Monoculture of Fresh Water Shrimps  
(Macrobranchium Species)

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Abstract

The sole reliance on wild catches of shrimps to meet the increasing demand globally can cause over fishing and destruction of shrimp fishery, pronounced by catch problem and habitat destruction. Freshwater shrimps of the genus Macrobrachium is found in West African waters and is widely distributed in Nigerian waters. These shrimps are more manageable than their marine relative where coastland culture is expensive, and there are usually many legal constraints on the use of coastland. Also construction costs are higher in saltwater and Penaeid shrimp farms sited at the coastland destroying the rich mangrove swamp ecosystem. Freshwater shrimp farms are sited inland and are not associated with the aforementioned problems. The culture of freshwater shrimps, which is well developed in Asian countries and America, is still at the infant stage in Nigeria. One of the factors limiting the development of this industry is lack of technical knowledge. The methods employed for semi intensive monoculture of freshwater shrimps. With the adoption of freshwater shrimp culture presented will make a headway and will lessen the fishing effort on the wild stock, provide employment opportunities, alleviate under-nutrition and poverty, enhance rural livelihoods and contribute to foreign exchange earnings, It was recommended that more research and piloting be done on the culture of freshwater shrimps using indigenous species. The economic viability of culturing these shrimps should be investigated and research on hatchery production of their post larvae be intensified.

Keywords:  Semi-intensive, monoculture, freshwater shrimps.

1. Introduction
Shrimps constitute a large group of crustaceans varying in size from a few millimeters to about 35cm long (FAO 1981). They are valued food organisms that are heavily exploited. In West Africa, it is a
very important export commodity (Chemonics, 2002; Enin, 1998). The reliance on wild catches in meeting the shrimp demand of the vastly growing Nigerian population is associated with several problems. These include depletion of the wild stock with the rapidly increasing catching effort. Ajana (1996) reported landing of an average of 5 basins of shrimps per fishing unit per day in the Niger Delta States of Nigeria. Ogbonna (2001) reported an annual catch of about 12,000 metric tonnes of shrimps in Nigeria between 1992 and 1997 despite the maximum sustainable yield (MSY) of 3,500 - 4,000 mt. Also, intense catching effort could lead to a pronounced by catch which can result in population loss and possible extinction of other organisms. In addition, some gears used by both artisanal and industrial trawlers can lead to habitat destruction. The cultivation of shrimps in certain parts of the world has made shrimp farming an important global aquaculture sector (Yakubu and Onunkwo, 2006). Front liners in the industry are Asian countries especially China, Thailand, Taiwan, Indonesia, Philippines, Japan and Vietnam. According to FAO (1999), Asia produces 78% of the total world farmed shrimp, which amounted to 737.80 mt in 1997. In the Western hemisphere where 21% of the world farmed shrimps comes from, Ecuador, Brazil, Mexico and Puerto Rico are the major producers. Although private sectors are the major players in these countries, the industry enjoys tremendous support from their respective governments. Penaeid shrimps are the leading cultured species but the culture of freshwater shrimps (prawn) had developed tremendously in the Asian countries such as Taiwan, Thailand, Vietnam and China. Global production of freshwater shrimp was estimated at 35,000t in 1993 (MSU 2007). With the adoption of the methods being employed for cultivating these freshwater shrimps, farming of the indigenous *Macrobrachium species* will make headway. Meanwhile, experimental trials on culture performance, propagation and hatchery seed production of freshwater shrimps are ongoing at the Nigerian Institute for Oceanography and Marine Research (NIOMR). This paper discusses the basic method of semi-intensive monoculture and propagation of freshwater shrimps.

