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A Review of the Biotic Factors Militating Against Successful African Catfish (*Clarias gariepinus B*urchell) Larviculture In Nigeria

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Abstract

*The African catfish (*Clarias gariepinus *Burchell) with its unique adaptive traits is one of the most successful fish species for culture in Africa. Despite its popularity and ability to spawn under controlled conditions with hormonal induction, the seasonality of spawning in the fish imposes considerable strain on the Nigerian commercial fingerling producers limited by unsophisticated hatcheries. On most Nigerian catfish farms, the established hatchery protocols are rarely observed leading to low egg hatchability and poor larval survival. Ignorance of the requisite hatchery protocols lead to the production of catfish juveniles lacking the expected vigour. Under optimal conditions after the yolk-sac absorption period, larval rearing requires feeding live-organism during the first four days before introduction of an exogenous feed. Imported cysts of* Artemia nauplii *which is usually the first choice of feed for the new catfish hatchlings is expensive and not affordable to an average Nigerian fish farmer who instead utilize mixed zooplanktonic assemblages as first choice live-feed usually for a maximum of 14 days. Mixed zooplanktonic assemblages mainly* Moina *spp,* Brachionus *spp and* Daphnia *spp which are produced in organically fertilized nursery ponds are instead used to wean the* Clarias *hatchlings in most farms. In most commercial fingerling production operations, economics and nursing space dictates the duration of the primary nursing period. Survival of the hatchlings have been found to be dependent on biotic factors such as availability of live food organisms, predation, cannibalism, nursing space and competition for food, all of which are dependent on the levels of abiotic factors such as water temperature, turbidity, levels of dissolved oxygen and ammonia.*

Key Words: Aquatic environment, Biotic, Abiotic, Spawning, Hatchling, Larviculture, Fry, African catfish.

Introduction

The African catfish (*Clarias gariepinus*) is one of the primary fish species of culture in Nigeria where it contributes immensely to improving the domestic supply of fish farmed for consumption. The popularity of the species is associated with its suitability in terms of morphological, physiological, ecological and behavioral traits that enable this fish species to succeed in freshwaters (Bruton, 1979). *C. gariepinus* popularity is enhanced by its high fecundity and ability to spawn easily under controlled conditions with hormonal induction using either homoplastic pituitary gland suspension (Hecht *et al.*, 1982) or synthetic hormonal preparations (De Leeuw *et al.*, 1985; Goos *et al.*, 1987).

African catfish is one of the most studied clariid species cultured on the African continent (Teugel, 1996). However, the seasonality of spawning in the fish imposes a considerable problem on the commercial fingerling producers in Nigeria who are limited by their unsophisticated hatcheries and limited access to research and extension oriented programmes.

In Europe, about 75% of the *Clarias* fingerling demands are supplied by a few producers (Verreth and Edling, 1993). In Nigeria however, the fingerlings supplied from both the government and privately owned hatcheries are not enough to meet the farmer's catfish fingerling demands. On most Nigerian catfish farms today, the development of a reliable method for production of catfish fry for stocking is a top priority. The primary concern of the Nigerian catfish hatchery therefore is the production of the maximum number of high quality eggs and fry year round since this is a tropical nation with no weather issues to deter production through the year from January to December. This article will therefore review the prospects and problems associated with African catfish larval production and management in Nigeria from the point of view of biotic factors, which affect the fish in the first few days after hatching from the egg.

Methods of Larval Propagation

Natural larval production

C. gariepinus female is highly fecund, naturally producing between 30,000-100,000 eggs/kg body weight (Balon, 1984). The fish is an egg scatterer, which awaits suitable conditions to spawn (Bruton, 1996). Rainy season is the primary reproductive period in *C. gariepinus*. Sexually matured individuals can be found all the year round in ponds, rivers, lakes and enclosures (Nwadukwe *et al.*, 1993; Legendre, 1986). In nature, gonadal maturation is associated with increasing water levels, temperature and photoperiod (Bruton, 1996). The male fish is known to stimulate ovarian development by both olfactory and tactile cues (Van Weerd *et al.*, 1991).

