimp are also the relatives of *Artemia.* They are also used as live feed. They are suitable for freshwater crustaceans and fish culture. They increase the color pigmentation in ornamental fishes because they contain carotenoids (Das *et al.* 2012).

The live food organisms also belong to class ciliata of phylum protozoa. These are the microscopic organisms and are single celled animalcules called infusoria. Infusoria are very small in size but they contain a very soft body and are nutritionally very rich. They serve as an ideal starter diet for early stages of fish larvae. Infusoria are crucial in the early life stages of many fish larvae. The common freshwater infusoria are *Paramoecium* and *Stylonchia.* The common marine infusoria are *Fabrea* and *Euplotes*. For culturing of infusoria certain media with lettuce, cabbage and banana peels are used which stimulate the growth of infusoria in laboratory conditions (Zableckis, 2010).

During the last few decades the industrial level rearing of many fish species and shrimp has flourished with tremendous rate. Much more progress is made in rearing methods regarding the per capita production of fish and shrimp. Progress is made in the methods of rearing fish as well as new food resources are introduced. Many countries are trying to get position over others regarding fish culture and other cultures. The country on the top position is japan. Japan is also considered as the pioneering country in culture of certain species i.e. the red seabream, *Pagrus major*, and the kuruma shrimp, *Panaeus japonicas*. Europe has also made progress in aquaculture in the last decade with prominent culturing of seabass, *Dicentrachus labrax* and of gilthead seabream, *Sparus aurata* (Evjemo *et al.*, 2003).

Penaeid shrimp culture has got great success in tropical Asia and Latin America because it gives very high output and profit. These days, the industries rearing the larvae of marine fish and shrimp produce more than 50 billion post-larvae of shrimp and more than 400 million marine fish fry. This industry values at several hundred million us dollars per year. The larviculture industry depends mostly on the quality of larvae and fry that are produced in hatcheries. The methods applied for the culture of fish and shrimp are not so good but the outputs of commercial hatcheries are predictable than ever before. But there is lot information to be known about the feeding behavior of fish and shrimp larvae for better culturing. Some fishes like salmons have big yoke sac by virtue of which the larvae survive the few first weeks of their life. Yolk sac provides embryo with food so threat to the life of embryo due to lack of food is lessened. Most marine fishes have very small yolk sac that provide food for some days and threaten the life of fish (Sorgeloos and Dhert, 2001).

In shrimp culture broodstock selection plays a key role. Perfect management is also very important during larval rearing to produce the best quality fry. The most common food used for shrimp culture is brine shrimp and rotifer. But of two the rotifers are less used due to their smaller size. There are many feeding difficulties when rotifers are used as shrimp feed. Because rotifers are of very small size, nutritional variability is common among different rotifers and mostly the rotifer cultures are susceptible to crashing. This can cause huge loss of money and resources. *Artemia* the brine shrimp is most commonly used food for shrimps. It is regarded as the optimal food for shrimps because it perfectly meets the nutritional needs of shrimps. The biomass of *Artemia* is used as food stabilizer for livestock. They are also used in pharmaceutical products extraction. *Artemia* are also used in making protein rich food products. Even humans use *Artemia* as food in some countries. But there also exist some disadvantages of using *Artemia*. *Artemia* from different cultures differ greatly in properties and nutrient composition that can cause the production of very small larvae which are rapidly developing and vulnerable to harsh conditions (Ananthi *et al.,* 2011).

The total fish production of the world is reported to be 142.3 million ton per year. This estimate includes totality of aquatic organisms which are eaten by humans or are used for other commercial activities. The main source of protein is supported by small aquatic food organisms. As it's the fact that larger levels are made of smaller ones the same way the larger organisms always relay for their food on smaller ones. The copepods form the starter level in order to provide food for larger animals. Copepods are of special value in sense that almost all higher organisms use copepods as food at least during their initial life stages. Copepods are used as main food for larvae of finfish and shellfish. The larvae which feed on copepods show better development and high survival rate than others which feed on artificial diet. *Artemia* and rotifers are also used as diet for rearing fish larvae but their nutritional value is very low as compared to copepods. *Artemia* and rotifers were used for aquatic animal feed for many decades but it was found that they were deficient in many nutrients with special reference of fatty acids (Santhanam and Perumal, 2012).

