Growth and Economic Performance of Diploid and Triploid African Catfish 
(*Clarias gariepinus*) in Outdoor Concrete Tanks

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Abstract: The growth and economic performance of diploids and triploid *Clarias gariepinus* was investigated. Triploid fishes were produced by subjecting freshly fertilized eggs collected through hypophysation to cold shock treatment three minutes after fertilization, for duration of ten minutes at a temperature of 0°C. Diploid *C. gariepinus* was produced by incubation and hatching of eggs (at normal average environmental temperature of 25°C) collected through hypophysation with no shock treatment applied. Both strains were cultured for a period of twenty four weeks. The study showed that diploid fishes hatched better than the triploid with mean hatching rates of 85.93±1.71% for the former and 41.32±3.32% for the latter. Survival rates were 94.94±1.7% and 93.65±0.69% for diploid and triploid respectively. Average Bi-weekly weight gain for both treatments were significantly different (p<0.05). Mean bi-weekly weight gain for triploid and diploid were 245.4±47.72g and 202.7±43.10g respectively. Average weight at harvest for both strain was significantly different (p<0.05) with diploid having an average weight of 436±25.28g and triploid having a weight of 519±27.12g. Mean feed conversion ratios (FCR) were 1.74±0.15 and 1.99±0.14 for diploid and triploid respectively. FCR was not significantly different (p>0.05). Profit index for triploid was 0.631 and 0.30 for diploids. Gross profit for diploid and triploid were N-18,901.58 and N-21.132.43 respectively and were not significantly different (p<0.05). Revenue for both triploid and diploid fishes was N19,267.43 and N13,601.58 respectively. Total cost of investment for diploid and triploid were N34,101.58 and N39,767.43 respectively. The findings of this study suggests that triploid *Clarias gariepinus* may have higher mean weight and revenue than its diploid but may not necessarily yield higher profits margins for a fish farmer than its diploid culture.

Key words: *Clarias gariepinus* · Triploid · Diploid growth · Economics

INTRODUCTION

African catfish of the family Claridae is the most cultivated fish species in Nigeria. The favoured African catfish cultured in Nigeria include: *Clarias gariepinus, Heterobranchus bidorsalis, Clarias X Heterobranchus* hybrid (‘Heteroclarias’) and *Clarias nigrodigitatus* [1]. *Clarias gariepinus* and *Heterobranchus bidorsalis* are the most farmed fish in Nigeria. The growth of aquaculture in Nigeria now is largely boosted by a steady rise in catfish culture. Catfish farming is a major area of interest to most fish farmers in Nigeria [2]. Majority of the farmers (76%) favoured the practice of catfish farming using concrete ponds, flow-through water supply method and intensive feeding technique. However, it was identified that a major limitation in the catfish farming is the unreliable supply of fish seed of good quality (fast growing fishes). In order for aquaculture to meet-up with the increasing demand for fish, there have to be the development of improved fish seed stock that can contribute to increased fish production while ensuring protection of biodiversity [3] thus, fish breeding is a major aspect that contributes significantly to the success of aquaculture.

Polyploidy is one of the major areas of biotechnology and its applications to fish breeding can help to increase yield in fish culture by improving their growth rate. Many fishes are known to be relatively tolerant to chromosomal manipulations especially in the early stages of their development and this give the advantage of easy application of polyploidy to their breeding procedure, as a means of improving seed quality. Triploid is a form of polyploidy that involves chromosomal manipulation in the early stages of the fish to produce fishes with three set of...
complete chromosomes [4]. Theoretically, it is believed that triploids are sterile and will spend more nutrients on developing their body (flesh and muscles) thus, leading to increase in weight rather than developing their gonads as is the case with their diploid counterpart. Also the extra set of chromosome is believed to create large cytoplasm in the cell thus producing enlarged cell size [5].

Most research in this aspect of biotechnology in Nigeria and other developing countries has been experimental without extensive testing under practical conditions that consider a wide range of environment in which aquaculture takes place. Hence a study on the growth performance of triploid catfish under practical environmental conditions such as concrete tanks will bring enormous benefits to the aquaculture industry. Shock methods have been used in producing triploids which include temperature shock (cold shock and warm shock), chemical shock and pressure shock. Koedprang and Na-Nakron [6] recorded high hatchability of 72.5% in the production of triploid silver barb when cold shock was applied for a duration of 10 minutes while, Hammed et al. [3] recorded 55% hatchability in triploid induced egg using cold shock method for a duration of 25 minutes at 0°C. A general rule of thumb is to use warm shock for cold water fishes and cold shock for warm water fishes like Clarias gariepinus.

**MATERIALS AND METHODS**

The growth and economic performance of diploid and triploid C. gariepinus was investigated. The study was carried out in two experiments (i.e. Experiment I and II).

