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A REVIEW OF REPRODUCTION AND GAMETE MANAGEMENT IN THE AFRICAN CATFISH *CLARIAS GARIEPINUS* (BURCHELL)

VICTOR F. OLALEYE
Department of Zoology, Obafemi Awolowo University, Ile-Ife, Nigeria.

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Abstract

Information on the current status of reproduction and gamete management of the African Catfish, *Clarias gariepinus* (Burchell) a highly appreciated culturable fish species in Nigeria were reviewed. Natural and artificial reproductive behaviour as well as gonadal maturation rhythm in the highly fecund fish were documented. Various artificial reproductive techniques utilized for induced breeding in captivity and the attendant limitation were highlighted to facilitate understanding of the fish reproductive behaviour. In nature, *C. gariepinus* has a discontinuous reproductive cycle regulated by cyclically active gonad tropes. A gonadotropin surge trigger off by environmental cues usually facilitates spontaneous oocyte maturation, ovulation or spermiation. Under captive condition, the fish spawn easily with hormonal induction using either homoplastic pituitary gland suspension or synthetic hormonal preparations. The Nigerian clariid farming communities however prefer the use of homoplastic pituitary gland suspensions instead of synthetic hormonal preparations to induce spawning in fish farms because of the very expensive nature of the imported synthetic hormonal preparations.

Keywords: Catfish, gonad tropes, hormone, oocytes, oogenesis, Spermatogenesis, *Claria gariepinus*

1. Introduction

The clariid catfishes characterized by an elongated naked body with long dorsal and anal fins are one of the world's economically important group of fresh and brackish water fishes. In many countries, they form a significant part of inland fisheries. Primarily, the clariid freshwater fishes belonging to the Family Clariidae had a wide geographical distribution in Africa consisting of 14 genera (Teugels, 1986a) and 32 species (Teugels, 1986b). In Nigeria, Syndenham (1980; 1981) reported the family consist of five subgenera namely: *Clarias, Clarioides, Anguilloclarias, Platycephaceloides* and *Brevicephaloides*.

The African catfish (*Clarias gariepinus*) (Syn. *C. lazera* C & V) is the most studied and is of high significant importance to fisheries in Africa (Teugels, 1996). Recently however, *Heterobranchus longifilis* has successfully been introduced in aquaculture under identical conditions with promising results (Legendre *et al.*, 1992). The most exciting feature of *C. gariepinus* is the high potential for high intensive culture without prerequisite for pond aeration or high water exchange (Hecht *et al.*, 1988).

Clarias gariepinus has a unique suite of morphological, physiological, ecological and behavioural traits that equip it to succeed in freshwaters (Bruton, 1979a). The fish is hardy and adaptable to thrive in diverse environments with questionable water quality principally as a consequence of its air breathing ability (Hecht *et al.*, 1996).*C. gariepinus* is a typically non-aggressive stalking predatory omnivore that hunts at night in turbid waters using non-visual primary sense organs especially, the senses of touch through the barbels and tactile organs on the mouth and skin (Bruton, 1996). The fish also exercise high trophic plasticity because it has ability to feed on wide array of natural preys under diverse conditions (Haylor, 1992).

Despite the potentials, its culture in Nigeria, *C. gariepinus* production is still unsophisticated. Production is basically at subsistence level farming with simple processing and marketing channels. Rarely is high-density culture practiced to meet either the domestic consumption demand or for export. Also there is the absence of a definitive clariid farming groups to facilitate cross-fertilization of ideas relating to the identified production problems.