In Uganda African catfish is one of the eminent commercial fish. Other fish larvae of freshwater take artificial feed formed in definite composition of different nutrients to guarantee maximum growth and survival of larvae. But in case of African catfish the larvae depend on yolk sac for nutrition in early stages of their growth. At the commencement of exogenous feeding, the larvae of African catfish need live feed for their proper growth. The live feed comprise of *Artemia* cysts, rotifer, unicellular algae, cladocerans and yeast. Larvae need starter feed for they are unable to digest dry artificial feed. The digestive system of larvae is incompletely developed. So, the most suitable feed is the live feed. Live feeds are richer source of enzymes and other nutrients and offer a proper diet for larvae of all sizes. So, use of live feed provides high yield achieving the real objective of a hatchery. Lipids are important nutrient in these live feed not only for their high oily energy but also for delivering PUFA (polyunsaturated fatty acids) that play an essential role in optimal pigmentation, maintenance membrane fluidity that is important in growth and survival of fish (Abaho *et al*., 2016).

Copepods are most widely used as feed for larvae of many aquatic species. They are miniature crustaceans and form a major component of marine ecosystem. Copepods use phytoplanktons as food. The organisms at higher trophic level use copepods as their food. So copepods are an important source of food for higher trophic levels. Fishes and whales also prey upon copepods. They serve as primary prey in early stages of many aquatic larvae. Copepods are preferred as most appropriate diet for larval and post larval stages of many fish and crustaceans species. The larvae mostly require a prey of 50-100µm wide at the time of first feeding. The rotifers are too large for some larval species to eat. Moreover the nutrient composition of rotifers or *Artemia* does not fit the dietary requirements of many larvae. In these cases substitution of existing feed is not the proper solution. So, there is a need to develop a superior feed (Santhanam *et al*., 2012).

The aim of the study was to find out the important live food organisms in aquaculture and their use.

REVIEW OF LITERATURE

Some important literature regarding the important live food organisms and their use in aquaculture given by various scientists is as under.

Treece (2004) reported that 60 marine finfish species and 18 species of crustaceans were cultured successfully by the use of rotifers and *Artemia* as live food source. *Artemia nauplii* were the most widely used species in larviculture. Cysts (after decapsulation), *nauplii*, juveniles, sub-adults all the stages of *Artemia* were used as food. The advantage of using *Artemia nauplii* as live food was that it could be made on demand when required and also the quantity required. It was produced from the storable powder which is dry called the *Artemia* cysts. More than 2, 00,000-3,00,000 *Artemia* hatch from 1 gram of high-quality cysts. *Artemia* cysts regained their metabolic activity when immersed in seawater. After regaining the metabolic activity larvae of *Artemia nauplii* were released within 24 hours. Prior to feeding larvae with *Artemia*, it was separated from the waste which mostly included bacteria and empty cysts shells. There were more than 50 geographical strains of *Artemia*. More than 90% of world's *Artemia* came from Great Salt Lake in Utah.

Kolkovski (2004) reported that in last two decades aquaculture has made extensive progress and thorough larviculture had increased its commercial value. These days, the larviculture of numerous fish and shellfish species constitute a multimillion dollar industry.

Ample progress has been occurred in identification of diet requirements of the larvae of many aquaculture species. For mass culturing of many marine species live feeds were still required. The live feeds were selected through trial and error method. Different feeds were tested on larvae of different species in order to know which feed was suitable. Feeds were also selected on the basis of convenience of getting the feed. The hatcheries relied on three types of live feeds those days. This comprises of various species of algae, brine shrimp *Artemia* and the rotifers. Many species of microscopic algae were found useful in rearing mollusks and shrimp larvae. Microscopic algae were also potent for farming of greenwater fish larvae. The dietary requirement for larvae was not always confirmed. It was always unpredictable. To avoid crashing of culture through wrong food, many supplements were used as food along with live algae. Rotifer *Brachionus* were cultured in hatcheries farming fish and shrimp. For rotifer culturing microalgae was used. But the use of yeast based products can replace microalgae in culturing for getting a cost effective diet. The nutrient content of rotifers can be adjusted by enrichment products. *Artemia* was most commonly used in fish and crustacean larviculture. It was practically convenient to use *Artemia* instead of other live feeds because it is easy to handle. 2000 million ton of *Artemia* cysts were used annually all over the world for aquaculture purpose. *Artemia* were also used for carrying vaccines, chemotherapeutics and hormones to the larvae.