**Experiment I: Production of Diploid and Triploid Seeds:**
Milt and eggs were obtained from the four pairs of broodstock C. gariepinus through hypophysation. The eggs obtained from each pair were shared into two. One half was used for the production of diploid and the other half to produce triploid. The cold shock method of triploid production was used as it gives better result than warm shock especially for warm water fishes [3, 5, 7, 8]. The cold shock medium was applied by keeping freshly fertilized eggs in refrigerator for a period of 10 minutes at a temperature of 0°C, three minutes after fertilization [3, 9, 10]. The mercury-in-glass thermometer was used in monitoring the temperature of the refrigerators prior to cold shocking and during cold shock application. Diploid fishes were produced through hypophysation without any cold shock application. Fertilized eggs for both treatments were incubated at ambient water temperature of about 28°C. The hatched eggs were nursed and raised for 4 weeks indoor till they became fingerlings. The hatchlings were fed thrice daily with artemia for the first 2 weeks and subsequently with multi-feed for the last 2 weeks at a frequency of 6 and 2 times daily for the first and last two weeks respectively. The data collected including hatching and survival rates.

**Experiment II: Culture of Diploid and Triploid Fishes:**
A concrete tank of 5 x 4 1.2 m was partitioned into eight compartment or unit using hapa nets. Each compartment measured 1m x 1m x 1.2m. Each unit was stocked at the rate of 20 fishes/M². Two treatment (i.e. stocking of diploid and diploid fishes) was carried out. Each treatment was replicated four times. Fishes were cultured for twenty four weeks with occasional flushing of water when water transparency is less than 30cm. The culture fish was fed twice daily (i.e. at 10.00 and 16.00 hrs) till satiation. The experiment was designed as a factorial in complete randomised design (i.e. 2 fish type (diploid/triploid) X 4 weeks culture period. The collected data included the growth parameters (such as bi-weekly weight gain, absolute growth rate, specific growth rate, fed conversion ratio and mean weight of fish at harvest) and the economic parameters (such as fixed and variable cost, revenue, gross profit, incidence of cost, profit index and benefit cost ratio. All data was subjected to statistical test using analyses of variance and means were separated using Duncan multiple range test and least significant differences of means.

**RESULTS**

Results of the hatching rate and survival rates of fish and growth performance for diploid and triploid fish are shown in Table1. There was significant difference in the hatching rate of diploid and triploid (P<0.05). The diploid fishes having a higher hatching rate than triploid. However, there was no significant difference between the survival rates of both treatments. Data on bi-weekly mean weight gain of fish during the study is shown in Figure 1. Both treatments showed a steady increase in growth. The bi-weekly mean weight gain of triploid treatments were significantly (p<0.05) higher than diploid. There was no significant difference (p<0.05) for the Feed Conversion Ratio (FCR), Specific Growth Rate (SGR) and Absolute Growth Rate (ABGR) of diploid and triploid fishes in this study. However, in absolute terms, triploid fish had the poorer FCR. Mean SGR and ABGR for triploid Clarias gariepinus was higher than the values of diploid fishes.
There was no significant difference in the average size at harvest (p<0.05). However, in absolute terms, triploid fish had higher average size at harvest than diploid fishes.

The results of the economic performance of diploid and triploid C. gariepinus are shown in Table 2. Diploid fishes had the lower revenue but however, generated more profit (i.e. lesser loss). There was no significant difference for revenue of both treatments. Diploid fishes had lower incidence of Cost compared to triploid in this study. Triploid fishes showed higher profit index and benefit cost ratio than diploid fishes.

**DISCUSSION**

The result showed that the hatching rate of triploid Clarias gariepinus was low while that of diploid C. gariepinus was high. This may not be connected with the shock treatment given to the triploid fish. Tave [5] reported that the low level of hatching in the triploid fish can be attributed to the stress on the eggs coming from the cold shock treatment. He further stated that this stress resulted in hardness effect on the hatched eggs which is expressed in their survival rate after hatching. The survival rates recorded in the present study after hatching of the eggs were high for both triploid and diploid. This is in agreement with work done by Hammed et al. [3], Smitherman et al. [5] and Tiwary et al. [10].