Technologies for farming *Clarias gariepinus* have now been developed to varying degrees of sophistication. Hormonal preparations used successfully to induce spawning in the African catfish all over the world include Human Chorionic Gonadotropin (HCG); 11-deoxycorticosterone-acetate (DOCA); carp pituitary suspension, progestagen, pimozide and Hypothalamic Hormone Analogue (LH-Rha) (de Kimpe and Micha, 1974; Hogendoorn, 1977; Schoonbee *et al.* 1980; Hecht *et al.*, 1982; Richter and van den Hurk, 1982; de Leeuw

email: olafoluwa_59@yahoo.com **or** foluwaola@oauife.edu.ng

et al. 1985; and Richter *et al.*, 1985). Hybrid cross between *Clarias gariepinus* and *Heterobranchus longifilis* has also been receiving considerable attention (Hecht and Lublinkhof, 1985; and Richter *et al.*, 1985). Comparative studies between *C. gariepinus* and *Heterobranchus longifilis* and their reciprocal hybrids have also been reported (Legendre *et al.*, 1992).

Unfortunately, local farmers have not translated the results of the research and development in Nigeria and elsewhere into practice. Farmers with smallholdings need to be convinced of the efficacy of a new technology as well as its cheapness before its adoption.Clariid farming community in Nigeria relies mainly on the use of homoplastic pituitary gland suspension than on synthetic hormonal preparations to induce spawnings in their fish farms. The use of carp or clariid pituitary suspension prepared freshly on the farm has been found to be cheap, practical and highly reliable compared to the expensive sophisticated synthetic hormone analogs. The objectives of the current exercise are to review the natural and artificial reproductive behaviour in *C. gariepinus* as well as to document the gonadal maturation rhythm. Various artificial reproductive techniques with their attendant limitations were also highlighted to facilitate better understanding of gamete management in the species.

2. Reproductive Physiology of the African Catfish

(a) Natural Reproductive Behaviour and Gonadal Maturation Rhythm

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.*, 1983; Legendre, 1986) provided adequate and unrestricted feeding is available (Pham and Raguel, 1977; Richter *et al.*, 1987a). Fecundity is relatively high in *C. gariepinus* ranging from about 30,000 to 100,000 eggs.kg^{-1} body weight (Balon, 1984a; Bruton, 1979). Ovaries present the same general morphology as in other teleosts (Balon, 1984b) with oviducts and the sperms being mono-flagellated (Legendre *et al.*, 1996). The eggs with an adhesive attachment disk are generally small and fertilization is external (Bruton, 1979). *C. gariepinus* show altrical or continuum of alternative reproductive style (Bruton, 1989). The fish is an egg scatterer which awaits suitable environmental condition before spawning.

Gonadal maturation is associated with increasing water levels, temperature and photoperiod (Bruton, 1996). Spawning (which is preceded by massive aggregation of the fish), courtship and aggressive encounters between males occur on dark nights after the rains (Bruton, 1979). Pairings takes place between isolated individuals in shallow waters among inundated plants. The incubation period of the fertilized egg is short (24 hours) and the yolk absorption phase takes 2-4 days (Hecht *et al.* 1988).

In nature, the african catfish has a discontinuous reproductive cycle regulated by cyclically active gonadotropes (Peute *et al.*, 1984). Under natural conditions, the annual breeding season of the species is limited to a few months (Bruton, 1979). Goos and Richter (1996) reported that both the ultrastructural appearance of the gonadotropes and the pituitary gonadotropin content showed cyclical changes in both sexes which parallel changes occurring in the reproductive cycle.

The internal gonadal rhythm for *Clarias* species has been shown to differ from region to region (Legendre *et al.*, 1996). However, the common factor for spawning behaviour to commence is the onset of the rainy season and the accompanying flood regime. The spawning season starts February - June in Nigeria; between July and September in the Nile Delta (Egypt) and in the Ubanqui River (Central African Republic). Spawning period commences March-April in Lake Victoria (Uganda); December - February in Mazoe (Zimbabwe) and May-August in Hula Reserve (Israel) (Richter, 1976; van den Hurk *et al.*, 1984;1985).

