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REVIEW ARTICLE

Production and application of live food organisms for freshwater ornamental fish Larviculture

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ABSTRACT
Ornamental fish are being kept for more than three centuries, particularly in Europe since the early 17th century. The culture of larvae of many species of ornamental fish is precariously dependent upon the availability of live foods, whether plant or animal. Although the recent progress in the production of artificial feeds for ornamental fish larvae, feeding of most species still relies on live foods during the early life stages. Besides their nutritional value, live foods are easily detected and captured, due to their swimming movements in the water column, and highly digestible. The present paper reviews the main types of live foods used in ornamental fish larviculture, their advantages and deficiencies, with a special stress on their nutritional value. The most frequently used live foods in ornamental fish larviculture are rotifers (Brachionus sp.) and brine shrimp (Artemia sp.). Though, both rotifers and Artemia have nutritional deficiencies for marine species, mainly in essential n-3 highly unsaturated fatty acids (HUFA). Enrichment of these live foods with HUFA before using them as live food appears to increase growth and survival of a variety of larvae. Several species of microalgae are also used in larviculture. These are used as feed for culture of other live food organisms in the green water technique in larval rearing of ornamental fish, with presumed beneficial effects on feeding behaviour, digestive function, nutritional value, water quality and micro flora. Copepods and other natural zooplankton organisms have also been used as live foods, normally with significantly better results in terms of larval survival rates, growth and quality, when compared with rotifers and Artemia. However, research on nutritional requirements of ornamental fishes is required in order to determine optimal dietary inclusion levels.
Keywords: Rotifers, *Artemia*, Microalgae, Copepods, Nutritional Value, Ornamental Fish Larvae.

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INTRODUCTION

The commercial propagation of fresh water ornamental fish culture has been hindered by the lack of suitable live food organisms for feeding the fish species at the various developmental Stage [1]. Live feeds refer to those living organisms which are directly consumed by the ornamental fishes. As the live feeds contain all the nutrients required by the ornamental fishes, they are known as "Living Capsules of Nutrition" [2-4]. Ornamental fishes, particularly at their larval stages largely depend on the live feeds for their nutritional requirement and the most important live food organisms are the microalgae, *Spirulina* sp., the rotifer, *Brachionus* sp., and the nauplii of brine shrimp, *Artemia sp* and cladocerans, *Moina* sp. [5, 6]. The success of the culture of ornamental fishes largely depends upon the consistent availability of sufficient quantities of live food organisms for feeding the ornamental fish larvae, fry and fingerlings [1]. The live feeds can be collected from the natural environment or cultured under controlled hygienic conditions. Live food organisms culture helps in uninterrupted supply of live feeds cheaply to the ornamental fish, with a least risk of diseases [4]. Lots of the live food organisms applied for fry production of marine species could also be used successfully in the fresh water ornamental fish culture to improve the growth, stress resistance and survivality [1].

Why is live feed necessary?

The first-feeding larvae of ornamental fishes are quite fragile and delicate creatures. At this critical phase of their life, they are required an appropriate nourishment for their survival and growth [2]. Therefore, the supplied diet should be easily digestible, have enzyme system that autolysis and provide all the essential nutrients required by the larval ornamental fishes, but formulated diets falls to support all these requirements and resulted poor growth and survival [7]. The yolk sack of altricial larvae of ornamental fishes are incapable of digesting formulated feeds due to the undeveloped state of their digestive system and those who feed on live food organisms show comparably much better growth and survival [8]. Larval stages of the most adult finfish and crustacean's species have to depend entirely on live feeds [9]. Fresh water ornamental fishes should be given live feeds during early stages of the live cycle [10J.

Live food organisms usually have much better contrast than formulated feeds and the continuous movement of live food organisms in water is likely to stimulate the ornamental fishes to approach and ingest feeds in sufficient quantities to sustain growth. The live food organisms swim ceaselessly in the water column which assures a sound distribution of food items and are available frequently to the ornamental fishes [11]. Whereas the formulated diets generally aggregate on the water surface or more commonly submerged to the bottom and are normally less available to the ornamental fishes than are the live feeds. Usually, live food organisms possess a thin exoskeleton and high water content that may be more palatable to the larvae of the ornamental fishes once taken into the mouth, compared with the hard, dry artificial diets [8]. Live feeds increases colouration and immunity of ornamental fishes, and they are instinctively fascinated towards the live food organisms [4].