Piasecki *et al*. (2004) reported the importance of copepoda in freshwater aquaculture. Copepods were manipulated in the pond environment in order to control the population of copepods. It was done to manage the aquatic ecosystem. In a pond ecosystem, copepods provided food for small fish and acted as the micropredators of fish and other aquatic organisms. Copepods also played role as fish parasite and even the intermediate hosts of fish parasites. Some copepods also carried certain diseases to human beings. Copepods specially provided food for the fish fry. They acted as important live food in aquatic environment. Copepods of genus *Lernaea* and *Salmincola* attach to gill filaments of fish and cause epithelial hyperplasia. It was indirectly responsible for fish-kills. Copepods also acted as intermediate hosts of tapeworms and nematodes and increased the mortality rate in fish.

Brown *et al*. (2005) studied the use of microalgae as a feed for mariculture. Microalgae were used as live feed for almost all growth stages of molluscs, fish species and crustaceans. It was also used as a live feed for zooplanktons which themselves were important live feeds. Microalgae was not nutrient sufficient and must provide nutrients essential nutrients necessary for larval growth and development. For this purpose it was provided with a balanced supply of nutrients. More than 40 species of microalgae were best adapted to Australian conditions. Different species of microalgae carried different protein, carbohydrate and lipid content. But all species had same content of amino acids. Microalgae were richer amino acid source, mostly essential amino acids. In different species of microalgae the sugar composition of polysaccharides was not the same. Most species had high proportion of glucose. Many species of microalgae were very good source of polyunsaturated fatty acids. Some species were with moderate levels of polyunsaturated fatty acids but others were totally deficient in acids. All species contained extraordinary concentration of ascorbic acid and riboflavin.

Saurabh *et al.* (2005) reported that there was a need to produce such strains of microalgae that can tolerate harsh tropical conditions. HUFA were advantageous for bivalve growth and development. *Brachionus plicatilisis* regarded as the starter diet in larviculture of marine fish. *Brachionus plicatilis* reproduce by the process of parthenogenesis. Cysts (after decapsulation), nauplii, juveniles, sub-adults all the stages of *Artemia* were used as food. *Artemia* cysts regained their metabolic activity when immersed in seawater. It was easily produced from the storable powder which when dry called the *Artemia* cysts. Yet rotifers and *Artemia* could not satisfy the nutritional requirements of larvae. For this purpose copepods can also be used as live feed in order to enhance the output.

Fernandez *et al*. (2006) reported that microalgae were important in nutritional value for black-lip pearl oyster. In recent years tropical microalgae had become available for bivalves. Seven species of microalgae include two diatom species, three species of golden brown flagellates, two green flagellates and one species of unidentified coccoid. These species were examined for the content of carbohydrate, lipids and proteins. The study provided important information in role of microalgae as live feed for bivalves.

Balcazar *et al.* (2006) studied that the most important factor which determines the quality of live feed was the content of HUFA. In recent years hard efforts resulted in many techniques of enrichment and bioencapsulation. The nutrients which were absent in an organism can be made available by enrichment techniques. In case of microalgae culturing the major problem was the cost of algae production. In organisms cultured in laboratory conditions the condition should remain constant. Any change in conditions like temperature or humidity change could cause destruction of culture. Live feed was also carrier of certain diseases some very dangerous. Maintenance of hygienic conditions was essential for good growth of culture. The enrichment techniques were costly for deprived farmers. There was still a need to develop suitable cost effective techniques.

Delbare *et al.,* (2006) reported that when the larviculture was first practiced there was a huge hurdle for biologists regarding the substitution of plankton food by other nutrient rich as well as cost benefit food. After many years of hard work the food for culturing species was found effective. Among the live foods for fish farming the most important foods include limited number of algal species, the rotifer *Brachionus plicatilis,* and the brine shrimp *Artemia.* These feeds are used on a worldwide scale in industrial farming of fish and many species of shellfish.

Wang (2007) reported that bioencapsulation was helpful for improvement of nutritional content of live feed organisms. The technique involved the enrichment of live feed organisms by feeding the live organisms with different kinds of nutrients. Bioencapsulation and enrichment play a vital role in attaining maximum production and profitability. The live feed organisms can also be integrated with various other kinds of nutrients. In this technique live feed organisms were used as carrier for transferring certain nutrients in host aquatic organisms. If there was possibility to introduce beneficial bacteria in a rearing system mortality rate can be reduced. High mortality rate was due to intensive culturing. Probiotics showed positive effect on growth, resistance of stress, enhancement of immune system and also the general welfare.