Spawning which takes place with the commencement of the raining season at night is typified by massive aggregation of the fish and aggressive encounters between males (Bruton, 1979). Eventual pairings between isolated pairs in shallow waters among inundated plants result in spawning (Hecht *et al.*, 1996). The egg products which are mostly independent and sticky are spread in a single layer or stuck on vegetable materials in spawning nests for fertilization (Bromage and Roberts, 1995). The incubation period of the fertilized eggs is short (about 24 hours) and the yolk-sac absorption phase takes between 2-4 days (Hecht *et al.*, 1988).

There is a definitive larval stage in *C. gariepinus* with no measure of parental investment except by careful choice of spawning site and time (Bruton, 1996). Early development is rapid and semi-direct with an abbreviated larval stage (Bruton, 1989). The extended larval stage takes between 11-15 days after the start of exogenous feeding (Hecht *et al.*, 1988). The extended larval period implies the species requires considerably more care in terms of nutrition and feeding (Verreth *et al.,* 1993; Verreth and Van Tongeren, 1989).

Typical larval production in controlled environment

Artificial propagation of *C. gariepinus* is carried out in a well-developed hatchery with hormonal induction using either homoplastic pituitary gland suspension (Micha, 1976; Schoonbe *et al.,* 1980 and Hecht *et al.,* 1982) or synthetic hormonal preparation (Hogendorn, 1979; Richter and Van Den Hurk, 1982; Richter *et al.,* 1985; Goos *et al.,* 1987). After hormonal treatment, the matured ova survive only a few hours after ovulation and must therefore be stripped from the female broodstock for fertilization soon after (Legendre *et al.,* 1996).

After stripping the eggs, fertilization is best effected by mixing the eggs with sperms, which have been previously treated with diluted physiological saline. Usually, 200ml of the eggs and 3ml of sperm are mixed together in a bowl to which 100ml of activating solution (17mM Nacl; 5mM Tris; pH8) has been added (Haylor, 1993a). The time of contact between the sperms and ova for fertilization to occur is about a minute (Hogendoorn and Vismans, 1980; Legendre, 1986). After 2-5 minutes of gentle stirring, the fertilized eggs are spread in a single layer on a horizontal 1mm material mesh to which they adhere rapidly (Haylor, 1993b). The material with the attached eggs is then suspended slightly off the vertical axis in the hatching troughs (of an incubator) containing well-aerated water. On hatching, the new hatchlings simply fall to the bottom of the hatching trough while the egg envelope remain adhered to the screen material.

African catfish larval production in Nigeria

The *C. gariepinus* broodstock weight used for artificial breeding by Nigerian commercial fish farmers ranges between 0.3 kg and 2 kg. The average Nigerian fish farmer prefers to induce the African catfish with homoplastic pituitary gland suspension as a substitute for the expensive and imported synthetic hormonal analogues. The farmers found injection of a crude homogenate of catfish pituitary (1:1, donor: recipient weight basis) freshly prepared (usually with clean rainwater or distilled water) to be cheaper, practical and highly reliable based on their personal experience for artificial inducement of spawning (Nwadukwe *et al.,* 1993).

Holding the female broodstock in a head-up vertical position tests readiness of the fish with eggs for fertilization. When the fish egg is ready to be fertilized, the eggs begin to run freely from the genital pore after a gentle head to tail palpation. After a successful hormonal induction with *Clarias* pituitary suspension, the ready-to-be-fertilized ova survival time in the fish is about 12 hours at 25ºC (Bromage and Roberts, 1995). The ready-to-be-fertilized eggs are stripped from the female broodstock into a plastic bowl or glass beaker and fertilized with sperms from males, which have been previously stripped from male fishes sacrificed for the process. Genetic variability in the hatchlings is increased when a minimum of two males are used to fertilize batches of eggs (Bruton, 1996). Fertilization is best effected by diluting the sperm stripped from the sacrificed male fish with physiological saline after which the resultant solution is mixed with the eggs. After about 5 minutes of gentle stirring with quill feather, the eggs are spread in a single layer on a substrate which is usually kacabbans or mosquito nets onto which the sticky fertilized eggs adhere.

The substrate with the attached eggs is then suspended vertically in hatching troughs containing aerated water. The development time during the incubation period is temperature dependent (Bromage and Roberts, 1995) and the hatching takes place between 16-24 hours after fertilization at 28EC. Complete yolk-sac absorption occurs about 50 hours later (Adeyemo *et al.*, 1994). Once hatching occurs, the new hatchlings simply fall to the bottom of the hatching trough while the egg envelope remain adhered to the kacabban substrate. The hatchlings are then easily separated from the eggshells and unhatched eggs by the farmer by simply lifting the kacabban out of the hatching trough.