Feeding synthetic diets to ornamental fishes, resulted improper production of viable eggs, but feeding live food organisms e.g. Tubifex with or without synthetic diet, resulted more production of eggs which are readily fertilizes [12]. Some live bearing ornamental fishes need to be feed with live food like brine shrimps, white worms, blood worms, small fishes shrimps and clam [13]. Live feeds can be given at fewer quantities, at lower rates and uneaten feed does not deteriorate as fast as artificial feeds. Culture with formulated feeds has been failed in numerous species of ornamental fishes in replacement of live feeds [11]. The fresh water rotifer, *Brachionus caliciflorus* and *Artemia* nauplii could be used for raising brown discus (*Symphysodon aeuifasciata axelrodi*) larvae in the absence of their parents which would reduced the possibilities of larvae being fed by parent fish and found comparable growth and survival [14]. The exact requirement of the minerals and nutrients for spawn and fry of ornamental fishes are not known so far and the elements can be provided through live feed, moreover spawn and fry prefers live feed rather than artificial feeds.

Large commercial aquarium fish producers in Singapore use live feed as supplementary feed with artificial diets as the application of live feed improves growth [15]. Regular supplementation of *Daphnia* sp., as live feed to sword tail *(Xiphophorus heleri)* brood stock maintained in formulated feeds resulted in a significant increase in fecundity due to more rapid growth, high number of embryos, and an improved feed conversion ratio [16]. Supplementation of formulated diets with *Artemia* increased growth of juvenile angel fish *(Pterophylum sealare)* [17]. Voracious and indiscriminate feeder, ruby barb *(Puntius nigrofaseiatus)* prefers live food organisms to formulated diets [18].

Important live food organisms

The most frequently used live food organisms for ornamental fish culture are microalgae, diatoms, *Chaetoceras* sp. *Skeletonema* sp. *Thalassiosira* sp. *Phaeodactylum* sp.*Nitzchia* sp.*Cyclotella* sp. flagellates, *Isochrysis* sp. *Tetraselmis* sp. green algae, *Chlorella* sp. *Dunaliella* sp. Blue green algae, *Spirulina* sp. *Clamydomonaus* sp. and red algae, *Porphyridium sp* **[19];** rotifers, *Brachionus plicatilis, B. caliciflorus,* brine shrimp, *Artemia salina* [20]*;* infusorians *Paramaeeium* sp. *Stylonehia sp* [4]*;* cladocerans *Daphnia* sp. *Moina sp* [2] copepods, *Cyclops* sp. [21]; microworms, *Tubifex* sp. *Anguillula silusiae,* chironomid larvae; nematodes, *Pangrellus redivivus* [22]; mosquito larvae [3], Fairy Shrimp *(Streptocephalus sp)* [23]; *earth* worms, white worms, glass worms, fresh water shrimps, gentles [24] and molluscs. Among molluscs, the most important live food items are gastropods. Black carp and Gouramy mostly feed on molluscs like *Limnea* and *Planorbis* .

Microalgae

Microalgae are highly diverse group of unicellular organisms, show enormous morphological diversity, occupy extreme habitats ranging from tropical coral reefs to Polar Regions and contribute to half of the globe's photosynthetic activity [25]. Among the live food organisms, the single cell proteins, micro algae are the most costly and probably least known live feed ranging in the size from 5 to 25 microns. Importance of micro algae in ornamental fish culture not only due to its nutritional attributes i.e. primary source of protein food but rather for its small size and satisfying well the feed size requirements for first-feeding stages of ornamental fishes [2]. Microalgae serve as live food for most of the important ornamental fishes as well as molluscs and crustaceans. In addition, micro algae can be used to grow

Brachionus sp. And *Artemia* sp. that are fed to young stages of ornamental fishes and used to enriched them with nutritional components especially fatty acids and sterols, required by the larval ornamental fishes [19]. Micro algae have antibacterial and immune stimulatory properties. In addition, Micro algae stimulate enzymatic synthesis and on-set feeding in young larvae of ornamental fishes. Blue-green algal forms like *spirulina* is rich source of proteins, beta-carotene, cyanocobalamine, lysine, threonine and methylalanine and diatoms are rich in as many as 17 amino acids and β-carotene and hence they are potential live feeds for ornamental fishes [26].