### 2. Advances in The Culture of Freshwater Shrimps

The culture of freshwater shrimps (prawns) is almost nonexistent in Nigeria though there are reports of a few artisan producers (Chemonics, 2002). The idea of culture dates back to 1986 when the Federal Government took interest in the World Bank assisted Agricultural Development Project (ADP). Following reports on the viability of culture by the then Federal Agriculture Coordinating unit, a pilot project was initiated at Epe, Lagos State by the Lagos State ADP. Production ponds and a hatchery complex were constructed and some officers of the ADP were sent to Puerto Rico to master the techniques of larvae production using *Macrobrachium vollenhovenii*. Post larvae were collected from the wild and tried out. About the same time the marine relative, *Penaeus notialis* was being tried out in the Rivers State ADP. Within the period 1992 - 1995, Lagos State ADP carried out culture trials of *M. vollenhovenii* at Epe. The trials were successful and they reared wild procured seed to table size. They went ahead to use them as broodstock for hatchery production of the post larvae. This research was in collaboration with Nigerian Institute for Oceanography and Marine Research (NIOMR), Lagos. They actually succeeded in the artificial breeding and reared the larvae produced to a certain early stage but failed to rear them to the post larval stage suitable as shrimp seed. Recently NIOMR has resumed work on the rearing and production of shrimp seed.

In recent years, there have been reports of the Private Sector attempting to venture into shrimp farming. Chemonics (2002) reported an artisanal freshwater shrimp farming of 0.25 hectare at Ikot Abasi, Akwa Ibom State. The farm relies on wild post larvae to produce shrimp in polyculture with Tilapia. The same author also reported the practice of some forms of shrimp farming at Epe, Lagos State and Eket, Akwa Ibom State. However, the production and status of these so-called shrimp farms are not defined. Recently, Shell Oil Company as part of her “community support program” built a trial shrimp rearing ponds at Irieba near Port-Harcourt, which was due to start operations in 2002. The key issue then was the choice of species to culture. Shell originally wished to import exotic *Macrobrachium rosenbergii* from U.S., rather than local species, but later considered *M. vollenhovenii*
as well. Agip had a similar project near Brass. These projects highlighted two critical issues: which species to culture and then devising a technology for doing so economically in Nigeria (particularly for the hatcheries). These issues especially the later may have been the major constraints that hindered the progress of these two prospective shrimp farms. Other researches done on the culture of shrimp in Nigeria include those of Daekae and Ayinla (1995) and Hart et al., (2003).

3. Freshwater Shrimp Monoculture Methods
According to FAO (2002), freshwater shrimp monoculture can be extensive, semi-intensive or intensive, though the definition of these terms is rather vague. Extensive culture means rearing in earthen ponds and other enclosures such as reservoirs, irrigation ponds and rice fields which produces less than 500 kg/ha/yr of freshwater shrimps. They are stocked with post larvae or juveniles at 1 - 4 m\(^2\). There is no control of water quality; the growth or mortality is not monitored; supplemental feeding and organic fertilization is rarely applied (FAO, 2002). This is not good for commercial shrimp culture. Intensive culture according to FAO (2002) refers to freshwater shrimp farming in small earth or concrete ponds provided with high water exchange and continuous aeration, stocked with not more than 20 juveniles per m\(^2\) and achieving an output of more than 5,000 kg/ha/yr. Production cost are high and a high degree of management is required, which includes the use of a nutritionally complete feed, the elimination of predators and competitors and strict control over all aspects of water quality. Semi-intensive system according to FAO (2002) involves stocking post larvae or juvenile prawns at 4 – 20 per m\(^2\) in ponds and result in a range of productivity of more than 500 kg/ha/yr and less than 5,000 kg/ha/yr. Fertilization is used and a balanced feed ration is supplied. Predators and competitors are controlled, water quality and shrimp health are monitored. FAO (2002) advised against using intensive system in the tropics because it requires more research, particularly on size management. Moreover, the frequent power failure in Nigeria will not favour intensive culture system. Also semi-intensive culture system is the most common in tropical areas (FAO, 2002).

4. Methods of Semi-Intensive Monoculture of Freshwater Shrimps
Rearing of these shrimps in pond entails a number of activities as follows and according to BFAR/FAO/UNDP (1981), similar ideas and methodology could be employed in culturing various freshwater shrimp species:

4.1. Site Selection
According to FAO (2002), it is important to consider the following factors in choosing your site for freshwater shrimp farming.

4.1.1. Topography
A survey is necessary to access the suitability of a site topographically. Flat or slightly sloping lands are the most satisfactory. The ideal site, which slopes close to 2% (2 m in 100 m) allows good savings on earth movement. Also this allows for ponds to be gravity filled and drained. The ideal site is rarely available even in finfish culture; however, many successful farms exist where the only feasible method to fill and drain the pond is by pumping.

