COMMERCIAL PRODUCTION OF NATURAL FRESHWATER FISH-FOOD

by

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INTRODUCTION

The availability of living food resources in intensive fish culture system has been shown to be a major handicap in the rearing of fingerlings of commercial fish species all over the world. Kirk and Howel (1972), Kirk (1972) and Kinne (1977) have shown that young fish, especially their larvae, live and grow better on living food than on non-living or artificially formulated feeds. Such non-living diets include those made from groundnut cakes, cotton seed cakes, rice, corn and wheat brans and a host of other artificially formulated feeds. There is hardly any known species of fish that does not utilize natural food at one stage or the other of its life cycle. In mass fish seed (fingerlings) production, therefore, one of the most important factors governing survival and growth of larvae, fry and fingerlings, is the availability and constant supply of live food.

These live foods are mostly the microscopic phyto-plankton and zooplankton which are normally present in many natural aquatic systems and form the most valuable natural food resources for aquatic predators, especially fish. The extensive fish farmer has all along depended on the benefit of these microscopic organisms. In intensive fish culture systems, however, where these organisms are not naturally present, they have to be collected from the wild, propagated and properly managed in enclosures to ensure their constant supply, especially in fish hatchery operations.

A highly simplified predator-prey relationship which exists between phytoplankton, zooplankton and fish is shown below:-

$$\text{Phytoplankton} \xrightarrow[\text{prey to}]{} \text{Zooplankton} \xrightarrow[\text{prey to}]{} \text{Fish}$$

The abundance of the zooplankton is in most cases dependent on the abundance and quality of the phytoplankton, while the growth, survival and well-being of the fish is dependent on the availability and abundance of the zooplankton.

To a great extent, therefore, there should be a sort of ecological equilibrium between the phytoplankton and the zooplankton to ensure successful fish production in any fish culture system.

It appears that the mass cultivation of natural fish-food only gained ground in the last couple of decades judging from what is available in the literature. Since then however, there has been some major thrust in fish-food aquaculture especially in those parts of the world such as the Philippines, Japan , USSR etc. where fish culture has been most intensively practised. These works have focussed on the cultivation of algae and zooplankton as food for fish larvae, fry and fingerlings. The algae is usually cultured as a food organism for the zooplankton which is the preferred live food for the young fish as most larvae cannot rely on phytoplankton as their sole food source (Uhlig, 1981).

Objective

The objective of this paper, therefore, is to review some of the methods that can been used for mass cultivation of natural fish-food, the types of organisms that are cultured and finally to give some examples of successful case histories in the mass cultivation of natural fish-food in order to stimulate the interest of Nigerian scientists on research activities that will encourage large scale production of live fish-food for use by fish farmers in this country.

METHODS FOR CULTURE OF LIVE FISH-FOOD

In starting up a fish-food culture, four important parameters should be considered. These include the species and scurce of the organism to be cultured, the nutrient source, the culture vessel, and the inoculation technique.

Species, Source and Isolation

One of the major problems of life fish food culture is the isolation of desirable species of algae from the wild for feeding the zooplankton which is ultimately used to feed the fish especially where the fish is not herbivorous. Also, in developing countries like Nigeria where algal banks are not available, it is necessary to produce pure cultures of algae whenever desired. The isolation of an algal unit into a medium suitable for growth is required to establish a unialgal culture. There are various methods of isolation such as capillary pipette, agar plating, cover glass attachment, repeated subculture etc. In our laboratory at Kainji Lake Research Institute pure culture of Scenedesmus has been produced by using the repeated subculture technique of Aujero (1981). This method involves inoculation of a mixed phytoplankton population into a known nutrient medium and the culture left to stand with continuous illumination from fluorescent tubes and aeration using air pumps. At the end of every three days, a

sub-sample was removed and inoculated into a fresh medium. This subculturing was repeated several times until a unialgal culture was established. Details of the utilisation of this technique by Kainji Lake Research Institute is available in Ovie et al (1986, in press).

Nutrient Source

All algae require a chemical environment for growth. Such environment is a dilute solution from which all the raw materials necessary for their structural and protoplasmic synthesis are drawn. Several standard laboratory algal nutrients are available for the culture of microalgae. Some of these include media formulations of Pravossoli et al (1957), Gullard and Ryther (1962), Walne (1974) and the modified Hirata (1979) medium. Others include standard CHO number 10 medium, Watanabe nitrogen free medium, SM_1 and SM_2 medium etc. Most algae as chlorophyll-bearing plants require N, P, K, C, O, Ca, Fe, Mg, Mn, Bo, Zn, Cu, and Co. Diatoms require silicates, while some algae require vitamins such as thiamine, cyanocobalamin and biotin. The reagent grade chemicals that make up these nutrient formulations are not only expensive but are also difficult to obtain as most of them have to be imported. In view of this, the Kainji Lake Research Institute (KLRI) is currently exploring the possibility of using local raw materials such as chicken droppings as nutrient source. The two most important components of algal nutrient are phosphates (phosphorus source) and nitrates (nitrogen source). An analysis of the chicken droppings collected from a poultry farm in the Kainji Lake area showed adequate concentrations of phosphate (2.2 mg/l) and nitrate (45 mg/l) in the extract. This extract was found by Ovie et al (1986, in press) to compare very favourably with standard CHO No.10 laboratory nutrient in the growth characteristics of Scenedesmus species isolated in the Kainji Lake Research Institute laboratory.