The higher bi-weekly mean weight gain of triploid Clarias gariepinus recorded in this study may be connected to the sterile nature of triploids which enables them to channel more energy for body building rather than sexual development. Smitherman et al. [5], Fast [9] and Tiwary et al. [10] have all shown that triploid fishes have poorly developed gonads and have higher mean weight gain compared to their diploids. The high average size of fish at harvest obtained in triploid C. gariepinus may also not be unconnected with the extra set of chromosome associated with triploids and also its sterile nature (poor sexual maturation) which allows it to channel less energy for gamete production and more energy for body building and development [5]. This finding agrees the report of Hammed et al. [3], Fast [9] and Agbebi et al. [11]. These researchers all recorded higher mean weight in the triploids of C. gariepinus and Clarias macrocephalus than its diploids. The finding however disagrees with that reported by Karami et al. [12]. They reported that triploid Thai silver barb (Puntius gonionotus) was shorter and weighed less compared to its diploids. The differences may be due to differences in fish species.
Poor FCR was generally recorded for both treatments in this study. This may be due to the challenge of insufficient water supply and poor water quality encountered. The inadequate water supply during the study made it difficult for regular flushing to be carried out thus leading to build up of ammonia which may have retarded fish growth as observed by Messer et al. [13]. Environmental effects, statistical error and experimental error may have also contributed to poor FCR. The FCR recorded in this study was in agreement with previous study reported by Henken et al. [14] for African catfish (C. gariepinus) and Burke [15] for triploid Atlantic salmon (Salmo salar). There was no significant difference for the FCR in both triploid and diploid C. gariepinus of this study suggesting that both triploid and diploid C. gariepinus may have similar food efficiency and this is in consonance with the findings in similar study reported by Burke [15] for triploid Atlantic salmon. Previous studies carried out by Oppedal et al. [16] for brook trout; Agbebi et al. and Benfey [11, 17] for African catfish (C. gariepinus) have failed to find a consistent effect of polyploidy on FCR with no significant difference reported for species studied by these researchers. Specific growth rate (SGR) for triploid catfish in this study was slightly higher than its diploid. However, there was no significant difference in the SGR of both treatments. This agrees with the findings of O’Keefe and Benfey [18]. The higher SGR recorded for triploid suggest that they may have a steady growth rate than diploids and this may be connected to the feeding attitude as well as fish behaviour especially during feeding. In this respect, Garner et al. [19] reported that general behaviours affect feed intake and hence affect SGR and ABGR. It was observed in this study that triploid C. gariepinus were less aggressive (active) during feeding and were able to ingest most feed or sometimes all feed given to them thus, having less cases of unconsumed feed in their tanks hence, resulting better utilization of feed for growth as observed by De Silva and Anderson [20]. This was in contrast to the diploids that were more aggressive and most times had a lot of unconsumed feeds in their tanks and may have led to poor utilization of feed administered to them and thus resulting in a low SGR and ABGR. This was more observed at the juvenile stage of their development and may have given rise to the steadier and higher SGR and ABGR as well as bi-weekly mean weight gain recorded in the triploids compared to diploid fishes. Similar observation had earlier been reported by Garner et al. and O’Flynn et al. [19,21] that triploid fishes were less aggressive and had a steadier SGR compared to the diploid fishes.

Generally, marketable size of C. gariepinus in Nigeria range between 1kg- 1.3kg [22]. In this study, marketable size fish was not attained after 24 weeks of fish culture. This may be due to the small culture unit (with similar growth trend recorded by Yakubu et al. [23] in a small culture unit) and poor water quality encountered as a result of shortage of water.

More revenue was generated from triploid C. gariepinus than diploids. The mean size at harvest of triploids was slightly higher than diploids and this explains the higher revenue obtained from triploid fish in this study. However, there was no significant difference in the revenue for both treatments. This observation suggests that the culture of triploid C. gariepinus may yield more revenue to a fish farmer than its diploid. However, the high feed consumption rate of triploid catfish resulted in higher cost of production there by leading to lower profit (i.e. more loss) than the diploid. Polyploidy tends to increase feeding but not proportionate with growth rate prior to sexual maturity which consequently raises the cost of feeding and lowers profit especially at the adult age [6, 9, 24].

Profit index of both treatments was less than 1 and this suggest poor profit. Triploid fishes had higher incidence of cost compared to diploid fishes. This suggests that, it cost more money to produce a kilogram (kg) of triploid fish than its diploid. This may not be unconnected to the poor FCR of the triploid fish especially at adult stage. The poor FCR may have been as a result of the fish inability to convert feed taken to flesh despite consuming much feed and this may have occurred as an effect of polyploidy interfering with growth just before sexual maturity [15-17].

Gross profit value for diploid fish was better than triploids. Less profit (i.e. more loss) was recorded for triploid C. gariepinus. This again may not be unconnected to the poor FCR, SGR and high cost of feeding. This finding is in agreement with that reported by Henken et al.[14] in African catfish (C. gariepinus) and Karami et al. [12] on juvenile African catfish (C. gariepinus). They reported that African catfish (C. gariepinus) did not attain marketable size and even weighed 18% less than its diploid and may likely not be a good source of potential profit to farmers than diploid. Generally, the economics of this culture unit is poor due to its small size. Larger surface area of culture pond is believed to be more productive than smaller surface areas.
CONCLUSION AND RECOMMENDATIONS

There was significant difference in bi-weekly weight gain and size of fish at harvest with the triploid performing better. However, there was no significant difference (p<0.05) for specific growth rate, feed conversion ratio, incidence of cost, Gross profit, Benefit cost ratio in the study suggest that, the culture of triploid C. gariepinus in outdoor concrete tank under commercial conditions, may not yield a better financial benefit to the fish farmer than the diploid. The revenue obtained from triploid culture was higher than diploid culture but higher profit margins were recorded for the latter than the former.

Further studies should be carried out on growth performance and economics of triploid African catfish using the intensive system of culture such as Flow-through and Water Re-circulatory System. Also, studies on the production of triploid by crossing tetraploidy with diploids should be encouraged because the system guarantees better water quality.

REFERENCES