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Research Article

Maternal Age Influence on Fry Survival, Growth and Size Variation in *Clarias gariepinus*

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Abstract

Background and Objectives: The maternal attributes could impact on the quality of eggs and life history trajectories of the hatchlings. The work aimed at analyzing the effects of maternal ages on fry quality in *Clarias gariepinus.* **Materials and Methods:** Hatchlings were produced from a single male *Clarias gariepinus* of 3.5 kg and females averaging 1.2 kg and aged 1, 2 and 3 years with 4 replicates of 3 fish in a complete randomized design. The initial, bi-weekly and final weights and number of hatchlings were taken. The survival rates, growth performance and size compositions of the hatchlings were evaluated at the end of 7 weeks experimental periods. The means were analysed with analysis of variance and Duncan Multiple Range Test ($p = 0.05$). **Results:** Fry survival rate was significantly higher between 3 and 1, but 3 and 2, and 2 and 1 years old brood stocks. Mean weight gain and specific growth rate were insignificant across the ages though, cumulative weight gain was highest in fry from 2 followed by 3 and least in 3 year old brood stocks. 4 fry size categories viz. A: (100-159), B: (160-359), C: (360-500) and D: (501-2900) were identified and discussed in the context of their significance. **Conclusion:** Age was found to affect offspring survival rate and size variation among the hatchlings of *C. gariepinus* greatly, and growth performance marginally.

Key words: *Clarias gariepinus*, maternal attributes, female brood stock, age, size variation, survival, hatchlings, fry, growth performance

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Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

The quality and quantity of fish seed propagated for stocking the fish farms are largely dependent on fecundity of the female brood stock; quality, fertilization and hatchability rates of the eggs; the survival rate and the growth performance of the hatchlings, all of which have been attributed to female brood stock age and size amongst other factors[1-10]. In a wide range of taxa within both plant and animal kingdom, maternal influences are considered the priming determinant of the progeny phenotypes[11] and are believed to supersede the genotype and the external environment[12].

According to Reed *et al.*[13], the females decide the phenotypes of their young by genes and somatic investments. Accordingly, a somatic investment in the offspring during the egg stage involves larger resource investments by females producing bigger eggs as compared to those with smaller ones. Maternal effects are considered as reproductive mechanisms that guarantee survival, thereby improving maternal fitness[14]. Egg quality often viewed in terms of egg size: diameter and total weight[8] and energy content[15] are known to exert significant influence on the fertilization rate, incubation success, the size of the larvae and other life-history trajectories[3,8,16]. The production of high-quality seeds for aquaculture inevitably hinges on the utilization of high premium gametes from domesticated brood stocks[1]. The implication of maternal attributes such as age here becomes very consequential. It is most times implied that older fish have larger sizes than their younger ones hence, it is seemingly difficult to aggregate older fish with similar size to their younger ones. These make it more customary to involve diverse sizes and ages of brood stock while testing the effects of maternal attributes on egg and progeny qualities.

It has been observed that egg sizes rise once there is an increase in the size and age of brood stock[2]. Large eggs are known to have the benefits of large juveniles which enhance the chance of better survival during the early days[3,15]. Maternal effects have also been linked with size variation in the offspring[7,17-19] even in the African sharp tooth catfish, *Clarias gariepinus*[20,9]. There is an obvious dominance of the Clariid catfish, especially *Clarias gariepinus* in the African aquaculture system[21-24]. This fish has proved to be a reliable culture species because of its fast growth rate, excellent adaptation to the compromised culture environment, satisfying taste, customers preference and high commercial value and high fecundity[6,25-27].

Sexual dimorphism has been reported in growth in the females' growth rate decreasing after 3 years, resulting in the males reaching larger sizes[28]. *Clarias gariepinus* does not reproduce in captivity hence, to stock the farms, wild collection is often practiced by local fish farmers with the attendant cost of poor stock performance. The dearth of quality seeds has been the bane of production efficiency in *C. gariepinus* culture in Nigeria. This deficient supply gap has prompted many hatchery managers to attempt to produce fish seeds from any available brood stocks irrespective of ages as well as combining brood stocks of sundry ages in the same batch of production without minding the effects of age on the seed quality. Bridging the supply gap of *C. gariepinus* seeds would require adequate information on its production dynamics to guarantee quality as well as quantity. According to Bavand and Khara[8], brood stock productivity significantly constrains commercial fish culture, thus adequate knowledge of all the factors governing brood stock productivity is of great essence[29].