Micro algae Culture

Algal cultures are potentially used for rearing larvae of ornamental fish. For successful culture of micro algae, different types of chemical media have been used depending upon the type of organisms cultured and their growth phase. In algal culture, isolation and purification forms important steps so as to produce pure diets for ornamental fish culture. Isolation and purification of the required species of algae is done by using different methods like pipette method, centrifuge or washing method, serial dilution culture method or by agar plating method. Among these, serial dilution culture technique is mostly used one. Here, 6 dilution steps are used for isolating the algae. 5 series of different concentrations culture tubes is inoculated with growth media and kept under illumination of 1000 lux with temperature maintained within 25° - 26° C. After 18-20 days, colour changes with the growth of algae. Then, sub culturing is done in 500 ml conical flask for purification. Then the culture is transferred into 3 or 4lit. Hoftkan's culture flasks for using as stock culture. From the stock culture tubes, cultures are transferred at regular intervals to small flasks followed by carboys or bag and 160 lit. cylinders ultimately shifted to outdoor 500lit. poly tanks. The mass culture is carried out for the commercially important algae [26]. Generally, 8-ton or 35-ton cylindrical fibre glass tanks are used for mass culture. 8-ton tank is inoculated dally either by pumping two 5001it. tanks from the algae culture room for getting the initial density is about 1,50,000 to 2,00,000 cells/ml. The fertilizers/nutrients (e.g. FOGG'S Medium; for blue-green algae) are mixed at the inoculation time by keeping them into a bolting-cloth sock hung in the tank. On the third day, the average cell density is 1.2 x 10^6 cells/ml and the 8-ton tank is then pumped into one 35-ton tank as the inoculums. Subsequently the 35-ton culture tank can be inoculated every day using a 3 day old culture of an 8-ton tank as starter. They are harvested after achieving a peak density. Algae are skimmed off from the surface of the mass culture containers and centrifuged at 4000 x g and washed with freshwater and then recentrifuged. Based on the need it is either fed immediately or frozen or dried by evaporation at 105°C for 24 hrs. for later use. Further, the algae are centrifuged, flocculated or immobilized as per the need.

Rotifers

Rotifers are usually microscopic and commonly called as "Wheel Animalcules". The rotifers are slightly larger than infusorians and inhabits in a wide range water bodies such as freshwater, brackish water, saltwater and backwaters. The marine rotifers, *Brachionus plicatilis* is pelagic euryhaline species and used world-wide as live food organism because of its high nutritive value, small size, slow swimming velocity, world wide distribution, fast multiplication easy adaptability to captive culture and easy catchability by the larvae [27, 28]. In addition, they have the habit of staying suspended in the water column, high reproductive rate and high density cultures. They can tolerate temperature of between 15 to 31^{0}C and optimum Ph is 6-8 at 25^{0}C [29]. *Brachionus plicatilis* forms the best starter-live food organisms for the early stages of ornamental fishes that can not ingest the larger *Artemia* nauplii [2, 3, 30]. Rotifers in small length (50-I00µm) as well as larger one (100-200μm) can be used for feeding of cultured ornamental fish larvae based on the mouth size of that species . The fresh water rotifer, *Brachionus calyciflorus* can also be used ideally as live feed for feeding the larvae stages of ornamental fishes and intensive larviculture of freshwater ornamental fishes can be possible by using the rotifers which influence better larval growth, survival and stress resistance and an exponential increase in the yield [31, 10]. The rotifer, *Brachionus calyciflorus* could be used as starter feed to improve growth and survival of juvenile dwarf gourami (*Colisa lalia*) [1] as well as white cloud mountain minnow, *Tanichthys albonubes* [1]. The brown discus larvae could be reared by using rotifers in the absence of the dependence of body slime of parents as nutrient source during exogenous feeding period [1]. The rotifers, *Brachionus plicatilis* and brine shrimp, *Artemia* are the two vehicles by which the nutritional components are delivered to the fish larvae and satisfy the dimension and numerical requirements [32, 33, 30]. As the rotifers could be kept alive in the aquarium, only one feeding per day is needed. It is cleaner, cause no pollution in the larval tank, hence water change after each feeding is not required [1]. Marine rotifers can be survived in fresh water for at least 2hrs. and have been used for feeding larvae of Japanese ornamental carp and bait fish *Carassius* sp.[32]. Enrichment of rotifers with HUFA before using them as live food appears to increase growth and survival of a variety of larvae [34].