4.1.2. Climate
Avoid highly unstable meteorological regions. Strong storms and winds increase the risks of flood and erosion damage. Temperature is a key factor. The optimum temperature range for year-round production is between 25 and 31°C (FAO, 2002; MSU, 2007). Rainfall, evaporation rates, relative air humidity and wind speed and direction also need to be investigated. Ideally, evaporation losses should be equal to or slightly lower than rainfall input. Farms should not be sited where the ponds are likely to
be affected by aerial drift of agricultural sprays. Freshwater shrimps are especially susceptible to pesticides (MSU, 2007; JIRCAS 2002).

4.1.3. Water quality and Supply
Freshwater is used for rearing *Macrobrachium* sp from post larvae to market size. Well water is the preferred source of water, although surface water or runoff can be used (FAO, 2002; MSU, 2007). Table I provides the recommended water quality range for freshwater shrimp culture. The water must be predator free as much as possible and should not have a total hardness of more than 150 mg/L (CaCO₃).

**Table I: Water Quality Requirement for Rearing *Macrobrachium Species***

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Recommended range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature (°C)</td>
<td>28 - 3</td>
</tr>
<tr>
<td>pH (units)</td>
<td>7.0 - 8.5</td>
</tr>
<tr>
<td>Dissolved Oxygen (ppm)</td>
<td>3 - 7</td>
</tr>
<tr>
<td>Salinity (ppt)</td>
<td>&lt; 4</td>
</tr>
<tr>
<td>Transparency (cm)</td>
<td>25 - 40</td>
</tr>
<tr>
<td>Alkalinity (ppm CaCO₃)</td>
<td>20 - 60</td>
</tr>
<tr>
<td>Total hardness (ppm CaCO₃)</td>
<td>30 - 150</td>
</tr>
<tr>
<td>Ammonia (ppm NH₃-N)</td>
<td>&lt; 0.3</td>
</tr>
<tr>
<td>Nitrite (ppm NO₂-N)</td>
<td>&lt; 2.0</td>
</tr>
<tr>
<td>Nitrate (ppm NO₃-N)</td>
<td>10</td>
</tr>
</tbody>
</table>

*ppm – parts per million, ppt – parts per thousand
Source: FAO (2002)*

4.2. Soil Characteristics
Unless good information about the soil characteristics is already available, site assessments should be done to determine its classification and chemistry. It is preferable to site the farm where soil is fertile avoiding acid sulphate soils. The ponds should be constructed on soil which has good water retention capacity. Soils which consist of silt and clay with small proportion of sand normally have good water retention capacity (JIRCAS, 2002).

4.3. Pond Morphology
Freshwater shrimp production ponds basically have the same features as catfish earthen ponds (MSU, 2007). The surface area of grow out ponds should ideally range from one to five acres. Although successful production has been achieved in larger ponds, the logistics of management and harvest present some problems. According to FAO (2002) and MSU (2007), the pond should be rectangular, thereby facilitating the distribution of feed across as much of the surface area as possible. MSU (2007) recommended that the shrimp ponds should have a minimum depth of 2.15 feet (0.65m) at the shallow end and slope to a maximum depth of 4 feet (1.20 m). A four-inch (10.16 cm) drop in elevation with every 100 feet (30.48 m) of pond length should allow for rapid drainage. A slightly deeper, 4 - 6 inch (10.2 - 15.2cm) area of 15 to 20 feet (4.57 - 6.09 m) should be constructed around the drain pipe to allow shrimps to congregate during drain harvest. In terms of constructing the shrimp pond drainage structures, best results for draining and harvesting of ponds with one to three acres of water surface have been realized with one 14 to 16 inch diameter drain pipe. With the flow capacity of this pipe, fill draining of most ponds will be completed within 24 to 48 hours (MSU, 2007).

4.4. Pond Preparation
The pond bottom is cleaned, leveled and allows to dry for between 2 and 4 weeks depending on the prevailing weather (BFAR/FAO/UNDP, 1981; FAO, 2002). For previously used pond, the pond is drained completely and during the drying period, the dyke and canals are repaired of damages. Semi-
intensive culture requires thorough drying to crack the soil to a depth of 2 - 3 inches to allow atmospheric oxygen to penetrate into the sub soil (Yakubu and Onunkwo, 2006) and elimination of Pest and Predators. These can be done through:

4.4.1. Mechanical Method
Unwanted fish can be killed by draining and thorough drying. Fencing of the pond also helps in preventing entry of land predators and pest.