Mandal *et al.* (2009) describes the feeding of fish in presence of natural and artificial feed in aquarium. The experiment was done to evaluate the enhancement in growth and performance of *Prochilodus argenteus* in presence of natural and artificial diet. Frozen *Artemia* was used as natural diet in comparison with artificially prepared diet. The larvae were reared for 21 days under optimal conditions with frozen *Artemia* and artificial diet. The larvae gained the same growth, performance, survival, weight and strength. But there was a huge difference in ammonia concentration in both groups. Ammonia concentration was less in larvae fed with *Artemia*. But in case of artificial diet the ammonia concentration also damaged the water quality. So, frozen *Artemia nauplii* were better feed for larviculture of *Prochilodus argenteus.*

Dave (2009) reported that waste-water cultured *Daphnia* can be used as first start feed of rainbow trout (*Salmo gairdneri*). *Daphnia* was cultured in wastewater medium from February to

May. The density of *Daphnia* was increased along with increment in amount of biomass in culture medium. Then, it was used as first-feed for larvae of rainbow trout. The larvae were examined for 56 days. There was an increase in weight and growth of larvae. Also the larvae take up the *Daphnia* at higher rate.

Ananthi *et al.* (2011) reported that marine copepods were one of the most important food sources for shrimp culture. Copepods were used as live feed for shrimp culture. The vulnerable and death causing diseases affected greatly the development of shrimp culture. Lack of suitable feed was also a problem in progress of shrimp industry. Due to less output shrimp export had gone through many highs and lows. Shrimps with bright color were considered of good quality. For this purpose the food with high nutritional value as well as with high pigmentation was preferred. To make shrimps look brighter carotenoid pigments were added in diet of shrimps. Astaxanthin was commonly used carotenoid pigment. Astaxanthin played a role in body pigmentation. It was also known to be a potent antioxidant and was suggested to play role as vitamin-A precursor. Carotenoids played role in intra- and intercellular signaling and also in expression of genes. Shrimp larvae that feed on copepods develop brighter colors with more weight and more growth. So, there was a need to develop copepods of good quality for survival and development of larvae. This was essential for high calorie content providing more energy to different larvae sizes. These nutrients also played role in easy digestion, rapid growth and metamorphosis. As copepods became mature from larvae to adult, broad range copepod size provided food for different developing sizes fishes or other larvae.

Sales (2011) reported the comparison of live feed with commercial compound diet. Experiments were carried out to know whether compound diet was suitable for fish larvae as a first-feed or not. 47 studies conducted with 27 freshwater species led to the formulation of same observation. The larvae fed with compound diets had 2.5% higher death rate than the larvae fed with live feed. When *Artemia* were used as live feed the mortality rate for larvae fed with compound diet was less that means compound diet was more effective when live feed was *Artemia*. But when live feed was zooplankton the compound diet was less effective.

Santhanam and Perumal (2012) stated that copepods proved to be nutritionally richer than *Artemia* or rotifers because copepods provide more nutrients to organisms than *Artemia* or rotifers. Comparison can be made about the growth rate and survival rate of fish and other aquatic larvae fed on copepods. Larvae of Asian seabass, *Lates calcarifer* fed on copepods as well as other organisms but the 21 day bass showed meaningfully upgraded growth and survival than other bass which fed on *Artemia* or rotifers. The weight of larvae fed on copepods was also higher than the weight of larvae fed on *Brachionus plicatilis* or *Artemia nauplii*. It indicated that the nutritional content of copepod *Oithona rigida* can support aquatic animals more with noticeable growth.

Das *et al.* (2012) reported that producers were trying to find new species for using as live food which were better suited to environment. The co-feeding of larvae on artificial and live feeding was recommended. To administer vaccines and certain other medicines microencapsulated diets were useful. In nature, larval stages feed on ciliates with a soft body and were rich in nutrients. Ciliates feed on organic wastes in the culture medium. But still, the nutrient content of ciliates as feed was not known. Earthworms were also an important food source. It was used as feed in combination with other feeds or alone. Bioencapsulation made fairy shrimp an excellent nominee to be used as food. The cysts of fairy shrimps contained 45-50% protein and 5-6% of lipids.

Santhanam *et al*. (2012) stated that copepods were better feed as compared to other conventional feeds. Copepods were regarded as most reliable feed for marine larvae and more than 60 species of copepods have been raised. The oldest cultures of copepods had come from Denmark. In 2006, world campaign was started to make people aware of the importance of copepods in aquaculture and other fields at large. For this purpose a database was established and more than 30 cultures of copepods have been known to this database. After a period of utilization of rotifers as live feed, aquaculturists started using copepods as live feed. *Artemia nauplii* were not introduced at that time. Copepods vary greatly in size species and qualities. Copepods also had high concentration of proteins, HUFA, carotenoids and other essential compounds. Other qualities of copepods were their swimming movements as larval visual stimulus with possible improvement of feeding rates and improved development and growth.