In most of Nigerian catfish farms, hatching procedures are rarely followed by the local farmer (Madu *et al.*, 1994). For example water temperature is rarely controlled, and, most of the time the hatching troughs in which the substrate laden with fertilized eggs are suspended are devoid of artificial aeration. The resultant effects of ignoring the hatching procedures are low egg hatching rates and poor larval survival. Only a few private hatcheries, which observe the requisite facets of larval and early juvenile rearing protocols are successful in Nigeria (Madu *et al.*, 1994). The national diagnostic survey of hatcheries and fingerling production resources carried out showed that other operational hatcheries for *C. gariepinus* fry production which are government funded facilities for demonstration purposes also suffer from irregular supply of electricity and water. Such government-funded hatcheries lack inadequate or incomplete infrastructures and require the ingenuity of the operators to make them functional (Madu *et al.*, 2000). Juvenile production from such hatcheries are poor because of low egg hatchability and poor hatchling survival (Ovie *et al.*, 1997).

Ignorance of the requisite hatchery protocol by the Nigerian fish farmers lead to production of juveniles lacking the expected vigour and which rarely satisfy the need of both small and large scale farmers (Madu *et al.*, 1994; Ovie *et al.*, 1997). Government hatcheries are inefficient and economically unviable because they operate under unnecessary bureaucratic set-up, which hinders timely purchase of essential hatchery inputs (Madu *et al.*, 2000). For propagation purposes, the original broodstock are usually collected from the wild population with inherent inbreeding problems. Van der Walt *et al.* (1992) reported that juveniles produced from parents from the wild always exhibit decrease fitness noticeable after only a few generations.

Biotic factors affecting successful African catfish larval rearing in Nigeria

In the natural environment, lack of parental care leads to non-concentration of the fry after hatchling. This amplifies the effect of biotic environmental factors such as cannibalism between the young fish, heavy predation by frogs, aquatic insects and other fishes all of which cause fry survival to be low. Abiotic factors that exert considerable influence on hatchling survival include water temperature, level of dissolved oxygen (which must not fall below $4.5 mgl^{-1}$), levels of ammonia and siltation. Under controlled culture conditions, the larvae are allowed to flow into rearing tanks where yolk-sac absorption takes within a maximum of four days (Bruton, 1979; 1989; Hecht *et al.*, 1988). Biotic factors which are of great importance when nursing first feeding larvae within earthen ponds are: availability of zooplankton, the stocking density of three day old larvae, the rearing period, predation and cannibalism. During the first week after stocking, the most critical factor for the successful nursing of the African catfish larvae is the availability of zooplankton (de Graff and Janssen, 1996).

The larval period could be divided into an early phase when larval diet consists mostly of live food and a later period when larvae and early juveniles are less dependent on live food. Clariid catfish hatchlings require live food organisms during the first four days (Verreth and Van Tongeren, 1989; Verreth *et al.*, 1993) before they can be weaned to dry feed. For improved growth and survival of *C. gariepinus* hatchlings, Hecht *et al.* (1988) recommended feeding them with *Artemia nauplii* during the first three to four days before exogenous feeding can start. *Artemia* contains protein in the range of 48% to 58% and lipid in the range of 10 - 16% (dry weight basis). Detailed research (Legendre *et al.*, 1996) have shown that the earliest time that catfish larvae should be weaned onto a dry feed is approximately four to five days after the beginning of exogenous feeding. This relates to the morphological and physiological ontogeny of the alimentary canal. Histological, histochemical and immunohistochemical studies have shown that the gut of the hatchling is only functionally complete five days after the beginning of exogenous feeding. This has been related physiologically to trypsin and pepsin activity and the fact that gastric acid secretion only commences four days after exogenous feeding.

Most fish farms in Nigeria lack sophisticated hatcheries with adequate resources to feed the new hatchlings with *Artemia nauplii* after the yolk-sac absorption stage is over. Various studies have recommended frequent live-feeding up to a maximum of twelve times per day with feeding intervals ranging between two to four hours and with ration ranging from 6% to 50% of the body weight and or *ad libitum* feeding (Hogendoorn and Vismans, 1980; Hecht and Appelbaum, 1988; Verreth and Van Tongeren, 1989; Appelbaum and Van Damme, 1988; Anderson and Fast, 1991; Haylor, 1993b). Various studies however made it obvious that feed intake approximates 21% of the body weight per day fed frequently over twenty four hours each day (Haylor, 1991) because of the high specific growth rate (SGR) during early life history stages.