4.4.2. Chemical Method
Tobacco dust at 200 - 400 kg/ha can be used to eradicate fish and snails. Minsalam and Chiu (1986) reported the efficiency of Tea seed cake which contains 5.2 - 7.2% saponin, a glycoside at a dosage of 15 ppm to eliminate fin fish. Also, since shrimps survive tea seed saponin unto 20 ppm (Minsalam and Chiu, 1986). Post stocking elimination of pest fin fish can be achieved with the cake. Deekae and Ayinla (1995) also reported the effectiveness of 2% lindane solution in killing wild fish in preparing ponds for shrimp culture.

4.4.3. Broadcasting
Rice Bran at 400 – 1000 kg/ha to the pond, flooding with water to 10cm pond level and leaving for one week for the fermentation to kill the predators was recommended by BFAR/FAO/UNDP (1981). The ponds are flushed for at least one week after application of pests and predators eliminating agent especially when chemical method is used (Deekae and Ayinla, 1995).

4.5. Pond Liming
Quick lime (CaO) of between 100 and 500 kg/ha depending on the acidity of the pond soil was recommended for liming shrimp ponds by BFAR/FAO/UNDP (1981). The quicklime apart from reducing the acidity will supply calcium needed by the shrimps during moulting as well as further reduce the pest infestation and wild fish (Deekae and Ayinla, 1995).

4.6. Fertilization

4.6.1. Organic Fertilization
1,000 - 2,000 kg/ha of organic manure such as chicken dung depending on quantum of organic content in the soil is broadcasted throughout the pond. A water level of about 15cm is maintained for 4-5 days after organic fertilization (Yakubu and Onunkwo 2006).

4.6.2. Inorganic Fertilization
Agricultural fertilizers such as NPK or Urea are broadcasted to the pond. Deekae and Ayinla (1995) recommended 25 – 50 kg/ha for either urea or NPK. The rate of 20kg N/ha and 25kg P/ha was recommended by Verghese (1978). A low level of water is still maintained at this stage for adequate penetration of light to the bottom for the growth of bottom algae. The process of fertilization promotes the growth of microbenthos complex known as “lab-lab” BFAR/FAO/UNDP 1981; New and Rabanal, 1984). The lab-lab is an association of many plants and animals dominated by diatoms and blue green algae. This will serve as food for young shrimps to be stocked in the pond.

4.7. Sourcing for seeds

4.7.1. Nets are used in collecting shrimp juveniles
This is done in lagoons, creeks and estuaries known to contain the desired species in abundance. It can be in form of dip netting from boat, (Bardach et al., 1976), fixed bag netting, push netting or drag
netting (Rahman 2001). As a rule, the net must have fine mesh to retain the small size post larvae or juveniles. Rahman (2001) reported annual collection of 2 billion post larvae of the marine shrimp *Penaeus monodon* from the wild in Bangladesh using fixed bag, push and drag nettings. Deekae and Ayinla (1995) used fixed bag net for collecting *P. notialis* post larvae from the new Calabar river estuary, Nigeria. Hart et al., (2003) used non-return valve trap to collect post larvae of the freshwater shrimp *Macrobrachium felicinum* from Nun River, Bayelsa State. The desired species is later sorted out of the entire catch.

4.7.2. The use of Lures
This practice is particularly popular in South East Asia for collecting *P monodon* post larvae. The lures consist of bundles of twigs tied at intervals of 1-2m to a line strung between two poles. These are set in brackish water body especially of the estuary mouth of the river near the bank. *P. monodon* post larvae entering the river attach themselves to the bundles and they are captured by being shaken off into a dip net (BFAR/FAO/UNDP 1981).

4.7.3. Hatchery Source
This is procurement of hatchery produced young shrimps for culture. This ensure, a relatively more regular and constant supply of seeds irrespective of the season. Recently, it is widely used in Asia to procure freshwater shrimp seeds. However, in Nigeria, the technology of hatchling production of shrimp seeds has not been developed. Research on this is still ongoing at NIOMR Lagos.

4.8. Seed Transportation
Post larvae transportation is by plastic bags (Styrofoam containers) at 5,000 - 8,000 post larvae per 20 litre bag containing 6 - 8 litres of water, with optimum temperature of 27 - 30°C. There should be oxygen supply (BFAR/FAO/UNDP, 1981).