Rotifers Culture

The culture of rotifers, *Brachionus plicatilis* is carried out in several methods like mass culture, continuous culture but foremost thing need to be developed is stock culture. *Brachionus plicatilis* is collected from brackish water bodies with the help of scoop net and diluted with fresh water. Examining under microscope, *Brachionus plicatilis* is picked up with the help of dropper and inoculated in a 10 ml glass tube. They are fed with yeast @ 200 ppm or Chlorella at l0 x 10^6 cells/ml density. Subsequent serially dilution is carried out daily through several large tubes like 20ml to 50ml and 100mi capacity beaker. These stock cultures are used as inoculums for mass culture. Mass culture of rotifers can be initiated in 200-500lit. culture tank through the inoculation with Chlorella by using 'F' medium. Then 25 to 50 individual/ml of *Brachionus plicatilis* are added in the culture tank after Chlorella density reaches in the ranges from l0x10^6 to 20x20^6 cell/ml. 50% of *Brachionus plicatilis* can be harvested within 24 hrs for feeding the ornamental fishes. The fresh water rotifer, *Brachionus calyciflorus* can also be cultured using 5 lit-vessels and fed with the fresh water Chlorella [35].

Artemia

Artemia salina is commonly known as "Sea Monkey or Brine Shrimp" and inhabits in salt pans and tolerates a wide range of environmental conditions. It is a non-selective filter feeder and capable of growing at a very high densities. It has high nutritional value, high fecundity rate and considerably long life span. All the life stages of *Artemia* i.e. cysts, nauplii, sub-adults, adults are used as fed for various stages of ornamental fishes and nauplii particularly acts as an excellent feed for early stages of ornamental fishes [2,3]. Among the live food organisms used for the feeding of ornamental fishes, *Artemia* constituted the widely used live food diets due to their convenience as an off the shelf feed and required only 24hrs of incubations from cysts [36]. *Artemia* do not have any anatomic defence mechanisms against predators; consequently, they are an easy prey for the ornamental fish larvae [37]. Freshly hatched *Artemia* nauplii provide important growth molecules like highly unsaturated fatty acids (HUF As), carotenoids and proteins to the ornamental fish larvae. Feeding the ornamental fishes with *Artemia* nauplii produce flourishing progeny and exhibit enhanced growth because of more efficient feed conversion and develop greater resistance to disease. *Artemia* stimulated the predatory responses in *Xiphophorus heleri* and resulted in higher food consumption and growth because of its large size, movement and high protein (56.5%) content. Adult *Artemia* provide all the amino acids and more protein than nauplii. Nauplii are lacking of histamine, methionine, phenylalanine and threonine. Live *Artemia* contains enzyme [38] that help in digestion of formulated feed in juvenile ornamental fishes. Despite of the marine origin of the *Artemia* nauplii, they have a good potential for application in the fresh water ornamental fish culture [20]. Ornamental fishes feed on *Artemia* have been observed to grow faster, survive better and even become more disease resistant compared to those fed on other type of live feed. They biggest advantage of using *Artemia* is that one can provide live food "on demand" from dry staple powder i.e. dormant *Artemia* cysts which upon immersion in sea water regain there metabolic activity and within 24 hours release free swimming larvae (nauplii) of about 0.4mm length. Generally *Artemia* nauplii die after 30-60 min. in fresh water must be feed to the fish intermittently every 2-3hrs. This problem could be overcome by adopting the cold storage technique which preserve the nutritional quality and energy content of *Artemia* nauplii at temperature near 4^0C [26]. Now-a-days frozen adult *Artemia* are widely used by ornamental fish breeders and aqua culturists [3]. The growth performance of guppy (*Poecilia reticulata*) fry and adults feed *Artemia* nauplii were significantly better than those feed Moina [39]. Decapsulated *Artemia* cysts could be used for feeding larvae of ornamental fishes because of their smaller size (200µm), more hygienic and containing 30% more energy than newly hatched *Artemia* nauplii and could be applied replacing *Artemia* nauplii or Moina in fresh water ornamental fish culture [20]. The fry of fresh water ornamental fishes like from guppy (*Poecilia reticulata*), platy, swordtail *(Xiphophorus heleri)*, molly and black neon tetra could readily accept decapsulated *Artemia* cysts and their performance is comparable or better in terms of growth, survival and stress resistance than those feed *Artemia* nauplii and Moina [39]. The older and bigger on-grown Artemia could be used as live feed in the hatchery for feeding brooders of ornamental fishes. The bigger Artemia would certain by meet the demand for live food organisms bigger than Moina in fresh water ornamental fish culture . the first growth and continuous non- selective feeding behaviour of Artemia makes it worth to consider their culture to a big size [40] used an ideal booster diet, as its nutritional quality could be enhanced to suit the fish requirements through bioencapsulation [20].