In a bid to solving the problem of live-food availability during the early days before the hatchling is weaned to feeding on exogenous food source, most Nigerian fish farmers simply allow the *C. gariepinus* larvae to subsist on assorted live zooplanktons. The zooplankters are usually produced in the nursery ponds prior to larvae introduction. In some farms, the nursery ponds are usually inoculated with planktonic water from the production ponds at least two days before seeding. In most of the nursery ponds in Nigeria however, organic manures such as poultry droppings or cow dung are used to provide suitable nutrients for the culture of moinids and other zooplanktonic assemblages (Ovie *et al.*, 2000). Some farmers prefer to spread the organic manures on the surface of the nursery ponds two weeks before seeding. Other farmers prefer to suspend the choice organic manure enclosed in a woven polyester bag as the needed source of nutrients for the plankters throughout the duration of the nursing period. Whatever the approach used to provide the needed zooplankters for weaning in nursery ponds, *C. gariepinus* larvae are usually seeded into the nursery ponds when they are approximately five days old.

Several efforts have been made to alleviate the problems of provision of essential live food as starter diets for catfish larvae in the absence of imported and expensive *Artemia nauplii* on the farms. In Nigeria, monospecies zooplankters such as *Brachionus* (Alam *et al.,* 1991), *Daphnia pulex* (Ovie *et al.,* 2000), *Moina micrura* (Ovie *et al.,* 1993) and *Moina dubia* (Adeyemo *et al.,* 1994) have been tried as potential live food for weaning catfish fry. Jeje (1992) however reported that mass culture of mixed zooplankton for hatchery operations is more realistic in Nigeria because the techniques involved are much easier to master by hatchery managers than culture of monospecific species. Rumsey (1994) also indicated that a mixture of the natural live food has proved a better diet for fish larvae as it provides a wider spectrum of nutrients to the young fish. Ovie *et al.* (1997) also concluded that mixed zooplanktons of appropriate type and size could be as efficient as zooplanktonic monoculture for larval rearing. In spite of the raging controversy on the alternative to the imported *Artemia* as starter diet for clariid larvae rearing in Nigeria, most local hatchery manager still rely on the crudely generated zooplanktonic mixtures from manure fertilized nursery ponds for larval sustenance. To avoid problems of early life exogenous feeding, many small farm holdings merely rear larvae to fingering size in organically fertilized ponds at a density of between 30 - 1000 larvae/m^2. In some instances, the ponds are equipped with compost enclosures covering between 10 - 25% of the total pond surface area.

Predation is another major problem frequently encountered during the nursing phase of African Catfish larvae and early juveniles in out-door culture systems. Tadpoles belonging to the species *Rana occipitalis* (Gunther), *Ptychadena pumilio* (Boulenger), and *Xenopus tropicalis* (Gray) have been reported in nursing tanks (de Graff *et al.,* 1995). Madu *et al.* (1994) also reported collection of 34 different aquatic organisms from outdoor nursery tanks of the Nigerian Institute for Freshwater Fisheries Research (NIFFR) fish hatchery complex nursery tanks some of which have been identified as being predatory to fish fry. The predatory aquatic organisms identified include dragonfly nymph, water beetle, water bug, water scorpion, leeches and tadpoles. Other listed predators of fish fry include monitor lizard, birds such as heron, water duck and kingfisher. Apart from tadpoles of *Xenopus* species, which is known to be predators of fish larvae (de Graff *et al.,* 1995), tadpoles of the other amphibians are known phytoplanktivores (de Graff and Janssen, 1996), which compete for the same food resources with the zooplanktons which catfish larvae needed for development.

Apart from predation, the stocking density and duration of larvae rearing period are other important biotic environmental factors that must be taken into consideration for successful African catfish larviculture. Table 1 shows the results of experimental nursing of *C. gariepinus* larvae for different duration within unprotected ponds in Congo Brazzaville and Kenya. In Congo Brazzaville, the larvae were stocked at different densities with a rearing period ranging between 34 and 45 days. Stocking between 29 and 100 hatchlings/m^2 in the unprotected ponds for between 34 and 39 days resulted in a survival rate which varied between 0.9 and 28.7% and production of a maximum of 8.4 fingerlings/m^2. However, rearing of 53 and 100 hatchlings for 44 to 45 days resulted in a survival rate ranging between 1.0 and 27.2% and production of a maximum of 27.1 fingerlings/m^2. Within some of the unprotected systems however, total mortality of the hatchlings still occurred irrespective of the stocking density and duration of rearing. The total mortality recorded in such systems could be attributed to factors such as predation and poor water quality.

