RELATIONSHIP OF FEMALE BROODSTOCK WEIGHT AND REPRODUCTIVE PERFORMANCE OF *C. gariepinus* (Burchell 1822)

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ABSTRACT
Achieving optimum reproductive performance in female broodstock and production of high-quality fish seed is a major challenge in fish farming. Selection is one of the breeding practices implored to achieve this. This study investigates the relationship of different bodyweight of female broodstock on the breeding performance of Clarias gariepinus. The experiment, a completely randomized design (CRD) with treatment combinations based on the average weight of female broodstock sizes, had Treatment I (Small size 1000 g), Treatment II (Medium size of 1500 g), and Treatment III (Large size of 2500 g). Data collected include volume and weight of eggs, fecundity, fertilization and hatching rates, and growth of yolk sac fry. The Physico-chemical parameters of the water had no significant ($p>0.05$) fluctuations. Treatment III had significantly ($p<0.05$) better spawning performance; with bigger eggs (32.67g/10 ml of eggs), highest fertilization rate (80.63%), hatching rate (88.90%), and survival rate of fry (91.70%). However, the average number of eggs/kg of spawners (fecundity) was highest in Treatment I (13,884). Fertilization (70.9 and 72.00%) and hatchability (74.9 and 75.57%) were not significantly different ($P>0.05$) between Treatments II and Treatment I respectively. Yolk-sac fry survival was not significantly different among Treatments. It was concluded that spawning performance increased with increasing broodstock size.

Keywords: Culture, Egg quality, Hatchery, Spawning

INTRODUCTION

In aquaculture, fish seed production of catfish and tilapia has been successfully carried out in Nigeria. Despite the success, there still exists a wide gap between fish seed demand and supply (Ponzoni *et al.* 2012). This, therefore, necessitates increased research for development. 'For many cultured fish species, hatcheries have been in operation without much genetic improvement programme, leading to low and deteriorating performance. This deterioration in hatchery performance may be attributed to the combined effect of selection in the wrong direction and inbreeding' noted Eknath and Doyle (1990). They added that 'this often leads to a large variation in fish size, low survival of fish fry, a low growth rate of fish seed, and poor feed conversion ratio. This eventually causes poor returns to farming'. Efforts have been made by Ponzoni *et al.* (2012), to explain the genetic basis of the deterioration of stock performance and to prescribe methods to avoid it. Various concerns about the safety of some breeding programme have limited their application, hence the need to rely on selective breeding and hybridization for the improvement of genetic resources in aquaculture' concluded Ponzoni *et al.* (2012).

Selective breeding programmes for cultured fish (e.g. salmon; Levin and Schiewe, 2001.) and invertebrates (e.g. scallops; Perez and Alfonsi, 1999) have shown that significant amounts of genetic heritability (the proportion of variation in a trait that is inherited or transferable from one generation to the next) exist for several characteristics, including yield-related traits important to fisheries (Law, 2000). This is the basis for the aquaculturists to breed and cultivate the largest or fastest-growing fish from generation to generation to increase their production. Generally, characteristics such as the number or size of eggs are heavily influenced by environmental conditions. However, Smoker *et al.* (2000) have recently shown a remarkably high degree of heritability in both the number and size of pink salmon eggs produced, which was seen as important to the persistence of populations in fluctuating environments. This is one of the numerous uses of genetics in fish breeding.

Methods of artificial seed propagation of African catfish (*Clarias gariepinus)* are relatively expensive in Nigeria and hatchery operators are usually scared of the big size of broodstock not just because of the large quantities of spawning hormone that will be required for induced breeding exercise, but also because of their high price as reported by Sule and Adikwu (2004).