Hatching of *Artemia*

Cysts are taken into a container with sea water @ 20ml/1gm dry cysts with vigorous aeration and after 30 minutes, the cysts become hydrated and turn spherical. The hydrated cysts are filtered through 100 micron mesh bolting silk cloth. Now, the hydrated cysts are treated with 5% sodium hypochlorite

solution @ 15ml for every 1gm cysts and placed in cool water or ice water where uniform cooling is maintained. In about 5 to 10 minutes, the chlorine gets dissolved and the decapsulated cysts are filtered through 100 micron mesh bolting silk cloth and washing thoroughly with freshwater, dipped in 0.1 % sodium thiosulphate solution. After properly washing with 200 ppm chlorine, the cylindroconical FRP jars are rinsed with the same water which will be used for hatching the hydrated cysts. The jars are filled with 25 to 30 ppt filtered seawater and 100 lux illumination is provided. The decapsulated cysts in the jars are stocked at the rate of 0.5 to 1.0g/lit. The cysts are kept in suspension with the help of vigorous aeration provided at the bottom of the cone of the jars. The cysts hatch into nauplii in about 12 to 24 hours. The freshly hatched nauplii of *Artemia* are harvested in a 100 micron mesh net and washed thoroughly and stocked in a container containing seawater of similar salinity as that of hatching of cysts and used as live food for the young stages of ornamental fishes.

Infusorians

Infusorians refers to the tiny microscopic, single celled, most primitive animalcules of all organisms in the animal kingdom. The infusorians microorganisms inhabit fresh, brackish and marine water. Besides being small in size, they are soft bodied and nutritionally very rich. Infusorians serve as an ideal food for all stages of ornamental fishes [2, 3]. Among the numerous species of infusorians, the most commonly used live food organisms are *Paramaecium* and *Stylonychia.* [4]. These ciliates are found in tanks, ponds, and ditches containing foul smelling debris. The can be easily collected with fine mesh (0.13µm) cloth.

Culture of Infusorians

They can be cultured by using banana peelings or hay (straw) infusion or lettuce leaves or milk or apple snail droppings containing half digested leaves [3, 4]. In banana peeling method, 2-3 banana peelings are taken in a glass aquarium with filling 50lit filtered fresh water. The aquarium is kept in a cool place after covering with a mosquito net for getting natural light. Within 2 days water will turn milky and emit foul smell. A film of slime will be formed on the water surface. After 4-5 days the water will turn clear, becoming transparent with light yellowish colour. This indicates that the floating spores of infusorians have settled on the water and are feeding upon on the bacteria and multiply in large numbers. Subsequently, the film of the slime on the water surface breaks up and disintegrate. Then the culture is harvested for feeding early stages of ornamental fishes.