The annual reproductive cycle in the African catfish has been divided into the breeding phase, the resting period and the gonadal recrudescence phase (Peute *et al.*, 1986; van den Hurk *et al.*, 1984;1985). Accordingly, during the breeding period the gonad tropes are large and fully granulated with the pituitary gonadotropin content reaching the maximum level. During the same period, gametogenesis comes to an end and the gonadotropin surge, which takes place at least once lead to oocyte maturation, ovulation or spermiation.

In Nigeria, the resting period occurs in September and February. During the period, an increasing number of fusion products of secretory granules and globules occur in the gonad tropes. Peute *et al.* (1986) associated the increased number of granules and globules to breakdown of stored hormones. Appearance of residual bodies, cell shrinkage and a considerable drop in the pituitary gonadotropin content characterise the late resting period (van den Hurk *et al.*, 1984) and gametogenesis remain absent (van den Hurk *et al.*, 1985). Gonadal recrudescence with full gametogenesis and restoration of sex steroid synthesis and redeveloping of the gonad tropes in the fish in Nigeria occur March and April (Nwadukwe *et al.*, 1983). The gonadal recrudescence phase is characterised by increase in the gonadal size, granulation and augmentation of the hypophysial gonadotropin content.

Gonadal functions are regulated by gonadotropic hormones (GTH) produced by the pituitary gland

(Goos *et al.*, 1986). The secretion of gonadotrophic hormones is regulated by neurohormones mainly of hypothalamic origin and by the gonadal hormones (Koide *et al.*, 1992). Consequently cells producing GTH play a central role in the control of reproduction (Nozaki *et al.*, 1990). Studies have shown that when the african catfish reach maturity under favourable conditions of adequate food supply, the female catfish undergo constant production and storage of gonadotropin (Goetz, 1983). Also, the fish pituitary system through a negative feedback action on the hypophysial gonadotropin secretion ensures a continuous but limited release of this hormone sufficient only for production and maintenance of postvitellogenic oocyte but not enough for spontaneous oocyte maturation, ovulation or spermiation.

In nature the prespawning gonadotropin surge is induced by environmental factors such as increase water level and flooding of marginal areas (Bruton, 1979). The environmental cue ensures increase in hypophysial gonadotropin secretion through a positive feedback action of the gonadal steroids to induce the hypothalamus-pituitary system to reach higher activity levels. Goos and Richter (1996) reported that the gonadotropin surge induces the conversion of 17α OH-progesterone into 17α hydroxy-20-β-dihydroprogesterone which is the final maturation inducing substance in *C. gariepinus*. In the absence of gonadotropin surge, the event behind the process that lead to oocyte maturation, ovulation or spermiation does not occur (Jalabert, 1976; Goetz, 1983).

(b) Gonadal Maturation Rhythm in Captivity

The african catfish grows and reaches sexual maturity in captivity within 6-9 months of age. However there is generally no spontaneous reproduction under culture conditions. In most cases, gametogenesis is completed, postvitellogenic eggs and ripe sperm cells are presented. Although oogenesis and spermatogenesis have been reported to be normal in *C. gariepinus* under culture, the final oocyte maturation, ovulation or spermiation do not occur because the environmental cues that trigger the gonadotropin surge are difficult to identify or mimic on the farm. Goos and Richter (1996) reported that the absence of an environmental cue in combination with unavoidable stress cause a blockage of the gonadotropin releasing hormone (GnRH) and consequently gonadotropin surge release fail to occur. The authors also reported that GnRH blockage in the fish is effectively enforced by hypothalamic dopaminergic inhibition and identified the sex steroids that play a role in the negative feedback control of gonadotropin release. The identified sex steroids, which were found to interact with hypothalamic dopamine metabolism to cause the inhibition were 11-keto-testosterone, and testosterone.