There is inadequate knowledge of the influence of maternal size on the reproductive performance of African catfish (*Clarias gariepinus).* The closest of such studies are those of Megbowon *et al*. (2013), where the breeding performance of species from different Nigerian waters was studied, and that of Olufeagba and Okomoda (2015), on *Heterobranchus longifilis*. However, Ataguba *et al.* (2012) carried out broodstock selection using the size range of *Clarias gariepinus* and not only the female but also the male broodstock weight as the selection criteria. The study did not particularly consider the maternal effect of the selection on reproductive performance. 'Beyond the third day of

life, only diet and light, as well as the quality of the water, determine the survival and growth of fish (including *Clarias gariepinus*) in addition to the genetic makeup' according to Owodeinde *et al.*, 2004). This study was designed to determine the effect of female broodstock selection (using weight), as a breeding programme, on the reproductive performance of *Clarias gariepinus.*

MATERIALS AND METHODS

The experiment was conducted within 18 months at a reputable fish hatchery facility called Marine Farms located at No.2 Orogun Street, Isiohor Village, Benin City. A concrete grow-out tank measuring 10 m X 12.5 m X 1.5 m, and three rectangular hatchery tanks of 2.3 m X 1.0 m X 1.0 m each partitioned into 3 compartments, nine 5 L plastic bowls, nine 60 L plastic aquaria, and nine grow-out ponds (2 m X 8 m X 1.5 m), were used for this study. The tanks were adequately washed using detergents and well rinsed and impounding with clean water before use. The selection of experimental fish was done in phases.

Phase I: Selection of foundation stock (500 fingerlings)

Five hundred fingerlings of *Clarias gariepinus* were selected from a reputable hatchery in Benin City-based on the uniformity of size (about 5 g), age (5 weeks old), health status (K= 0.9), nutritional history, and parental origin. These fingerlings were raised for 12 months, under the same environmental conditions i.e. same feeding regime, water quality maintenance, etc., to obtain the broodstock.

Phase II: Selection of female broodstock from the foundation stock (selection within the cohort)

From the foundation population (500 individuals), using individual selection methods based on biological fitness and weight, one-year-old *Clarias gariepinus* females with an average weight category of 1000g, 1500g, and 2500g were selected. The biological fitness was based on the presence of a round and turgid papilla, the softness of the abdomen, and uniform size of intra-ovarian oocytes (Sahoo *et al*., 2004) obtained by applying slight pressure on the abdomen. The selected females were grouped into three categories based on their weights which represent treatments i.e. 1,000g (Treatment I), 1,500g (Treatment II), and 2,500g (Treatment III).

Phase III: Selection of male broodstock (3 males)

The individual selection method was used to obtain the males, progeny of a different set of parents, weighing about 2.5-3 kg each. They were sourced from a farm in Ibadan, South-West Nigeria, and selected based on elongated and turgid, reddish genital papilla (Billard *et al*., 1984). One male was used for each of the three trials.

A three-trial experiment set up in a Completely Randomized Design (CRD) was used where the broodstocks were allotted into three treatments and each treatment was replicated three times. The treatments were; Treatment I (Small size females of 1000g average weight), Treatment II (Medium size females of 1,500g average weight), and Treatment III (Large size females of 2,500g average weight). Eggs obtained from a total of nine selected females and milt from one selected male was used for the breeding performance study for each trial.

The fish used as the parental generation (500 in number) were pure-line descendants of the study species obtained from a reputable hatchery in Benin City, Nigeria. From this base population, a paternal full-sibling offspring was established by mating ♀s for all 3 female size categories to one proven ♂ from another population as shown in Table 1 (i.e. 27 ♀ and 3 ♂ in total for the 3 trials). A total of 9 ♀ were mated to 1 ♂ in each trial. In all, 30 broodstock were used for the study. Fertilization of eggs was conducted (Table 1) to minimize possible differential maternal effects that can inflate ♂ variances (Kotiaho *et al.*, 2003).

Table 1. Brood stock mating design in the three trials (1-3) is in the order (♀× ♂):

		♂		
Weight (Average)	♀	A_1	A_2	A_3
1000g (I or Small size)	a	A_1a	A_2a	A_3a
1,500g (II or Medium size)	b	A_1b	A_2b	A_3b
2,500g (III or Large size)	c	A_1c	A_2c	A_3c

Nine broodstock were selected based on the earlier established criteria. A single intramuscular dose (0.5 ml/kg) of the Ovaprim hormone Releasing Hormone analogue, GRHa) was administered to each of the selected females in each treatment. The injected fish were returned to a holding tank with water until they were ready to ovulate.