Cladocerans

The cladocerans are commonly called "Water Fleas". The commonest representatives of this group of crustacean are *Moina* and *Daphnia .Moina* and *Daphnia* inhibit fresh and low saline water ponds, tanks, lakes, puddle and some sewage lagoons. They have high reproduction rate, wide environment tolerance and ability to live on phytoplankton and organic wastes. *Moina* used to be the most common live food organisms in fresh water ornamental fish culture for feeding the early stages of fish [41]. They are quite popular live feed because of their easy availability and adaptability to captive condition [3]. *Moina* is smaller in size than *Daphnia* containing 70% more protein and therefore goes well as replacement of *Artemia* as live feed in ornamental fish culture. *Moina* feed on algae, bacteria and organic debris etc and multiple very fast. *Moina* is a major live food species used in the propagation of fresh water ornamental fish culture [42]. Having in the range of 10-16micron, measuring 0.5-2.0µm length, *Moina* forms a cheap source of live feed for ornamental fishes [2]. The food and feeding habits of Daphnia are the same that of *Moina. Daphnia* contains a broad spectrum of digestive enzymes such as proteinases, peptidases, amylase, lipase and even cellulose which serves as exoenzymes in the gut of the ornamental fishes. *Daphnia* is very cheap source of live feed for advanced stages of fry and Juvenile stages of ornamental fishes [2] and can be enriched with Ω-3 essential fatty acids to increase its nutritional status. Microalgae which are rich in Ω -3 essential fatty acids can be feed to *Daphnia* to increase their food value.

Culture of Moina

Before starting mass culture of *Moina,* stock culture need to be developed. For stock culture, *Moina* can be collected from freshwater ponds by using a scoop net and diluted it by adding fresh clean water and examined under a microscope to pick up *Moina.* Each *Moina* is inoculated in 20ml glass tube containing 10ml filtered water and fed with yeast @ 220 ppm or Chlorella at a cell density of l0 x 10^6 cells/ml. Each gravid *Moina* produces 8 to 10 off springs in about 24hrs. Subsequent serially dilution is carried out through several large beakers like 100ml to 1 or 2lit capacity. These stock cultures are used as inoculums for mass culture after one week. For mass culture of *Moina* the tanks should be fertilized with ground nut oil cake, single super phosphate and urea @75ppm, 20ppm and 8ppm respectively. Then the tank is inoculated with Chlorella or mixed phytoplankton. When algae blooms are developed within 3-4 days, *Moina* is inoculated @40-50 individuals/lit. *Moina* attains a peak density of 20,000 to 25,000 individuals/lit after a week of inoculation. After attaining peak density it is regularly harvested to feed the larval stages of the ornamental fishes.

Culture of daphnia: The stock and mass culture technique of Daphnia are quite similar to that of Moina culture.

Copepods

Copepods have higher nutritional value than commonly used live feed, *Artemia* and meet well the nutritional requirements of ornamental fishes [28]. Furthermore they can be used under different forms either as nauplii or copepodites at a start feeding of the larvae of ornamental fishes. Moreover, their typical zigzag movement, followed by short gliding phase, is an important visual stimulus for many ornamental fish which prefer them over rotifers. Another advantage of the use of copepods keeps the walls of the fish larval rearing tanks clean by grazing on algae and debris [22]. Majority of fish larvae prefers copepods than other live feeds in their larval and adult stages. The larvae feed with copepods resulted better survival and growth. Among the copepods, *Cyclops* generally inhabits in freshwater. They are usually found in ponds containing *Daphnia* and can be collected. These tiny crustaceans can be feed to all aquarium fishes and are particularly useful for small fry just out of the infusorians stages and fingerlings of ornamental fishes [3].Cyclops developing double sac cointalning eggs is situated at the side of body and adds to their desirability as a aquarium fish food [24]. Some of the larval stages of ornamental fishes prefers smaller copepod larvae over *Brachionus* because of its large size that may be unable to ingest. Copepods have high protein content and good amino acid profile with the exception of Methione, and histidine [28].

Copepods Culture: Culture techniques are the same as described for *Moina.*

Nematodes

Nematodes are free living organisms and successfully applied as larval food for several species, including *Crangon crangon,* king shrimp *(Penaeus blebejus),* common carp *(Cyprinus carpio)* and silver carp *(Hypophthalmichthys molitrix).* Among the nematodes, *P. redivivus* is a suitable larval live food as the size is very small (50µm) and it has an amino acid profile that matches that of *Artemia,* while its EPA and DHA content is respectively nearly a third and almost the same or a little higher of that of *Artemia* [22] used for the direct enrichment a culture medium which was fortified with a 10% fish oil emulsion, obtaining nematodes that had significantly higher total lipid content and elevated levels of (Ω-3) HUFA.