The chicken droppings extract was obtained by soaking about 3 kg of chicken droppings in 15 litres of water and making sure that droppings were completely covered with water. The droppings were allowed to 'ferment' for 2 - 3 days with occasional stirring once or twice a day and finally filtered, with the residue rinsed two or three times with water, through a clean white nylon cloth into a bowl.

The above concentrated filtrate has been found by Ovie et al (op. cit.) to produce a bloom of Scenedesmus sp. in a tank which is 5 x 4 x 0.5m or $10m^3$ (i.e. 10,000 litres of culture volume).

Culture Vessels

Culture vessels for natural fish-food production are of various shapes and sizes and the volume of each vessel depends on the magnitude of feeding to be performed.

For small-scale feeding programmes, circular or conical tanks approximately 0.5 m^3 capacity made of fibre glass can be used. Rectangular iron tanks 1.23 x 0.885 x.6m approximately 650 litres capacity is currently being used in KLRI laboratory. Concrete tanks are, however, recommended for large-scale feeding programmes. The concrete tanks that are currently being used in our hatchery complex at Kainji Lake Research Institute are 5 x 4 x 1.5m which is approximately 30,000 litres at full capacity. However, it is recommended that such tanks should only be filled to the 0.5m depth mark to ensure maximum light penetration and ease of manual stirring if mechanical aerators are not available.

Inoculation

To initiate a batch culture, a small volume (50 or 100 mls) of the pure isolated algal stock is inoculated into a 1 or 2 litre flat bottom flask containing the nutrient medium. After 2 - 3 days when culture has bloomed, the culture volume is increased by using a bigger vessel. For large scale cultures, the culture vessels are gradually increased and greater amount of algal inoculum added for faster turnover of algal cells. A bloom is assumed to have occurred when the culture medium turns green. Just prior to (when the cells are still actively dividing) or at the end of the exponential phase, the vessel is inoculated with zooplankton. The exponential phase could be determined microscopically by direct algal count or by chlorophyll analysis using the spectrophotometric method. The chlorophyll analysis has been found to be a more reliable method for identifying the various stages in the growth curve. Once the zooplankton are inoculated into the vessel, they feed actively and reproduce very rapidly, thus increasing the zooplankton population density. At the peak of their population density, the zooplankton culture is harvested and fed to the fish larvae, fry or fingerlings. The whole cycle of algal-zooplankton development takes approximately 7 - 8 days in the case of small-scale culture. However, in outside concrete tanks where cultures could be left going for weeks, only a fraction of the culture is harvested at each feeding time.

Harvesting

Algae could be harvested by concentrating with sand filters and backwashing with filtered water (Yap, 1979). Hand plankton nets with very fine mesh size (153 or 180 µm) are usually applied for harvesting zooplankton. In small-scale culture, the entire culture volume is filtered through the net bucket, is emptied into a plastic or any suitable container for onward transfer to the tanks holding the fish larvae, fry or fingerlings. For large-scale cultures in concrete tanks, the plankton net is towed from one end of the tank to the other to concentrate the zooplankton.

Concrete tanks are drained, washed and dried periodically to avoid pollution of the bottom layer resulting from accumulation of nutrients and dead decaying organisms. If pollution is allowed to build up, oxygen depletion will occur to such an extent that the organisms may become stressed and eventually die.

Fertilization and aeration have been identified as two important parameters that affect algal and zooplankton development in culture media.

Fertilization

Periodic fertilization with nutrients at every two weeks interval or when algal population density is observed to be decreasing, is applied to ensure adequate supply of nutrients for algal growth.

One obvoius effect of fertilization is the rapid increase in the population density of phytoplankton and it is common knowledge that the rate of bloom is proportional to the level of fertilization. In other words, high phytoplankton densities are achieved at higher levels of fertilization. Heisig (1979) however, found the reverse to be the case with zooplankton development. He found that in highly fertilized ponds with 10.28 and 8.19 mg PO_4-P/l respectively, zooplankton density never exceeded 160 individuals/litre. In another pair of moderately fertilized ponds (5.98 and 3.86 mg PO_4-P/l) densities of up to 260 Daphnias per litre were achieved. The highest density (425 Daphnias per litre) was recorded in the least fertilized ponds containing 1.10 - 1.63 mg PO_4-P/l. This inverse relationship has been attributed to a temporary oxygen deficiency and increase in pH values caused by phytoplankton metabolism which tends to inhibit zooplankton development. Furthermore, it has also been shown that every high densities of food particles (algal cells) inhibit uptake by the zooplankton.