The Physico-chemical parameters of the water were maintained by regular flow through to ensure uniform water quality. Drops of sperm extracted from a male per trial were used to quickly fertilize the eggs by mixing them appropriately. Fertilized eggs were quickly rinsed with more saline water. The eggs were spread in single layers on a suspended nylon mesh net (kakabans) in the shape of trays immersed below the water of about 15cm depth in a flow-through system with a 0.2 L / min flow rate for aeration and removal of metabolites during incubation (Olumuji and Mustapha, 2012).

The latency period, (time between the administering of hormone and point of ovulation) was noted for all treatments. The weights of injected females were taken just before stripping. The weight of stripped eggs from each pair of females was also taken. Three 10 ml volume sample of eggs was

measured and weighed, using a Dura scale D2TM 300g x 0.01g capacity pocket scale (Precision 0.01g), for each treatment. The three 10 ml samples were counted to estimate the number of eggs per female in each Treatment i.e. total spawning fecundity. The total weight of eggs spawned by each female was noted and this was multiplied by the average number of eggs already determined to be present in each weighed sample (10ml of eggs). Three samples of 250-300mg eggs each were weighed, from the fertilized eggs and spread in a monolayer pattern on a 1 mm diameter net in nine 0.8 m × 0.8 m × 0.8 m aquarium tank under a flow-through system. From the three kakabans, each with 250-300 mg of eggs, the mean fertilized eggs were recorded. Fertilized eggs from each of the three kakabans per treatment were counted and the mean value for each treatment was obtained. This is like the method described by Egwenomhe and Obi (2012). A control sample of eggs that were not fertilized was also used to confirm fertilization. The time taken for these control eggs to become white (dead eggs) was noted, after which the brownish/greenish eggs in the incubation tanks were termed fertilized. Actual fertilized eggs (translucent ones with embryonic eyes) were counted by the third hour of incubation. Translucent eggs without embryonic eyes were regarded as unfertilized eggs. The hatching rates in each trial were evaluated 24 – 48 hours depending on temperature after fertilization. The number of eggs that hatched from each of the 3 kakabans (with 250-300mg eggs each) per Treatment was also recorded and mean values were used to calculate the mean percentage hatching rate.

By the third day of hatching (60-72 hrs old fry), percent normal and deformed larvae were calculated from the total percent mean hatching per Treatment from the three trays. Percent survival from hatching to first feeding was estimated using 50 hatchlings from each treatment. Water in these bowls was changed once daily. The time of first feeding was the moment the larvae showed signs of exogenous feeding which was monitored closely especially at 72 hours after hatching i.e. swim-up fry stage. Survival up to the first feeding stage was determined by counting the remaining larvae in each bowl. Following the method of Olumuji and Mustapha (2012), to compare the growth of the African catfish in each Treatment 50 four days old larvae from each weight category were randomly collected from each aquarium and weighed using Dura scale D2TM 300g x 0.01g capacity pocket scale (Precision 0.01g) while they remained in a 10 ml plastic cup containing water whose weight had been pre-determined

The data on Fecundity, percentage fertilization, and hatchability were determined according to the method described by Oyelese, (2006) using the formulae:

$$\text{Fecundity} = \text{Total weight of stripped eggs x } \frac{\text{Total Number. of eggs in sub} - \text{sample}}{\text{Weight of eggs in sub} - \text{sample}}$$

$$\text{Percentage Fertilization} = \frac{\text{No. of fertilized eggs}}{\text{No. of eggs stripped}} \text{x100}$$

$$\text{Percentage Hatchability} = \frac{\text{No.of fry}}{\text{No.of fertilized eggs}} \text{ x100}$$

Survival Rate (SR) of yolk sac fry was calculated according to Coulibaly, *et al.*, (2007) as

$$\text{SR (\%)} = \frac{\text{Total number of fish harvested}}{\text{Total number of fish stocked}} \text{x100}$$

Data collected were subjected to a one way analyses of variance (ANOVA) using Genstat statistical package Version 2005. Differences in means were compared using Duncan Multiple Range Test (DMRT) at $p<0.05$. Descriptive statistics were used to present results where relevant.