Rasdi and Qin (2014) stated that quality of live feed can be enhanced by nutrient enrichment. In hatchery at commercial level the better quality of live feed was very important. The adequate supply of food to growing larvae was of enormous importance. At the onset of feeding in larvae, the use of live feed was mandatory. In nature, the marine larvae feed mainly on copepods. But in hatcheries the production of copepods was more than a challenge. Copepods could not be cultured with same nutrients used for culturing of rotifers or *Artemia*. There existed some production protocols for rearing of copepods in artificial media. The emulsion oil used for rearing of rotifers was not effective in culturing of copepods. There was some alteration in copepod food before they are used to feed larvae.

Dey *et al.* (2015) stated that probiotics were essential for growth and progress of various aquaculture species. The constant goal of aquaculture was to attain maximum profit and minimize the losses. Microbial control strategy was needed for intensification and commercialization of aquaculture production. The distribution of micronutrients as well as probiotics through diet or as supplement was a conventional method of aquaculture. If probiotics were given to organisms directly there was no guarantee of them to be absorbed by organisms. But conventional methods were not so feasible because some probiotics were not able to bear the high temperature of food processing. Normal growth and other activities of larvae depended directly on the quality of feed provided to those organisms. Bioencapsulation of live feed with probiotics was therefore useful in proper growth of organisms. The microorganisms, which affect the host with increased growth and other benefits when administered in correct amount, are called probiotics.

Abaho *et al.* (2016) studied the use of locally grown rotifer, *Brachionus calyciflorus* as a starter live feed in nourishing of African catfish, *Clarias gariepinus*. Rotifer was used as an alternative to *Artemia* in this case. For this purpose the catfish larvae fed with rotifer, freshly decapsulated *Aremia* cysts and a mixture of both feeds in three experimental groups for three days. After these three days the larvae were thought to find their food themselves. Before placing in groups the length of larvae was measured with the help of gas chromatography mass spectrometry (GC-MS). The larvae were six days old at the time of measurement. It showed that the larvae fed with rotifer showed more growth than larvae fed with *Artemia*. But there was a remarkable fact that the larvae fed with a mixture of both *Artemia* and rotifers showed faster growth than those larvae fed on either *Artemia* or rotifers. The larvae fed with rotifers illustrated a remarkably high concentration of some fatty acids like Arachidonic Acid (AA) and Docosahexaenoic Acid (DHA) than those fed on *Artemia.* Better growth of rotifer fed larvae was due to the fact that AA and DHA played a very outstanding role in functional, structural and physiological development of larvae. In case of larvae fed with both *Artemia* and rotifer there was an enhanced catchability. It was probably due to larger size of *Artemia* which increased the capturing sense of larvae. Thus partial of total replacement of *Artemia* was favorable for larval growth.