There exist myriads of literature on the effects of maternal brood stock size and age on the fecundity, fertilization, hatchability and survival rates of *C. gariepinus*[20,6,9]. However, information on the effects of various ages of female brood stock of *C. gariepinus* with similar weight on the survival of hatchlings, growth performance and size composition of resultant fry are lacking. This work was therefore aimed at investigating the effects of the female brood stock age on the quality of seeds produced by the African sharp tooth catfish, *Clarias gariepinus*. Specifically, to determine the survival rates of hatchlings obtained from female brood stocks of *C. gariepinus* of various ages; determine the growth rate of hatchlings of *C. gariepinus* obtained from female brood stocks of different ages and evaluate the size composition of fry obtained from female brood stocks of *C. gariepinus* of various ages.

MATERIALS AND METHODS

Study location: The study was carried out at the Saekufr Fish Farm, Obio Nsit, Mbiokporo 1, Nsit Ibom Local Government Area, Akwa Ibom State, Nigeria between May 4th and August 27, 2016 total of 116 days. The area lies between Latitude 4°59'1.80 N and Longitude 7°52'43.60 E.

Acquisition and maintenance of brood stocks: A total of 36 female and 5 male brood stocks were acquired for this experiment. Females of about 10 and 23 and males of about 36 months old were obtained from Saekufr Farm. The females of about 33 months old were gotten from Bajims Farms in Essien Udim LGA, Akwa Ibom State, Nigeria. The females were stripped of eggs to commence the next round of egg production at the same time.

They were stocked in three separate concrete tanks (2.5×2.0 m) according to age at 12 fish per tank. The males were stocked in a separate tank. All the fish were fed from the second day of the stocking with a commercial floating catfish diet (Coppens feed 42% crude protein) to satiation twice daily. Dissolved oxygen, pH, temperature and turbidity of the water were monitored weekly in the morning and evening hours. About 75% of the water in each tank was exchanged for freshwater biweekly. The females were checked every two weeks with effect from the fifth week to ascertain their gravid status. All the females were fully gravid by the ninth week of feeding.

Experiment design: The female brood stocks were fully ripe and of uniform size (1.2 kg) in each category corresponding to approximate ages of one year (12 months), two years (25 months) and three years (36 months), respectively. Fish in each age class were divided into four groups, each containing 3 brood stocks. Hatchlings were obtained from each member of the group and reared separately for seven weeks. Data were obtained separately from each member of the group and the mean recorded as the value for each respective group in the age category. Each category was a treatment and the groups under it were replicates: thus three treatments each having four replications in a complete randomized design.

Production of hatchlings: Each female weighing about 1.2 kg was induced with ovaprim (Syndel, Canada) at 0.5 mL kg^{-1} b.wt. The three fish in each replicate of treatment were kept together in a partition demarcated by framed netting screens in the tank containing all the fish in that particular treatment. Fish from one replication were taken in each of the treatments before another replication. A latency period of 12 h was observed for every replication before each fish was stripped. A fully ripened male weighing 3.5 kg was selected, sacrificed and milt obtained by dissection of the testes. The milt was diluted in a small plastic bowl with 0.9% normal saline solution. Procurement of the milt preceded the commencement of stripping of the females for eggs. 20 g of eggs stripped from each female were fertilized and incubated separately in a well-labeled round plastic vat. Each plastic vat was installed with a flow-through device and had a capacity of 50 litres and was kept at 45 L of clean water. The incubation period lasted for 28 h in stagnant water. The temperature, dissolved oxygen and pH of the water were tested each day.

Rearing of hatchlings: The larvae were separated from the mass of egg shells and unhatched eggs on the kakabans of netting by gently lifting up the kakabans and shaking before removing. The larvae were carefully siphoned out into a transparent plastic bucket. The incubation vat was cleaned and filled to the 45 L watermark and re-stocked with 2000 of the larvae siphoned out from it. The larvae were picked randomly from a particular batch counted and weighed before restocking. The hatchlings in each vat were fed at 30% body weight in 6 rations per day (about 4 h intervals). The first feeding started on the third day after hatching with artemia shell-free (Aqua-Lush marketed by Burish Nigeria Ltd, Lagos), for three weeks.