In the Kenyan experiment, between 15 and 45 *Clarias gariepinus* hatchlings were stocked for a nursing period ranging between 18 and 45 days. Data collected showed that the number of fingerlings harvested per square meter of the unprotected ponds after an 18-day nursing period was between 6.3 and 10.1. Rearing of the hatchlings between 21 and 29 days resulted in the harvest of between 0.6 and 11.7 fingerlings/m^2. Rearing hatchlings for between 30 and 38 days resulted in harvesting 0.7 and 21.6 fingerlings/m^2. A rearing period of between 40 and 45 days resulted in a harvest of 0.7 – 5.6 fingerlings/m^2. From the result obtained, it could be deduced that a larvae rearing period of about 33 days is the most suitable to obtain the maximum harvestable number of fingerlings/m^2 in unprotected ponds.

Recommended optimal stocking density for culture of African catfish larvae is 100 larvae/m^2 with about 35-40 fingerlings/m^2 harvested after thirty five days (de Graaf *et al.*, 1995). However, in Kenya Campbell *et al.* (1995) reported higher stocking densities resulted in more fingerlings/square meter being harvested. The average fingerlings production figures for nursing *C. gariepinus* larvae is unprotected pond systems in Africa is shown in Table 2. In Nigeria, stocking densities as high as 250 larvae/m^2 with an average production of 85 fingerlings/m^2 have also been reported (de Graaf and Janssen, 1996). In South Africa where nursery ponds are usually stocked with ten-day-old fry at the rate of 2000 fry/m^2, about 500 - 800 fingerlings/m^2 are harvested (Hecht *et al.,* 1988). Various figures have also been reported for Kenya, Cameroon, Cote D'Ivoire and Congo Brazzaville.

Irrespective of the stocking densities, the length of the nursing phase is very significant because after 35 days of rearing, two distinct size groups could always be recognized (Campbell *et al.*, 1995; de Graaf *et al.*, 1995; Aluko *et al.*, 2000). The larger group (80 - 90% of the biomass) consisting of small-sized fingerlings and a small group of fingerlings (10 - 20% of total biomass) consisting of large-sized fingerlings. Cannibalism will occur with the larger-sized fishes eating the small ones if the two groups remain unseparated resulting in small number of large fish being harvested (Dada *et al.,* 1994). As was shown in the experiment carried out in the Congo Brazzaville (de Graaf and Janssen, 1996) (Table 1), 3.6%, 2.8% and 1.0% of the hatchling population which survived to fingerling stages weighed 12.8g, 15.5g and 22.4g respectively after 34 to 45 days rearing period.

Cannibalism is another major factor, which could affect successful larvae and early juvenile rearing in the African catfish. Coeval sibling cannibalism could range from 15 to 90% and above. Factors predisposing the hatchling to cannibalism could either be genetic or behavioural, the latter being controlled principally by environmental limiting factors (Hecht and Appelbaum, 1988). According to the authors, genetically induced size variation within a cohort caused by genetic differences dictate individual growth rate. Hecht *et al.* (1988) also reported that size variation primarily caused agnostic behaviour, which results in cannibalism.

The behavioural causative factors of cannibalism is intimately linked to the genome (Aluko *et al.,* 2000). Social dominance, which is one of the causes of size variation results in hierarchical territoriality and behavioural patterns, propensity towards higher relative aggression leading to a cannibalistic response (Hecht and Appelbaum, 1988). When fish successfully start preying on their own kind, they exhibit increased robustness and vigour, a reduction in development time, increased somatic growth rate and enhanced gonadal development (Aluko *et al.*, 2000). Rate and extent of cannibalism is affected by several environmental factors such as availability of alternative prey and nutritional composition of food and prey (Hecht *et al.*, 1988). Other important factors include sibling density, available refuges, water clarity, light intensity, feeding frequency and the frequency at which alternative prey is presented (de Graaf and Janssen, 1996). High rate of cannibalism would be counter productive in terms of survival of population and therefore need to be controlled.