RESULTS AND FINDINGS

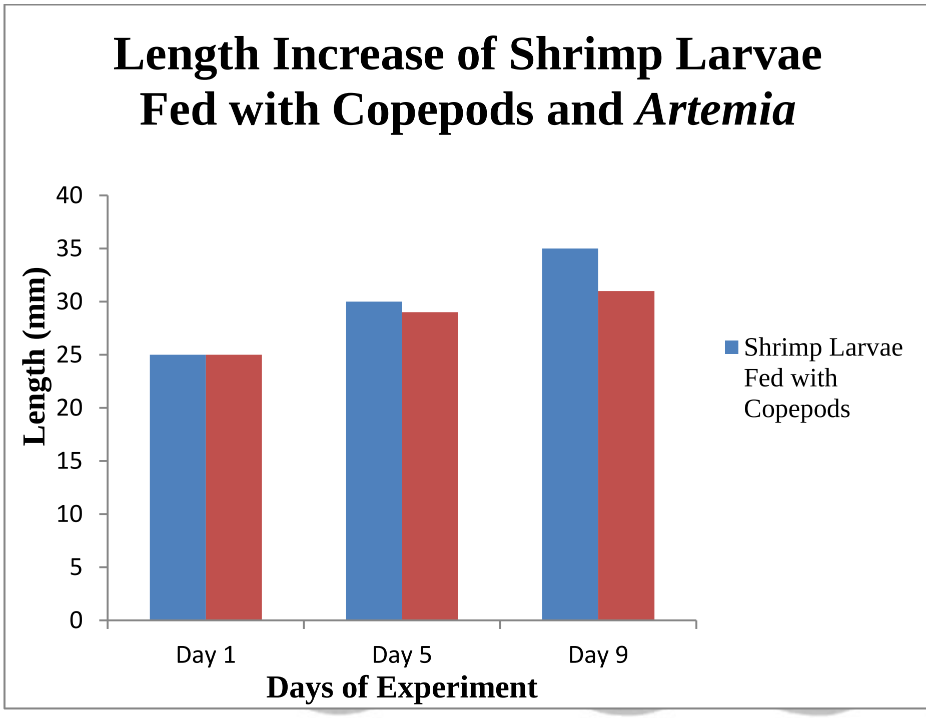
In aquaculture freshwater and saltwater populations are reared under perfectly controlled conditions to assure better possibilities for future food production. Planktons are the main source of energy and start the food chain in aquatic environment. There are many different kinds of aquaculture. Fish farming, oyster farming, shrimp farming, mariculture, algaculture i.e. Seaweed farming, and cultivation of ornamental fish but most of the time the ornamental fish cultivation is not consider in aquaculture. Europe has also made progress in aquaculture in the last decade with prominent culturing of seabass, *dicentrachus labrax* and of gilthead seabream, *sparus aurata* mostly zooplankton and phytoplankton are used as food by larvae of many fish, shellfish species and other marine animals.

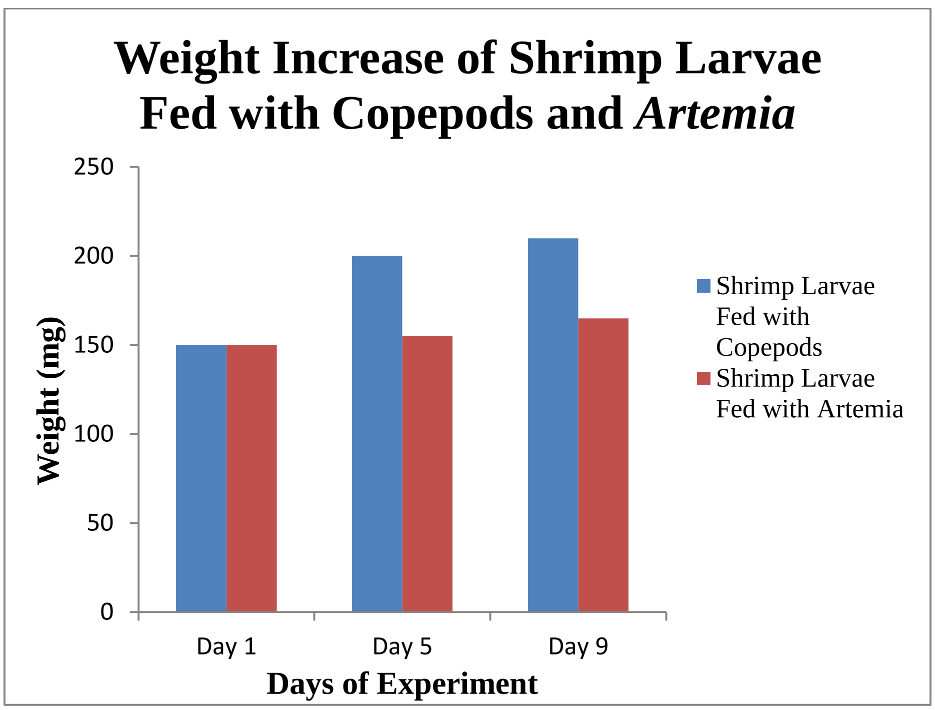
As zooplanktons vary in size from minute to large they provide suitable food source to larvae of all sizes whether small or large. The parasites brought by zooplanktons include fish flea (*Argulus faliaceus*, the fresh water flea and *Livoneca* species, and the marine water flea) and parasitic copepods (*Lernaea* species are the freshwater parasitic copepods and *Lernaeascus* species are the marine water copepods).

Cladocerans are known as water fleas in general. Two cladocerans called *Daphnia* and *Moina* are commonly used as live feed. Cladocerans are highly advantageous because they have high reproduction rate. Daphnia is more than 70% protein. *Miona* is also replacement feed for Artemia in rearing of most fishes like rainbow trout, salmon, striped bass, *Lates calcarifer*, *Macrobrachium.* The 50% of the dry weight of *Moina* contains protein. Adult *Moina* have elevated fat content as compared to juveniles. Fat content is 20-27% of dry weight in adults and 4-6% in juveniles. Live foods for aquaculture also include nematodes. The total fish production of the world is reported to be 142.3 million ton per year. The best know worm as food is red worm *Tubifex tubifex*.