RESULTS

The result of the reproductive and growth performance of various selected broodstock weight of *C. gariepinus* is presented below. It includes water quality parameters monitored, spawning performance of the broodstocks including growth and survival of 4 days old larvae.

Water Quality Parameters

The result of some water quality parameters monitored is shown in Table 2. There was no significant fluctuation in the Physico-chemical parameters of the water. The values of the parameters were within the optimal range (Table 2). Table 2 shows that dissolved oxygen, ammonia, total alkalinity concentrations varied from minimum values of 5.80, 0.18, and 120.00 mg/l to maximum values of 6.70, 0.28, and 128.00 mg/l, respectively. The mean values were 6.25, 0.23, and 124.00 respectively.

Table 2: Range of Water quality variables recorded during the experiment.

Variable	Minimum	Mean	Maximum	Ideal Range
Dissolved oxygen (mg/l)	5.80	6.25	6.70	⩾ 4
Ph	6.80	7.15	7.50	6.8-8.6
Ammonia (mg/l)	0.18	0.23	0.28	<3
Temperature (°C)	27.00	28.00	29.00	26-30
Total alkalinity(mg/l)	120.00	124.00	128.00	75- 200

Spawning Performance of the Various Selected Weights of Female *Clarias gariepinus*

There is no significant difference in the survival rate at 4 days old ($p > 0.05$) as shown in Table 3. All other spawning performance parameters showed significant differences ($P<0.05$). The weight of stripped eggs (g) was highest in Treatment III (Large size, 300.0g of eggs), followed by Treatment II (Medium size, 250.0g of eggs), and finally Treatment 1 (Small size, 150.0g of eggs). However, the average number of eggs/kg of spawners (fecundity), was highest in Treatment 1(13,884), followed by Treatment II (12,396) and finally Treatment III (9,074). Latency period was not significantly different ($p>0.05$) among Treatment II (600.0 min) and III (613.3 min) which were significantly higher than Treatment 1(548.3 min) Percentage fertilization, hatchability and weight of 4 days old fry were highest in Treatment III (80.63, 88.90 and 0.2165 g) and were significantly different from Treatment II (72.00, 75.57 and 0.1068 g) and Treatment I (70.90, 74.9 and 0.0850 g), respectively. Fertilization and hatchability were not significantly different ($P>0.05$) between Treatment II and Treatment I. Thus, the total weight of stripped eggs, individual weight of eggs, and percentage fertilization increased with the weight of selected broodstocks. While fecundity decreased with the increasing weight of selected broodstock.

Table 3: Mean spawning performance of various weight of female *Clarias gariepinus*

Parameters	Treatment I	Treatment II	Treatment III
Weight of spawners (g)	1000^{c}	1500^{b}	2500^{a}
Weight of stripped eggs (g)	150.0^{c}	250.0^{b}	300.0^{a}
Weight of 10ml of eggs(g)	35.67^{a}	34.67^{a}	32.67^{b}
Average number of eggs/kg of spawners	$13,884^{a}$	$12,396^{b}$	$9,074^{c}$
Latency period (minutes)	548.3^{b}	600.0^{a}	613.3^{a}
Percentage fertilization	70.9^{b}	72.00^{b}	80.63^{a}
Percentage hatchability	74.9^{b}	75.57^{b}	88.90^{a}
Survival of 4 days old (%)	78.3^{a}	88.3^{a}	91.70^{a}
Weight of 4 days old fry (g)	0.0850^{c}	0.1068^{b}	0.2165^{a}

Note: Means with a different superscript in each row are significantly different at 5% probability level.

DISCUSSION

The above result of the reproductive performance of various selected broodstock weight of *C. gariepinus* is discussed below

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Water Quality Parameters

The mean water quality parameters values observed (Temperature, DO, pH) were within the recommended range for fish culture (Abdelrahman *et al*., 2019). The fish culture water was constantly renewed by a flow-through system such that uneaten food among other potential pollutants was quickly eliminated as soon as they entered the culture medium. Thus, the potential possibility of the environmental influence on the growth of fish was restricted to only feed influence

Weight of female spawners

The weight of the female spawners was significantly different ($p<0.05$) to generate the various treatments for this work. The selection of the female broodstock was purposively done to have females with significantly different body weights.