Nematode Culture

P. Redivivus can be cultured in trays filled with 70g of flour/100cm^2; the latter kept humid by spraying with water. The culture medium is supplemented weekly with 0.5g baker's yeast/100 cm^2. Covering with cloth, the containers should be stored in a well ventilated room at a temperature of 20-23°C. A maximum dally production of 75-100 mg/100 cm^2 is reached with in three week. The nematodes are harvested daily for about 53 days using the same culture medium by removal from the substrate with a spatula. The nematodes have a short generation time ranging from 5-7 days and a high fecundity.

Microworms

Among the micro-worms *Tubifex* and chironomid larvae are commonly used live food organisms for the rearing of aquatic organisms like ornamental fishes. *Tubifex* worms are commonly known as sludge worms and cluster of Tubifex worms can be found in sewage drain. *Tubifex* worms forms an ideal live food for breeders of various ornamental fishes [3]. Whereas, Chironomid larvae are commonly known as blood worms or red worms and moves towards foul smell where organic matters decomposes and lay eggs. Chironomid larvae forms one of the staple food items in the diets of almost all carnivorous young ornamental fishes [2, 3]. Large Scale Discus *(Symphysodon aequifasciata)* breeders depend chiefly on live foods such as *Tubifex,* Blood worms *Artemia* nauplii to feed the growing fry [44].

Culture of *Tubifex*:

A container can be taken with 50 to 75mm thickness pond mud at the bottom, blended with decaying organic matters and masses of bran and bread and then continuous water flow should be maintained with a suitable drainage system. After that, *Tubifex* is inoculated from nearby muddy canals. Within 15 days clusters of Tubifex worms develops and this can be removed with mud in masses by means of spade and kept in large mouth plastic container. When the worms come out to the surface due to lack of oxygen, they are collected and washed under brisk stream of water to remove mud attached to the body. The worms should be kept long enough in the stream of water to evacuate the gut. Then the worms are given to the ornamental fishes.

Culture of Chironomid larvae

Flat trays with water are added with soil and compose manure or organic matter or decaying vegetable matter to attract chironomid lies to lay eggs. The female chironomid larvae lay eggs in the stagnant water. Each female may eggs 20000 eggs in a batch which may hatch out in 3 days. Initially the larvae live in soft tubes made of organic matter which can be clearly seen from the bottom of the tray. After 3- 4 days the

larvae come out of the tube and swim freely in water vertically. The larvae are harvested with scoop net and washed thoroughly with freshwater and fed to the ornamental fishes.

Mosquito Larvae

Mosquito larvae are wriggling creature and have a knob like head and 'V' shaped tall and about 0.25 inch in length. The female lays eggs in water surface from which the larvae hatch. After few days the larvae metamorphose into pupa. Pupa molts into mosquito. Mosquito larvae are an ideal food for larger ornamental fishes [3]. Mosquito larvae can be collected easily from ponds, puddles, water logs, ditches and almost in any containers near dwelling houses. The mosquito larvae are collected with scoop net just like *Moina* and *Daphnia* and feed to the larger aquarium fishes. The pupa had a little harder head and sometimes fishes may have to split them out after grabbing them [24].

Microworms *(Anguillula silusiae)*

Micro worms *(Anguillula silusiae)* are tiny and almost invisible worms and ideal baby food and fed to fry of ornamental fishes just out of the infusorians stage. Fresh supply of these micro worms is useful for the ornamental fishes [24], otherwise they may deteriorate naturall;: for better collection of worms. Micro worms *(Anguillula silusiae)* also proved to be cheaper live feed that result in satisfactory larval growth and survival of guppy (*Poecilia reticulata*) [43].

Earth worms

Earth worms are favourable and mostly accepted live food item for the ornamental fishes [24]. They are chopped up or shredded before use. Before shredding, the worms should be cleaned well. Aquarist should avoid worms that exude a yellowish secretion, the ornamental fishes will not feed them and finally it will make the water dirty. Nottingham red worms and other red worms found in compost heaps are one of the best live food.