Thereafter, 0.2-0.5 and 0.5-0. 7 mm starter feed Skretting was respectively used from the forth to the fifth week and sixth to the seventh week. The feeding rate was reduced to 15% body weight fed in 3 rations (about 8 h intervals). Left over feed was removed every evening before the next feeding. Water flow through was maintained in each vat for 8 h in a day at 2 h routines. On the days of weighing, feeding was reduced to 50% daily rate fed in two rations and water flow through for 4 h. Water quality was monitored twice daily and the mean values recorded weekly.

Data collection: The hatchings in every vat were removed and weighed collectively using sensitive weighing balance (mallet TD 6002A, Max 600 g) and the number surviving counted individually, each week till the end of the experiment on the 7th week. The mean weight was determined.

Water quality monitoring: Dissolved oxygen was measured by Hanna Instrument while pH and water temperature were measured with thermometer and pH meter respectively.

Size composition of hatchings: At the end of the 7 weeks rearing period, the hatchlings in each vat were weighed individually. The hatchlings were categorized into four different groups based on weight: A (100-159 mg), B (160-359 mg), C (360-500 mg), D (501-2900 mg). The mean for each replicate was recorded.

Data analysis: The data obtained in the course of this study were processed as follows:

Mean Specific Growth Rate (SGR)[30]:

$$SGR = \frac{LnW_2 - LnW_1}{t_2 - t_1} \times 100$$

Where:

W_2 : Final mean weight
W_1 : Initial mean weight
t_1 : Beginning of growth period
t_2 : End of the growth period

Mean survival rate (SR)[31]:

$$SR = \frac{100 \times \text{Nubmer of fry at the end}}{\text{Number of larvae at the beginning}}$$

Percentage Composition of Fry (PC)[32]:

$$PC = \frac{\text{No. of fry of a particular size}}{\text{Total no. of fry}} \times 100$$

Arc sine transformation: The percentage data in the fry composition was transformed into angular arc sine for analyses as follows[33]:

$$X^1 = \text{ArcSin}\sqrt{X}$$

Where:

X^1 : Transformed percentage
X : Percentage data to be transformed
Arcsin : Sin^{-1}

Statistical analysis: The processed data from the experiment were subjected to one-way Analysis of Variance (ANOVA) to test if there were significant differences among the various means at 0.05 level of probability using SPSS version 19.0 on a Windows Laptop computer. Means separation was carried out using Duncan Multiple Range Test (p = 0.05).

RESULTS

The results obtained from the research were presented in Table 1-3 and Fig. 1. The water quality prevalent during the study was as presented in Table 1 and the values of these parameters were adequate for a warm water fish such as *Clarias gariepinus.* Table 2 shows the growth performance and survival rate of *C. gariepinus* hatchlings recorded during the experiment. The results in Table 2 reveals that two years old brood stocks gave the highest mean weight gain, which however was not significantly different from the lowest mean value obtained from brood stocks of one year old. Mean Specific Growth Rate (SGR) had a similar trend to mean weight gain. The mean survival rate was highest in fry from 3 years old brood stocks and least from brood stocks of one year old with significant difference ($p<0.05$). Both, however, did not differ significantly from hatchlings obtained from brood stocks of 2 years old. Weekly mean cumulative weight gain presented in Fig. 1 graphically highlights the growth trend of the hatchlings over the experimental period. The highest cumulative weight gain was found in hatchlings obtained from brood stocks of two years old followed by three years and a year old brood stocks.

Details of the mean size composition of the hatchlings are given in Table 3. Four size categories were identified. Hatchlings of categories A and B were evenly distributed

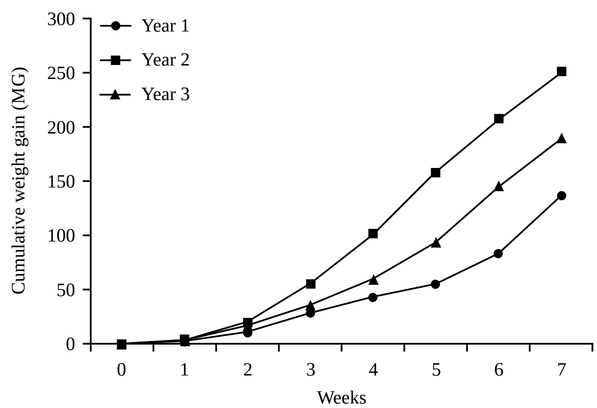

Fig. 1: Mean weekly cumulative weight gain of *C. gariepinus* hatchlings obtained from brood stock of various ages