The african catfish raised in captivity and constantly kept under favourable husbandry conditions throughout the year have pituitaries containing large and densely granulated gonadotropes (Peute *et al.*, 1984) storing large amount of gonadotropin (de Leeuw *et al.*, 1985). Such fish show a continuous cycle with numerous ripe sperm cells and postvitellogenic oocytes at all seasons (Richter and van den Hurk, 1982) but without spontaneous spermiation, ovulation and maturation. The absence of a discontinuity in the annual reproductive cycle of the fish primarily results from the absence of a prespawning gonadotropin surge and a postspawning regression of the gonadotropes (Richter *et al.*, 1987b). The failure to release large amount of gonadotropin has been found related not to insufficient storage of the hormones in the gonadotrophic cells (de Leeuw *et al.*, 1985) but rather to the hypothalamic dopaminergic inhibition which prevented the release of GnRH in the fish and/or prevention of the hormone from eliciting the desired effects (Goos and Richter, 1996). Also the involvement of extracellular Ca^{2+} seem to be obligatory for the GnRH induced GTH release. Van Asselt *et al.* (1989) reported that the GnRH stimulation of GTH release was strongly inhibited in the absence of Ca^{2+} or in the presence of the Ca^{2+}x -channel blocker (Nifedipine).

3. Reproductive Techniques

(a) Gamete Biology, Pheromonal Induced Ovulation, Spermiation and Spawning

The study of gamete biology of the clariid species, which is still at a nascent stage in Nigeria, precludes the optimization of gamete management and manipulation techniques for successful natural and artificial reproduction in *C. gariepinus*. Studies have shown that simple endocrinological methods can be used to evoke oocyte maturation, ovulation or spermiation to meet both scientific and practical applications on the farms. Goos and Richter (1996) reported that african catfish reared from egg to maturity in the laboratory under similar feeding and temperature condition with different photoperiodic regimes showed an uninterrupted ovarian activity with postvitellogenic oocyte at all seasons. According to them such fish could be induced all year round to produce large quantities of viable eggs. Matured African catfish brought from the natural habitat to an indoor hatchery under conditions of opitmal food supply, constant water temperature (about 25 °C) and normal local changes in day length makes the period of successful artificial propagation to increase from 10 to 11 months a year.

Old broodstock are preferable for reliable spawning. Good African catfish broodstock care entails maintenance of appropriate standing crop weight with density not exceeding 1300 kg.ha^{-1} (Legendre, 1986) and the provision of adequate food supply usually in form of supplemented pelleted feed. Under hatchery conditions, good quality eggs and sperms can be obtained continuously in *C. gariepinus* when the water temperature is constantly maintained at 25 °C (Richter *et al.*, 1987a). Good broodstock can be stripped every 6-8 weeks (Hogendoorn and Vismans, 1980). However, temperature plays a very vital role in achieving optimum pre-spawning conditions. Richter *et al.* (1982) observed that at 30 °C the proportion of atretic oocytes increased and the testis regressed.

The African catfish do not spawn individually but in groups. During the period of spawning, pheromonal interaction between females is an important process to synchronise the spawning process. Several studies have shown that the absence of spontaneous spawning in *C. gariepinus* kept under husbandry conditions is caused by shortage of suitable pheromones eliciting spawning behaviour, gonadotropin release, oocyte maturation and ovulation (Stacey *et al.*, 1986; Schoonen and Lambert, 1986; Schoonen *et al.*, 1987a, b, c).

Steroid conjugates have been shown to act as pheromones (Resink *et al.*, 1987). Female fish exposed to ovarian fluid of ovulated females also has an increased plasma GTH levels (Resink *et al.*, 1989a). A combination of male and female pheromones administered as a replacement of the ovulated female also instigated ovulation responses. Resink *et al.* (1989b) also reported that ovulation could be induced when female fish were held in the presence of a male and tactile stimuli were avoided. However, the authors reported such responses were limited to natural breeding periods only. *C. gariepinus* has also been induced to spawn naturally and successfully when ripe fish were placed in freshly filled ponds that has been dried for a time (De Kimpe and Micha, 1974; van der Waal, 1974). However, the number of fingerlings thus obtained is generally very poor (Goos and Richter, 1996).