In general, the population density of zooplankton follows very closely that of phytoplankton population until such a point when the density of the latter becomes inhibitory. The goal of fertilization should, therefore, be to obtain optimum algal cell concentration that guarantees optimum zooplankton production.

Aeration

Aeration which is tbe bubbling of gaseous air through cultures, prevents stratification of cells, makes provision for gas and heat transfer, dispersion of dissolved nutrients and prevents adherence of cells to the walls of the culture vessels. Uhlig (1981) maintained that aeration increases cell size of organisms. Heisig (1979) compared the effect of aeration on primary production and zooplankton development in two ponds in which one was aerated and the other was not. He found that aeration increased algal

production and consequently, led to increased egg production in Daphnia. The number of egg-bearing females and the number of eggs per egg-bearing females was found to be considerably higher in the aerated than in the unaerated ponds. While the aerated pond attained an average density of more than 500 individuals per litre, the unaerated pond had only half of that population density. It is therefore, recommended that aeration should be provided in order to achieve maximum zooplankton population in fish-food culture. This is most important in indoor hatcheries where atmospheric reoxygenation is highly limited.

SOME COMMONLY CULTURED NATURAL FISH FOOD

Different species of phytoplankton and zooplankton have been employed in aquacultural practices (Kirk and Howel, 1972; Kirk, 1972; Kinne, 1979, Hirata, 1979; Heisig, 1979). Some of the algae commonly cultured include Chlorella, Scenedesmus, Closterium, Chlamydomonas, Skeletonema, Rhizosolenia, Chaetoceros etc. The first four genera are members of the Chlorophyceae (Green Algae), while the last three genera belong to the Bacillariophyceae (Diatoms). Others include small flagellates such as Platymonas viridis, Dunaliella tertiolecta, D. viridis etc. Members of the Cyanophyceae (blue-greens) are not normally cultured for use in fish culture systems because they produce toxic alkaloids, cyclic polypeptides etc (Darley, 1982) and are also difficult to digest because of the outer-coat of mucus surrounding their cells.

Although there is a wide spectrum of potentially available live fish-food organisms, these organisms must satisfy certain basic aquacultural requirements before they can be employed for aquacultural purposes. Some of these basic requirements are:-

- Easy availability of the organism
- High reproductive potential
- Short regeneration time
- High nutritional quality, and above all
- Acceptability of organism by fish larvae, fry or fingerlings.

SOME SUCCESSFUL CASE HISTORIES

Heisig (1979) described the successful mass cultivation of Daphnia pulex in ponds measuring 50 m^2. These ponds were situated in a line and were interconnected by vertical pipes that serve to maintain the water level constant at 1.1 m. The ponds were aerated and fertilized

periodically at an interval of 3 or 2 weeks, first with potassium nitrate and later with calcium nitrate. A population density of 500 individuals per litre was achieved in this culture.

Hirata (1979) in Japan described the mass production of rotifers notably Brachionus sp. This rotifer was found to be the best food for the larvae of the Ayu fish, Plecoglossus altivelis, and this has also been used as food for the larvae of the prawn, Penaeus japonicus. The rotifers were grown both in small (1.5 m^3) wooden tanks and in outdoor concrete tanks measuring 100 or 200 m^3. A population density of over 514 individuals/ml was achieved in the outdoor concrete tanks while the small tank had a maximum population density of 80 individuals per ml. Chlorella grown on Hirata medium (Hirata, 1979) or on the modified medium by Villegas (1981) consisting of 10g/ton of ammonium sulphate, 12 g/ton of urea, and 30 g/ton of N.P.K. in the proportion of 14-14-14- along with yeast formed the basic food of rotifer.

Debeljak et al (1979) described the rearing of cyprinid fish fry and a mixed population of zooplankton as fish-food in 70 litres aquaria, and in 4m^3 and 8m^3 plastic tanks. N.P.K. in the proportion of 17 : 8 : 9 was used as the fertilizing agent, with baker's yeast as the major food item for the zooplankton. In the aquaria, a nine fold increase was obtained from an initial inoculation density of 352 individuals per litre. Maximum biomass of 68 g/m^3 and 89g/m^3 respectively were noted in the 4 m^3 tanks and a 2 - 17 fold increase in biomass was achieved in the 8m^3 tank. Uhlig (1981) also reported the mass cultivation of the heterotrichous ciliate Fabrea salina and the hepaticoid copepod, Tisbe holoth uriae in continuously running food flow system and in enclosed flat culture systems respectively. F. salina and T. holothuriae reached a population density of 400 individuals/ml and 121 individuals/ml respectively.

CONCLUSION

The above account and the examples of successful cultivation of algae and zooplankton as natural fish-food are not exhaustive. Other examples can be found in some of the works cited in this paper. It is however, important to add that the cultivation of natural fish food in fresh-water and also in developing countries like Nigeria is quite new and a concerted effort by all interested scientists is likely to be the best solution to the present low level of work in this area of applied limnological research so that useful information can be made available to our fish farmers for the utilisation of our local natural fish-food in fish production.

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