4.9. Pond Stocking
It is better to stock ponds immediately after filling them, this prevent predators and causes no photosynthetically - induced pH changes (FAO, 2002). Juveniles are more tolerant of high pH and ammonia than post larvae, so there are some advantages in stocking juveniles instead of post larvae. On transporting the juveniles to the pond site, great care should be taken to acclimatize the juveniles to the temperature of the pond water by floating the transport bags in the pond for 15 minutes before emptying them into the water. Severe mortalities can be caused not only by thermal shock but also by sudden changes in pH. Verghese (1978) suggested acclimatization by graded mixing of grow out pond water and that in which the juveniles have been transported from the collection site. Further conditioning to the new habitat is done by keeping the juveniles for 6 - 24 hours in suitable floating exposure fixed in the grow-out pond in which the juveniles are to be reared ultimately. During sunny days, stocking should be done preferably early in the morning or late afternoon. Stocking can be done anytime of the day provided it is cloudy and water temperature and turbidity are low (BFAR/FAO/UNFP, 1981).

4.10. Stocking Density
Bardach et al., (1976) recommended 10,000 - 12,500 juveniles/ha in production ponds, BFAR/FAO/UNDP (1981) suggested 10,000 - 20,000 juveniles/ha and FAO (2002) recommended between 4 and 20 post larvae m⁻² (40,000 - 2000, 000/ha)
5. Routine Management Practices

5.1. Feeding

FAO (2002) reports that a small production level of freshwater shrimps can be achieved by relying on the natural productivity of the ponds. However, successful semi-intensive farming must involve supplementary feeding. Some farms rely on fertilization, rather than feeding, at the beginning of the rearing period. Some stimulate an initial algal bloom through the addition of fertilizers. Generally, providing feed from the beginning of the rearing period improves performance and is cost-effective.

Supplemental feeds for shrimp production according to Yakubu and Onukwo (2006) include:

- Fresh trash fish mixed with rice bran
- Mussel meat, shrimp head, small crustaceans
- Slaughter house and poultry left over chopped into small pieces and scattered in the pond, usually along the edge of the pond.
- Commercial feeds in form of pellets.

Deekae and Ayinla (1995) recommended a mixture of palm kernel meal, brewers wastes and shrimp waste in the ratio 1 : 1.3 as supplemental food for *Penaeus notialis*.

Meanwhile crude protein content of the diet should be within the optimum level. Teichait-Coddington and Rodriguez (1995) observed that 20% protein content of the diet is ideal for semi-intensive shrimp culture, while Teichart-Coddington (1989) recommended 25% protein content for diet of shrimps cultured in land tanks.

5.2. Feeding Rate and Method

FAO (2002) reported that some farmers feed at the rate 20 — 10% of the body weight of juvenile shrimps and gradually reduce to about 2% by harvest time. Feeding ‘to demand’ (giving as much feed as the shrimps will eat but no more) is recommended by FAO (2003). The feed should be spread around the periphery of the pond in the shallows, which are good feeding zones. Putting the feed in defined ‘feeding areas’ a few metres apart makes it easier to observe how much is consumed.

5.3. Pond Maintenance

Special care should be taken concerning the prevention and treatment of pond bank erosion and the maintenance of water inlet and outlet structures, (FAO, 2002). Vegetation on and around the pond bank minimizes erosion. The pond surface area available to the shrimp can be increased by placing rows of netting suspended from floaters and weighed down with sinkers, across the pond (FAO, 2002; MSU, 2007). The pond depth should be maintained at an average of 0.9m and extensive shallow areas should not be allowed to develop. This makes rooted aquatic plants to grow extensively on the pond bottom. The growth of benthic algae and rooted aquatic plants must be discouraged by management practices that encourage phytoplankton growth, thus reducing light penetration to the pond bottom (FAO, 2002).