(b) Hormonal Induced Ovulation, Spermiation and Maturation

Studies have shown that stepwise control of reproduction in *C. gariepinus* allow gamete preservation and manipulation under husbandry conditions. Presently, hormonal inducement and artificial fertilization are attracting much attention in terms of research and its applicability in farm situations as they allow for greater control over various steps in the fish reproductive cycle. Many techniques using hormonal-induced ovulation and artificial insemination to ensure spawning and fertilization of the african catfish in captivity have been perfected. The exogenous hormone sources commonly adopted either stimulate hypophysation or the gonadotropic hormone or artificially induce hypothalamic hormone discharges (Legendre *et al.*, 1996).

Gonadotropin is central to *C. gariepinus* reproductive processes. The regulation of the release of the hormone from the gonadotrophic cells in the pituitary is very important. Oocyte maturation and ovulation are induced by administering exogenous gonadotropin (Eding *et al.*, 1982). Under farm condition, injection of a crude homogenate of catfish pituitaries forms a simple and reliable method to induce ovulation in *C. gariepinus* (Hogendoorn and Vismans, 1980). In most farm holdings in Nigeria, whole pituitaries are removed from sexually matured adult male African catfish during spawning season and are either used immediately or stored in absolute ethanol or acetone (Nwadukwe *et al.*, 1983). During application, the pituitaries are simply homogenised in sterile water or in most cases on the farm applications uncontaminated rainwater is used. The homogenate obtained is then injected into females where it elicits the required response.

Pituitary gonadotropin induces oocyte maturation and ovulation indirectly by stimulating synthesis of maturational steroids in the ovarian follicles (Goetz, 1983). Studies have however shown that ovulation induction is of no avail when the ovaries do not contain numerous postvitellogenic oocytes (Richter *et al.*, 1987a). The implication is that artificial propagation can be applied successfully under natural conditions only during the breeding period or at the beginning of the resting period.

Hormonal preparations which have been tested for artificially-induced breeding of African catfish female broodstock and the various limitations include:

(i) *Clarias* pituitary extract (Van der Waal, 1974; Micha, 1976; Schoonbee *et al.*, 1980; Hecht *et al.*, 1982). The limitation of using the *Clarias* extract is that fish must be sacrificed to get at the pituitary gland. Also, the dose must be calculated on a donor: recipient weight basis.

(ii) 11-deoxycorticosterone-acetate (DOCA) (De Kimpe and Micha, 1974; Pham and Raugel, 1977; Hogendoorn, 1979). The artificial hormone is limited by the fact that the steroid could only induce oocyte maturation only and not ovulation (Richter and Van den Hurk, 1982). However, stripping of eggs could be possible after DOCA treatment as ovulation could only be evoked mechanically. Also infections under the skin (which follow intramuscular injections) have been reported.

iv) 17α-hydroxyprogesterone successfully induces both oocyte maturation and ovulation (Richter *et al.*, 1985). Two successive injections are however required with time interval of 4 hr to achieve the required result.

v) Carp pituitary extract (Hogendoorn, 1979; Hogendoorn and Vismans, 1980; Richter and van den Hurk, 1982). Using the extract involves sacrificing the fish.

vi) Human Chorionic Gonadotropin (HCG) alone (Eding *et al.*, 1982). The limitation to its usage is the cost.

vii) HCG + Carp pituitary extract (Shoonbee *et al.*, 1980). The limitation of the usage of the combination of the two hormones is the cost.

viii) Hypothalamic hormone analogue (LHRHa) (de Leeuw *et al.*, 1985a). The hormone analogue is efficient in inducing oocyte maturation and ovulation but its potency is increased when administered with pimozide.

ix) Hypothalamic hormone analogue (LHRHa) with antidopamine antagonist (Goos *et al.*, 1987). The limitation to its use is the cost.

x) hormonal-induced ovulation and spontaneous oviposition and fertilization by male in culture media (semi-natural spawning). The method is unreliable for *C. gariepinus* fingerling production due to heavy losses of eggs and fry (Hogendoorn, 1979).