White worms

White worms (*Enchytraeids* sp.) are soil dwelling creature and very similar to earth worms. They are used as live food organisms for ornamental fishes that are highly nutritious [24]. The worms obtained from market are placed in the depression and mesh spread over them and they multiply at temperature near 15°C and when the soil is wet. After boxes are set up, rotate them for feeding the ornamental fish. They may get culture time to reproduce and ensures an adequate supply. Before feeding, worms should be free of soil particle and give quick rinse in water. Worms will amalgamate into ball for making collection easy.

Glass Worms

Glass worms *(Chaoborus* or *Corethera* Larvae) are also called ghost worms. They are tiny and transparent creatures of about 1/2 to 3/4 inch in length but without the blood of course. They are found during winter in ponds well shaded by the overhanging foliage. At the time of netting, they must be swept through the water swiftly and steadily. The glass worms lend themselves quite well to storage in small aquarium. They are ideally used for rearing of ornamental fish culture [24].

Gentles

Gentles are the food and feeding larvae of bluebottle or blow fly pale, whitish grubs about 1/2 to 3/4 inch long. These are excellent food for the larger ornamental fish species and specially favoured by cold water fishes Due to their bigger size they quickly satisfy the appetite [24].

Fresh Water Shrimp

The fresh water shrimps, *Gammarus pulex* are ideal live feed for the larger ornamental Fishes [24]. They grow to about 3-4 inch and feed on decaying animals and vegetable matters.

Fairy Shrimp

Fairy Shrimp *(Streptocephalus dichotomus)* are fresh water organisms and inhabit in ponds that lack fish because they are eaten by fish in natural waters. Fairy Shrimp nauplii are similar in size and closely resemble with brine shrimp, *Artemia sp* [23]. Fairy shrimp can be used as live feed for ornamental fish culture [47] and their cysts and nauplii can be incorporated for larval rearing of ornamental fishes. Fairy shrimp contains high level carotenoid content and many essential amino acids than Moina and can be used for colour enhancement of ornamental fishes. Fairy Shrimp improves the pigmentation of gold fish and feed conversion ratio is very high compared to other live feeds like Chironomid larvae and *Artemia* [23]. The ornamental angel fish (*Pterphylum scalare*) larvae readily consume the decapsulated cysts of fairy shrimp and utilized them efficiently during the early days of exogenous feeding and compared with other live feeds like brine shrimp (Artemia sp.) micro worms *(Anguillula silusiae)* resulted better weight gain and growth [45]. Fairy shrimp contains high level of carotenoids than *Artemia* [23], with large amount of asthaxanthin and cathaxanthin and antheraxanthin [46]. The larvae as well as adult live fairy shrimps can be used as nursery and maturation feed for ornamental fishes as the fairy shrimp have high

individual biomass, possibility of bioencapsulation with PUFA and then other nutrients and rich source of carotenoid contents [23].

CONCLUSION

The live food organisms have been incorporated successfully in the diets of ornamental fish culture but overall prospects of ornamental fish culture will be regulated mainly by economical factors. Uninterrupted supply of live food organisms regularly to ornamental fish culture is the most essential criteria. The live food organisms involve risk of pathogenic contamination. In order to avoid contamination of pathogens, special measures need to be applied. If live food culture falls due to power outage, low hatch rate of cysts, etc., the rearing of the ornamental fishes will suffer. Wild collection of live feeds for rearing fishes is susceptible to availability because of weather or other factors and also may introduce predators, toxins or disease causing agents. Special care need to be taken to check any kinds of unhealthy situations. Well balanced diets is the basic need for larval development of any individual, but till today, compared to natural food artificial or supplementary feeds are unable to answer to the demands of unidentified growth factors and certain micronutrients by the larvae. To till the gap, live food organisms culture is the only solution. This is nothing but providing natural environment to the larva under domesticated or controlled conditions. So live food organisms can be applied as potential, cost effective, nutritionally adequate, yet economically feasible source of palatable diet for ornamental fish culture. Techniques for culture of these live food organisms need to be popularized so as to meet the requirements for successful culture of ornamental fishes.

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