Table 1: Mean water quality parameters of the brood stock and hatchlings tanks

Parameters	Temperature (°C)	DO (mg L^{-1})	pH
Brood stock	26.83±0.425	8.57±0.13	8.57±0.13
Hatchlings	26.71±0.29	8.93±0.1brood stock	7.20±0.9

DO: Dissolved oxygen, mg L^{-1}: Milligram per liter, pH: Degree of acidity and alkalinity, °C: Degree Centigrade

Table 2: Growth parameters and survival of *Clarias gariepinus* hatchlings obtained from various ages of brood stock

Parameters	Year 1	Year 2	Year 3
Mean initial weight (mg)	1.828±0.218[a]	1.826±0.014[a]	1.840±0.014[a]
mean final weight (mg)	136.378±1.651[a]	250.373±58.890[a]	189.270±50.754[a]
Mean weight gain (mg)	134.550±1.648[a]	248.547±58.880[a]	187.430±50.756[a]
Mean specific growth rate (%/day)	8.975±0.568[a]	10.095±0.568[a]	9.445±0.568[a]
Survival rate (%)	15.175±0.155[b]	20.975±3.407[ab]	26.500±3.506[a]

Means with same superscript in the same row are not significantly different from each other (p>0.05)

Table 3: The size composition of *Clarias gariepinus* hatchlings obtained from various female brood stock ages

	Size of hatchlings (mg)			
Brood stock age (year)	A: (100-159)	B: (160-359)	C: (360-500)	D:(501-2900)
Year 1	34.68±.821[a]	55.07±0.646[a]	0.00±0.000[b]	0.00±0.000[b]
Year 2	42.54±4.535[a]	45.09±4.302[a]	9.91±2.009[a]	5.58±1.907[a]
Year 3	48.11±9.343[a]	43.08±12.276[a]	7.11±0.937[a]	7.85±0.758[a]

Mean values with the same superscript along each column are not significantly different (p>0.05)

among brood stocks of ages 1-3 years without significant difference in their relative composition (p>0.05). The relative composition of Category C hatchings showed no significant difference between brood stock of ages 2 and 3 years (p>0.05) but differed significantly from 1-year-old brood stocks (p<0.05). No category D hatchling was obtained from one-year-old brood stocks and this was significant when compared to those of ages two and three both of which were not significantly different from each other.

DISCUSSION

The maternal age did not significantly impact on the growth performance of the *Clarias gariepinus* fry rather, survival rate and size heterogeneity were significantly affected. The water quality during the experiment was adequate and thus unlikely to adversely affect the performance of the hatchlings. The superlative survival rate of hatchlings from female brood stock of 3 years (36 months) old as well as the better mean weight gain, mean specific growth rate and mean weekly cumulative weight gain of hatchlings recorded in older brood stocks of 2-3 years old as against a year old brood fish could be due to the likelihood of higher maturity levels of the older fish. The older the brood stock, the higher the quality of eggs produced and the better the hatchlings life-history trajectories and fitness. Homogeneity in the size compositions of hatchlings can be an important factor in assessing the quality of hatchlings from a particular batch of production viz-a-viz the quality of the brood stock used and ultimately, the potential of stock recovery at harvest. This is particularly important when a cannibalistic species like *Clarias gariepinus* is involved. Size variation observed in this work was more obvious among hatchlings from brood stocks of years 2 and 3 with high potentials for survival implications under inefficient culture situations. The large offspring, categories C (jumpers) and D (shooters) were absent among hatchlings from a year old brood stocks.

The results of this work are consistent with the reports from many investigations on relationships between maternal age and offspring life-history performance[1,3,6,8,10,20,34]. The maternal age is believed to positively correlate to egg size[4,35] which determines egg quality. Jokthan[20] had obtained a higher number and weight of fry from *Clarias gariepinus* female brood stock of 24-30 months old. Older females produce eggs with a large amount of yolk reserve for the fry to overcome a longer period of starvation[34] and to execute higher growth rates from the start of external feeding[36]. Furthermore, the superior survival and growth performance of the offspring from an older maternal parent was related to their being provisioned with significantly greater oil globules by the older females than the younger spawners do[4]. These oil globules are believed to be a repository of endogenous energy in the form of triacylglycerol (TAG), which provide energy for metabolism and growth even as the larger proportion of the yolk has been depleted[37].