(c) Hormonal Dosage and Gamete Management

Close monitoring of the optimal hormone and hormone dosage essential for inducing oocyte maturation is essential for proper gamete preservation and management. The recommended dose of *Clarias* pituitary to be administered to the female broodstock is calculated on a 1.5:1 (donor: recipient) ratio. Such induced females with suitably developed eggs can usually be stripped 12 hours after receiving a single dose at a temperature of 28 °C or 20 hours at a temperature of 22 °C (Legendre *et al.* 1996). Owing to high levels of aggression, the injected broodstock females are usually separated from each other in holding tanks by sturdy screens. Ovulation is not synchronous in individual female broodstock and is usually affected by the exogenous hormonal application. After hCG injection for example, ovulation takes 7-11 hours at 30 °C in *C. gariepinus* (Legendre and Otéme, 1995).

Factors and mechanism governing ova survivability *in vivo* are poorly understood. It is pertinent to note however that survival time during which ova are able to develop are normally very short and temperature dependent. The phenomenon of ageing that leads to over-ripening of ova maintained within ovaries occur rapidly. Survival time measured by hatching percentage is estimated by the time lapse between ovulation and the moment at which the initial egg fertilisability begins to drop. The correct time of stripping therefore becomes increasingly critical at higher temperatures (Hogendoorn and Vismans, 1980; Espinach Ros *et al.*, 1984). After successful hormonal induction of ovulation in *C. gariepinus* with carp pituitary suspension at the rate of 4 $mg.kg^{-1}$, Hogendoorn and Vismans (1980) reported that the ova survival time was about 9 hours at 20 °C while the survival time reduced to 2 hours at 30 °C. Unlike in the females, the volume of sperm collected after hormonal stimulation (induced spermiation) is generally low no matter the time lag (van der Waal, 1985).

(d) Artificial Insemination and Fertilization

Holding the female broodstock in a head-up vertical position tests readiness of the eggs for fertilization. The eggs begin to run freely from the genital pore when the fish is ready to be fertilized. Stripping *C. gariepinus* females as soon as free-running ova (referred to as unriped ova) could be obtained immediately after carp pituitary suspension treatment without waiting for the post-ovulatory maturation period led to low hatching percentages (Richter and van den Hurk, 1982) and high proportion of deformed larvae after fertilization (Hogendoorn and Vismans, 1980). In a later study, the first free-running eggs were found by Legendre and Ótémé (1995) to be of good quality with high hatching rates and low proportion of deformed larvae. Ova post-ovulating maturation period is dependent on temperature. Richter and van den Hurk (1982) reported that the best results were obtained about 10, 3, and 1 hours after pituitary suspension treatment at 20 °C, 25 °C and 30 °C respectively. Waiting the mandatory post-ovulatory maturation period also ensures that the eggs could be stripped more easily than before (Legendre and Ótémé, 1995).

The time lapse during which fertilization of ovulated oocytes remain possible after being emitted by the female or exposed soon after stripping to water or various solution is referred to as ova viability. In the african catfish the egg viability is very short (van den Hurk, 1982). The attendant loss of fertility after the mandatory time lapse was probably due to the closing of the micropile resulting from expansion of the ova envelopes (Legendre *et al.*, 1996). The eggs are also heat labile with thermal tolerance limits between 22 °C and 35 °C (Legendre and Teugels, 1991). A temperature of 30 °C was however considered optimal for egg incubation (Mollah and Tan, 1982; Haylor and Mollah, 1995).