6. Water Quality Management

6.1. Dissolved Oxygen (DO)

Electronic oxygen meters are the most reliable and accurate means to determine levels of dissolved oxygen but a chemical oxygen test kit can be used. Since, shrimps are bottom dwellers, levels of dissolved oxygen concentration should be routinely monitored within the bottom 0.3m depth of water (MSU, 2007). DO concentrations should always be maintained above 3 ppm. At lower concentrations, stressful conditions and eventually mortality occurs. Also chronically lower levels of DO throughout the growing season markedly impact yields. (Hart *et al.*, 2003; MSU, 2007). Emergency aeration can be achieved by an aerator.
6.2. Nitrogenous Compounds

According to FAO (2002) nitrite and ammonia levels in freshwater shrimp ponds should be maintained at less than 2.0 ppm and 0.3 ppm respectively. However, MSU (2007) reported that at concentration of un-ionized ammonia as low as 0.26 ppm at a pH of 6.83, 50% of the cultured shrimps died within 144 hours. Therefore, concentrations of un-ionized ammonia that exceeds 0.1 ppm should be avoided.

6.3. pH

A high pH can cause mortality either directly by creating a pH imbalance relative to the shrimp tissue or indirectly by causing a larger proportion of ammonia to exist in the toxic unionized form (MSU, 2007). The same author recommended a pH range of 6.5 and 9.5 while FAO (2002) recommend pH range of 7.0 and 8.5. A high pH value is often stimulated by dense algal bloom in the pond water (MSU, 2007). One management practice to control this is periodic flushing of the top 30.5 cm of surface water to reduce the quantity of photosynthetic algae in pond. Another management approach is to spread organic matter such as corn grain or rice bran over the surface area of the pond (MSU, 2007). The organic matter should be introduced gradually, over a two-week period to achieve a level of 32kg/ha. The decomposition of the organic material releases carbon dioxide that reduces pH. This procedure must be accompanied by careful monitoring of oxygen levels that tends to decrease due to the heavy oxygen demand arising from the decomposition of the organic material. On the other hand, adding lime to the bottom soil of ponds that are constructed in acid soils helps to minimize lethal fluctuations that might occur during grow-out (MSU, 2007; JIRCAS, 2002).

6.4. Hardness

Although freshwater shrimps have been successfully raised in soft water (5 - 7 ppm total hardness), the shell is softer and may be more susceptible to bacterial infection. To avoid this condition, water hardness should range between 50 and 200 ppm (MSU, 2007). FAO (2002) recommended pond water hardness of between 30 and 150 ppm. Hardness of pond water can be increased through an application of a source of calcium such as agricultural gypsum or calcium chloride. According to MSU (2007), an increase of 1.00 ppm in total hardness can be achieved with an application rate of 1.72 ppm of gypsum. In very hard water 300 ppm or higher, reduced growth and lime encrustations on the exoskeleton have been observed (FAO, 2002; MSU, 2007).

7. Harvesting of Shrimps

According to FAO (2002) freshwater shrimps are best harvested by batch harvesting whereby the shrimps are culled every month after six months of rearing. Marketable shrimps are taken first and the rest are retained for further rearing until they are big enough. This brings about high yields. In terms of harvesting method, in addition to the methods earlier described for catching juvenile shrimps, other methods for harvesting adult shrimp as reported by Yakubu and Onunkwo (2006) include:

- the use of cast net in the pond
- fixing of net at the pond gate during water discharge at night
- gradually reducing the water to a small level, and subsequently using seine net for shrimp collection.
- manual picking of the shrimps is also used.

8. Conclusion

The culture of shrimps which is well developed in Asia and some other parts of the world is at infant stage in Nigeria. Most of our farmers do not know that shrimps are culturable food organisms. Some equally belief that it is a highly technical task out of reach of an average Nigerian farmer, but studies
has shown that it is not technically out of reach of Nigerians. Recently due to the success in the trial culture of shrimps in this part of the world, the private sector is beginning to show interest in the venture. However, limited knowledge of the technology of shrimp culture had hindered the realization of this dream. With the adoption of these methods and procedures employed for cultivating freshwater shrimps presented in this paper, the culture of freshwater shrimp in Nigeria will make headway. This will provide employment opportunities, improve protein consumption, help in alleviating poverty, enhance the rural livelihoods of our people and contribute to our foreign exchange earnings.

9. Recommendations

- More research and pilot scheme project is needed on the culture of freshwater shrimps using indigenous species.
- Research on the hatchery production of freshwater shrimp seed should be intensified.
- The economic viability of freshwater shrimp farming in Nigeria needs to be investigated.

References

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