Nursing and nursing space more than anything else largely dictates the duration of the primary nursing period in most commercial operations. Based on practicability, exogenous feeding is introduced to the larvae as early as possible. The frequency of feeding on the farms is usually based on the observation of the larval behavioural pattern. In most cases, the farmer's feeding regime balances what is biologically possible to what is economically acceptable. If optimal conditions are maintained in the larval rearing environment, food intake is maximized and mortality will be reduced. After the weaning process is accomplished, some of the proteinous feedstuffs which have been used to compound fry rations include groundnut cake and palm kernel cake (Egwui, 1986); groundnut cake and cooked soybean (Balogun and Ologhobo, 1989); fish meal, poultry meal and soybean meal (Fagbenro *et al.*, 1992).

Competition for food is minimized by distributing food evenly over the water surface (Salami *et al.*, 1993). Food must always be made available in excess to reduce cannibalism. Weaning success is dependent largely on the nutritional quality of both live food organisms and the formulated compound diet (Bromage and Roberts, 1995). Under an ideal situation, feeding in nursery ponds should be guided by the knowledge of environmental conditions particularly those of oxygen and temperature (Haylor and Mollah, 1995). These two variables, which are rarely monitored in on-the farm situations in Nigeria have been reported by Viveen *et al.* (1985) to depress feeding activities in nursery ponds resulting in food wastage. It has been reported in Nigeria however that overloading the nursery ponds with uneaten food negatively impact on the water quality and ultimately affect fry survival and growth rate in out-door nursery ponds (Ovie *et al.*, 1997).

Ordinarily, all life stages of *C. gariepinus* in Nigeria should be resistant to infectious diseases (Ogbonna and Alabi, 1991). Bad culture conditions is responsible if the species becomes diseased at any stage, it is nearly always related to (Boon *et al.*, 1987) or the quantity and quality of feed as reported for a closely related species by Fracalossi and Lovell (1994). Identified stressors on the Nigerian clariid fish farms which can predispose the fish fry to diseases include overcrowding as was in the case for channel catfish (*Ictalurus punctatus*) (Ventura and Grizzle, 1987) and water quality related problems also as reported for the channel catfish (Tucker *et al.*, 1984). Other related environmental stressors which were reported for the channel catfish include temperature and oxygen extremes (Mollah and Tan, 1982), rapid environmental changes (Ciember *et al.*, 1995) and social interaction (Wise *et al.*, 1993).

After about 42 days of nursing and with an average weight of four to five grams, weaned *C. gareipinus* juveniles are either sold or transferred to production ponds. It is important to highlight the fact that stocking or selling of juveniles in a poor condition without the necessary vigour will have serious consequences for planning, production and productivity on the farms as have been shown from experimental findings of researches carried out on the channel catfish (Mollah and Tan, 1982).

Conclusion

The bane of successful clariid culture operations on Nigerian fish farms is primarily hinged on the inability to produce or procure suitably sized juveniles for propagation as it is well demonstrated from studies carried out in other regions of the world. Larval production on most catfish farms in Nigeria is inadequate because the farmers lack the necessary training, background and skill for running successful larval rearing operations. Juveniles being stocked on most farms therefore lack the expected vigour and genetic variability (Ovie *et al.*, 1997; Aluko *et al.*, 2000).

For *C. gariepinus*, the extended larval period, which is usually about 14 days, implies that this particular fish species requires considerably more care in terms of nutrition and feeding. Primary nursing of *C. gariepinus* larvae during the first four days has been shown to require *Artemia* as the best exclusive first feed. High cost of imported *Artemia* cyst has made feeding the fish larvae on the live-food organisms before being weaned to exogenous feed problematic and uneconomical for an average Nigerian fish farmer. The problem of *Artemia* inavailability on the farms has however been inadequately addressed by feeding with mixed zooplanktonic assemblages produced in organically fertilized ponds. The efficacy of feeding the mixed zooplanktonic assemblages dominated by *Brachionus* sp., *Daphnia* sp. and *Moina* sp. as first choice larva food for the Nigerian clariids is yet to be conclusively researched.