Microalgae are used in rearing of bivalves but from the beginning the microalgae used for rearing bivalves were of temperate origin. Among rotifers *Brachionus plicatilis* is used as food source for marine fish and some shrimp species. Copepods show a better proteolytic activity than

Artemia. They also have good fatty acid composition having more DHA than *Artemia*. Thus, copepods are an excellent source of nutrients with high energy value. Larvae of Asian seabass, *Lates calcarifer* feed on copepods as well as other organisms but the 21 day bass show meaningfully upgraded growth and survival than other bass which fed on *Artemia* or rotifers.





Chironomids are the non-biting midges. They are 56% protein. They are also a source of lipids, vitamins and minerals. *Tubifex* is also used as live feed but is not used as live feed for larval and post larval stages of fish and shellfish species. *Tubifex* is best favored diet for many ornamental fish species. Orthodox live feeds like rotifers and *Artemia* are useful for finfish or crustacean larvae but they are not good for certain fish species like bluefin tuna because these fish feed mainly on planktonic copepods. The live feed is added to fish tank in which larvae are cultured. The larvae mostly require a prey of 50-100μm wide at the time of first feeding. The rotifers are too large for some larval species to eat. So, there is a need to develop a superior feed. Planktonic food organisms include photosynthetic organisms *Volvox, Eudorina, Oscillatoria*, *Microcystis* etc. and non-photosynthetic organisms and saproplanktons e.g. bacteria and fungi.

Zooplanktonic organisms include plankters of animal origin. In tropical areas main zooplanktons are protozoans like *Arcella* spp., *Difflugia* spp., *Actinophrys* spp., *Vorticella* spp., etc., rotifers like *Brachionus* spp., *Keratella* spp., *Polyarthra vulgaris* etc. Cladocerans, ortracoda like *Cypris*, and copepods and their larvae. The live food organisms also belong to class ciliata of phylum protozoa. These are the microscopic organisms and are single celled animalcules called infusoria. Microalgae provide nutrients as proteins with essential amino acids, PUFA, pigments and sterols. Microbes can also be used as live feed for larvae of many species.

Bacteria are good in their nutritional content with essential amino acids, proteins and polysaccharides. Astaxanthin plays a role in body pigmentation. It is also known to be a potent antioxidant and is suggested to play role as vitamin-a precursor. Marine copepods are undertaken as “nutritionally superior live feeds” when commercial species are concerned because they are valuable source of proteins, enzymes (exonucleases, proteases, esterase etc.), carbohydrates and lipids. Live foods organisms are commonly known as “living capsules of nutrition” because they contain all the essential nutrients like protein, lipids, carbohydrates, vitamins, minerals and fatty acids. The larvae fed with rotifers illustrated a remarkably high concentration of some fatty acids like arachidonic acid (AA) and docosahexaenoic acid (DHA) than those fed on *Artemia.*

The cysts of fairy shrimps contain 45-50% protein and 5-6% of lipids. Seven species of microalgae include two diatom species, three species of golden brown flagellates, two green flagellates and one species of unidentified coccoid. Probiotics are very important in avoiding the colonization of pathogenic bacteria.

Live food Organisms	Species	Use in Aquaculture
Zooplanktons	*Arcella spp.* *Difflugia spp.* *Actinophrys spp.* *Vorticella spp.*	Varying sized organisms for varying sized larvae and adults. Starter food for larvae.
Rotifers	*Brachionus spp.,* *Keratella spp.,* *Polyarthra vulgaris* *Artemia nauplii*	Food for shrimp larvae and adult. Easy to culture. Artemia develop rapidly from cysts.
Phyoplanktons	*Volvox,* *Eudorina,* *Oscillatoria,* *Microcystis*	Makes 1st tropic level in marine food chain. Food for zooplanktons. Food for fish and finfish larvae.
Cladocerans	*Daphnia* *Moina*	High reproduction rate. Live food for ornamental and freshwater fish species. Replacement feed for Artemia.
Ortracoda	*Cypris*	Food for larvae
Ciliates	Infusoria *Paramoecium* *Stylonchia* *Fabrea* *Euplotes*	Ideal starter diet for larvae.
Microalgae	Diatoms Flagellates	Food for adult and larvae of bivalves. Food for rotifers.
Copepods	harpacticoid & calanoid copepods	Superior to Artemia.
Nemaodes	*Panagrellus revives* *Caenorhabditis elegans*	Live food for larvae in laboratory.
Tubifex	*Tubifex tuifex*	Food for larval and post larval stages of fish