In considering older female brood stocks for optimization of brood stock productivity, fry growth performance and fitness, due caution must be exercised to avoid senile individuals. Reduced maternal fitness has been observed with an increase in brood stock age[2]. It has been reported that an increase in age, weight and stripping frequency could alter certain ovarian fluid composition and egg content[8]. Following these morphological, biochemical and physiological changes, possible reduction in egg quality, fertilization rate, hatching percentage, deformity and mortality could be risked subsequently[38]. SRAC[39] observed that though eggs could be obtained from catfish brood stock of 2 years old, they must be at least 3 years old and weigh at least 1.4 kg for reliable spawning. This assertion might only consider the ease of spawning. However, when considering the better growth performance of fry from two-year-old brood stock in terms of rate and mean weight gain as obtained in this study, brood stock of this age seems to hold better promise to the farmer since superior growth performance is a key determinant of harvest yield. Bello *et al.*[40] observed that the main goal of aquaculture is to optimize growth and to produce high quality fish. Growth optimization could be better if the fish seed has the natural capability of a higher growth rate.

Egg size precipitates most of the variation in hatchlings size[6] which is suggested to be a vital aspect of juvenile fitness[36], as larger eggs come from older and larger females.

This probably could be another consequence of the biochemical, morphological and physiological changes associated with old age asserted by Lahasteiner[38]. *Clarias gariepinus* had been observed to have large variability in egg size within and among populations as a result of age and size[41,42]. Adams[6] and Tyor and Pahwa[9] had reported intra individual variation in egg size in the catfish as well. Adams[6] classified the egg size into 3 categories which is similar to the classes of fingerlings obtained in this work. According to Chambers and Leggett[43], a significant proportion of variation in sizes of larvae and juveniles and perhaps, even adults, could be a product of propagation trough the growth of initial size heterogeneities among individuals.

Size heterogeneity may result from the inability of the female to adequately appropriate energy equally across a large number of eggs[18]. This difficulty suspected to be a possible feature of fish in a poor resource environment might as well be the handicap of increasing age judging from the increased variation with age in this work. Kurita and Kjesbu[44] had opined that continual intra ovary variation in egg size may be an egg-packing mechanism to increase apparent fecundity. It has also been suggested that intra progeny size variation could be a bet-hedging strategy for maternal brooders faced with unstable environment[18]. Under such situations bearing of a large range of heterogeneous progeny sizes improve the likelihood of better fitness in the future environment thereby enhancing the total maternal fitness[45,7].

The jumpers and shooters are believed to be cannibals and can greatly reduce the population of fingerlings[31], the survival of stock and recovery at harvest[46]. Under proper hatchery operations, these larger individuals have to be progressively removed by routine sorting and reared separately to avoid cannibalism within the stock of the normal growing individuals and the concomitant economic set back. The consequences of sorting are high in terms of high operational costs in time, energy, materials, finance and fish but it still makes economic sense as the recovery of both the larger and smaller fish shall be improved. Brood stock size[47] and food accessibility[48-49] amongst other factors could induce size variation among hatchlings. In this study, the brood stocks were about the same size and the quantity of feed available to the hatchlings was quite adequate, therefore the observed variations in the size of hatchlings could have more to do with variation in the parent stock age. Limited resources hindered the furtherance of the study beyond the seven weeks growth period. Subsequent works on this should extend to cover the juvenile and early adult stages to access the integrity of the results beyond the fingerling stage.

CONCLUSION

The success of fish farming depends on stocking quality seed, proper feeding of the stock and the ability of the stock to survive and grow to an economic size at harvest. Thus, the quality of input determines the output hence, the quality of brood stock greatly influences both quantity and quality of fish seeds made available for economic stocking of the fish farms. This research has shown that more homogenous fingerlings could be obtained from brood stock of one year old, followed by two-year-old parent stock while heterogeneity of three years old was the highest. It was also shown that the growth performance was best in hatchlings from two-year-old brood stock though this was not significantly different from other brood stock ages. Age was considered to affect survival rate and size variation among the hatchlings of *C. gariepinus* greatly and growth performance marginally.

SIGNIFICANCE STATEMENT

This study reveals the implication of female brood stock age on the quality of offspring produced by *Clarias gariepinus* which could help the fish culturist to optimize product viability and performance. This study will help the researcher to uncover the critical areas of catfish seed quality assurance that many researchers were not able to explore. Thus a new theory on maternal stock selection may be arrived at.

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