C. gariepinus is oligospermic (GSI < 1%) (Legendre *et al.*, 1996) and the spermatozoa may be present in the testis all year round although their viability cannot

be ascertained. Semen is easily collected from males injected with *Clarias* pituitary homogenate unlike in the untreated fish (van der Waal, 1985). In case of insufficient sperm availability males are sacrificed and the milt is extracted from the testis cut into small pieces extended in a saline solution or pressed through a net fabric into the egg (Hogendoorn and Vismans, 1980; Mollah and Tan, 1983; Legendre, 1986). The fertilizing capacity of the intratesticular sperm is maintained when inactivated in 155 mM NaCl solution (dilution 1: 10 or 1:100) (Hogendoorn and Vismans, 1980). *In vitro* sperm storage in non-diluted state after sampling for 24 hours usually at 4-5 °C reduces the fertilizing capacity of spermatozoa by about 4 % (Legendre, 1986).

Ova generally survive only a few hours after ovulation and as such fertilization must be carried out soon after (Legendre *et al.*, 1996). Genetic variability in the hatchlings is increased when a minimum of two males are used to fertilize batches of eggs. Fertilization is best effected by first diluting the sperm in physiological saline after which the solution is mixed with the eggs. After the stripping of the female broodstock, 200 ml of eggs and 3 ml of sperm are mixed together in a bowl to which 100 ml of activating solution (17 mM NaCl; 5 mM Tris; pH 8) is added (Haylor, 1983). 3 $g.l^{-1}$ NaCl solution could also be used as activating solution for the fertilization process (Horvath and Tamas, 1976). After 2-5 minutes of gentle stirring, the eggs are transferred to an incubator. The time of contact between sperm and ova for fertilization to occur is about 1 minute (Hogendoorn and Vismans, 1980; Legendre, 1986).

The African catfish produce mostly independent sticky eggs spread in a single layer or stuck on vegetable materials in spawning nests in case of natural spawning. After fertilization, the fertilized eggs become sticky on contact with water. In the hatchery, the fertilized eggs are spread in a single layer on a horizontal 1 mm material mesh to which they adhere rapidly (Haylor, 1993). In Nigeria where there are very few sophisticated hatcheries, the fish farmers commonly use mosquito nets and cacabans as substrate. The fertilized eggs are spread in a single layer on the substrate to which the sticky fertilized eggs adhere. The material with the attached eggs is then suspended slightly off the vertical axis in hatching troughs containing well-aerated water. The development time during the incubation period is temperature dependent. Once hatching occurs, the new hatchlings simply fall to the bottom of the hatching troughs while the egg envelope remain adhered to the screen material. The larvae are then easily separated from the unfertilized egg and egg shells by farmers by simply lifting the cacaban or the screen net.

4. Conclusion

C. gariepinus is highly relished as food fish in Nigeria because of its excellent meat quality. Apart from being highly priced for its food value, the potential for high intensive culture of the species makes the fish to be preferable to any other culturable species. *C. gariepinus* is known to have an excellent food conversion apart from its trophic plasticity in captivity (Haylor, 1992). The fish is also resistant to diseases (Hecht *et al.*, 1988) and has relatively low requirement for water quality (Teugels, 1996). It is also very highly fecund and has ability to spawn under captive conditions (de Leeuw *et al.*, 1985). Ensuring sustainable production of such priced species entails proper broodstock management with hormonal injection using either homoplastic pituitary gland suspension or synthetic hormonal preparations to enhance propagation and continual recruitment into both the wild and the cultured populations.

Most catfish farms in Nigeria however depend on broodstocks collected from the wild populations with attendant inherent inbreeding problems. Most of the time, *C. gariepinus* broodstocks from the wild produce fingerlings with decreased fitness noticeable after only a few generations. Successful catfish farming operations require the local fish farmer to observe requisite protocols, which is a *sine qua non* for successful reproduction and gamete management in the species. Such important protocols for broodstock management include those on the nutritional requirements, optimal environmental conditions and feeding practices. Currently the problems appear insurmountable because the extension workers who are supposed to be in-charge of the on-the-farm training are poorly remunerated and badly motivated. Also, without Government subsidy, most of the imported farm inputs and technologies will forever be beyond the reach of the average Nigerian African catfish farmer.

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