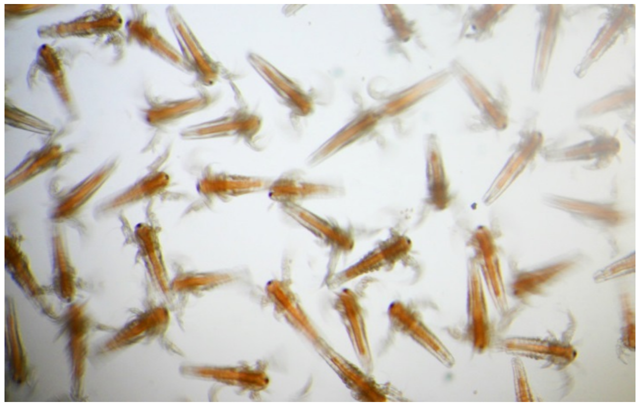


Figure 1 *Artemia nauplii*

Figure 2 Copepod

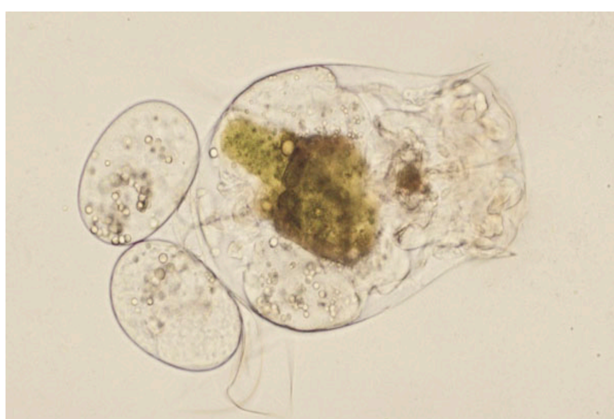


Figure 3 *Brachionus plicatilis*

Figure 4 Zooplankton

Figure 5 *Daphnia*

Figure 6 *Moina*

Figure 7 Infusoria

Figure 8 Microalgae

Figure 9 *Cypris*

SUMMARY

Aquaculture is the farming of aquatic organisms which are of some use for us. In aquaculture perfectly controlled conditions are maintained to assure better possibilities for future food production. In aquaculture farming the rearing processes are somehow changed and modified to increase the production. Planktons are the main source of energy and start the food chain in aquatic environment.

Japan is considered as the pioneering country in culture of certain species i.e. the red seabream, *pagrus major*, and the kuruma shrimp, *panaeus japonicas*. Penaeid shrimp culture has got great success in tropical Asia and Latin America because it gives very high output and profit. These days, the industries rearing the larvae of marine fish and shrimp produce more than 50 billion post-larvae of shrimp and more than 400 million marine fish fry. Some fishes like salmons have big yoke sac that provides embryo with food and marine fishes have very small yolk sac that provide food for some days.

The plankton diet provides the larvae with important nutrients needed for growth and metabolism. It also facilitates the nutrient uptake by larvae and the larvae feed on a very broad range of zooplanktons. The hatcheries which are located near some large water body make use of zooplanktons as natural feed of larvae. Zooplanktons can be used as a sole source of food or a supplement diet for larvae. Microalgae are mass-cultured in order to provide food for larvae and juvenile bivalves.

Mostly harpacticoid and calanoid copepods are used as food but they are difficult to culture. Daphnia and Moina are commonly used as live feed. Daphnia are mostly use as replacement of live feed for Artemia in mariculture. Mostly free-living nematodes are used as food for rearing organisms. Tubifex is best favored diet for many ornamental fish species.

Chronomid are copious group of benthos insects. The soft tubes made of organic matter provide first shelter to larvae. The copepods form the starter level in order to provide food for larger animals. The larvae which feed on copepods show better development and high survival rate than others which feed on artificial diet. Lipids are important nutrient in these live feed not only for their high oily energy but also for delivering PUFA (polyunsaturated fatty acids) that

play an essential role in optimal pigmentation, maintenance membrane fluidity that is important in growth and survival of fish. The movement of live feed stimulates feeding behavior in larvae and various live feeds are with high water content.

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