Apart from being hampered by the requisite facilities, most farmers lack the understanding of specific environmental conditions, nutritional requirements and optimal feeding practices essential for a productive *Clariid* larva rearing. The few government-funded hatcheries expected to be vanguards in juvenile catfish production business are weighted down by inefficient bureaucracy and epileptic social infrastructures. The private hatcheries, which are supposed to provide back-up services, are few because of the high capital outlay and intensiveness of the larva production operations. Provision of extension services to farmers in Nigeria is also problematic because the extension workers are poorly remunerated and badly motivated. Other factors inimical to *C. gariepinus* larvae survival and growth, which must be properly addressed on the farms, include:

i. research on optimal environmental conditions and general hygiene to maximize fry feed intake.
ii. research on feeding practices with attendant cannibalism and shooting phenomenon. The clariid farming community also need to be properly appraised of the facts that larvae weaning success is dependent largely on:
    (a) the nutritional quality of live food organisms especially where the larvae are fed on assorted zooplanktonic assemblages.
    (b) quality of the formulated compound diet fed to the fry at the start of exogenous feeding metamorphosis.

(c) the real time knowledge of environmental conditions particularly those of dissolved oxygen and temperature, which depresses feeding activities, feed utilization and could cause mortality in the nursery ponds.

This review has deliberately concentrated on biotic factors not because the abiotic factors are not important, but because of the paucity of information on the abiotic factors affecting larviculture in Nigeria. Temperature for example, is the most critical abiotic variable affecting the clariid larvae survivability and growth rate on commercial fish farms in Nigeria. The temperature fluctuations which occur in some locations is far above and below the range of between 26^{o} – $30\ ^{o}$ C suggested as being optimal for clariid larvae and early juvenile rearing by Verreth and Den Bieman (1987). Apart from seasonal temperature fluctuation, the design and shallowness of most nursery ponds in most farms aid wide temperature fluctuation in the culture medium. Attention should be directed at abiotic factors, which are greatly influenced by biotic factors in comprehensive investigations on the problems and prospects of larviculture in nursery ponds in Nigeria and other tropical countries in general.

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Table 1: Results of nursing *Clarias gariepinus* larvae within unprotected ponds in Congo Brazzaville and Kenya (source: de Graaf and Janssen 1996).

Congo Brazzaville (de Graaf *et al.* 1995)					Kenya (Obuja *et al.*, 1995)		
Rearing period (days)	**No of hatchling stocked (No/m^2)**	**No. of Fingerlings harvested (No/m^2)**	**Survival rates (%)**	**Wt of fingerling (g)**	**Rearing period (days)**	**Estimated No. of hatchling stocked**	**No. of Fingerlings harvested (No/m^2)**
34	32	1.2	3.6	12.8	18	15 – 45	10.1
36	29	8.4	28.7	2.8	18	15 – 45	6.3
37	34	0.0	0.0	-	21	15 – 45	4.3
37	68	1.3	1.9	5.5	23	15 – 45	5.1
37	71	0.6	0.9	8.2	24	15 – 45	11.7
37	87	0.9	1.1	2.9	28	15 – 45	11.1
37	100	0	0.0	-	29	15 – 45	0.6
38	30	1.9	6.3	4.1	29	15 – 45	4.1
39	75	2.1	2.8	15.5	33	15 – 45	21.6
44	100	1.2	1.2	16.9	35	15 – 45	5.0
45	53	0.0	0.0	-	36	15 – 45	6.4
45	68	0.0	0.0	-	36	15 – 45	0.7
45	71	0.7	1.0	22.4	37	15 – 45	0.8
45	100	27.1	27.2	2.9	38	15 – 45	6.9
45	100	26.5	26.5	2.9	40	15 – 45	2.6
45	100	0	0	-	42	15 – 45	5.6
					44	15 – 45	1.9
					45	15 – 45	0.7

Table 2: Average production figures for the nursing of *C. gariepinus* larvae in unprotected pond system within Africa continent.

Country	Hatchling stocking rate /m^2	Average No. of fingerlings produced/m^2	Source
South Africa*	2000	500 – 800	Hecht *et al.*, 1988
Nigeria	250	85	de Graaf and Janssen, 1996
Kenya	15 – 45	5.8	Obuja *et al.*, 1995
Cameroon	30 – 55	2.5	Hogendoorn, 1979
Ivory Coast	40 – 70	6.8	de Graaf, 1989
Congo Brazzaville	29 - 100	5.0	de Graaf *et al.*, 1995

* *Ten day old fry stocked instead of fish hatchlings.*