This was intended to induce possible maternal effects. Schier (2007) noted that maternal effects occur when an organism shows the phenotype expected from the genotype of the mother, irrespective of its genotype, often due to the mother supplying messenger RNA or proteins to the egg. Maternal influences are female non-genetic and genetic factors that contribute to offspring fitness and have been reported to be a major source of phenotypic variation and offspring survival even in Turtle (Taku and Suzuki 2010).

Weight of stripped eggs

The large size female broodstock (Treatment III) spawned the highest weight (300g) of eggs followed by Treatment II (medium size) and then Treatment I (small size) i.e. weight of eggs produced increased with the weight of broodstock. This weight difference can be attributed to the size difference of the female broodstocks. The larger a

fish is, the greater the volume of her ovaries as reported by Guarino (2018). The difference in weight of stripped eggs is due to different maternal energy investment in the production of fish eggs. Bigger females invest more energy in egg production thus having bigger eggs compared to smaller females. This agrees with Diego *et al*. (2018), who reported that the energy content of eggs from fish collected at sites around the world from Japan to Corsica ranged from seven-hundredths of a Joule to almost 300 Joules, adding that larger eggs have slightly less energy per unit volume than small eggs but a much higher energy content overall. Rather than finding a straight linear relationship: more weight implies more egg production, they found a power-function relationship: as weight goes up, the effort put into reproduction rises exponentially.

Azubuike (2016), while studying the relationships of egg size of *Clarias gariepinus* on fertilization, hatching, and fry survival rates, reported that larger eggs came from larger females. Ataguba *et al.* (2012), while studying broodstock size combination in artificial spawning of cultured *Clarias gariepinus*, reported that egg weight increased significantly from the lighter to the heaviest females. In many fish species, larger females often produce larger eggs, and egg mass decrease with each progressive batch through spawning (Rideout *et al.,* 2005).

Weight of 10ml of eggs (as a measure of egg size)

The treatment I (small size) had the highest density (35.67g/10ml) of eggs i.e. weight/known volume of eggs, albeit it was not significantly different ($p>0.05$) from Treatment II (34.67g/10ml). Treatment III (big size) had the least density of eggs (32.67g/10ml) which was significantly different from the other two treatments. This means Treatment III (large size) had the biggest eggs in this study as fewer eggs occupied the same volume. This can be attributed to the difference in maternal energy investment and the fact that the relationship between the number of eggs and female size is not linear. Diego *et al*. (2018) earlier supported this phenomenon. *Clarias gariepinus* exhibited considerable variability in egg size, both within and among populations. This was due mainly to female age and size. Larger eggs were produced by larger broodstock, while smaller sized eggs were produced by smaller females. The trend in this study agrees with the findings of Azubuike (2016) that the eggs' size range of *Clarias gariepinus* is between 0.3-0.5mm for small females (Small-sized eggs), 0.6-0.9mm for medium-sized females (Medium-sized eggs), and 1.0-1.2mm for large size female (large size eggs).

Fecundity

The fecundity of broodstock used for this experiment showed significant differences ($P < 0.05$) between the treatments with TI, small females, (13,884) having the highest number of eggs per kg of spawners followed by TII, medium females, (12,396), and TIII, large females, (9,076). This can be attributed to the significant ($P < 0.05$) weight and length difference between the three female sizes (Treatments). This difference in number due to the difference in the size of eggs is due to different maternal energy investment in the production of fish eggs. Bigger females invest more energy in egg production thus having bigger eggs compared to smaller female, bigger eggs means small quantity per female weight as a result of the energy demand. This agrees with Diego *et al*. (2018), who reported that bigger female broodstocks do not have more reserves available for egg production hence the less quantity of eggs produced. This was similarly concluded by Cooch *et al*. (1992), who reported that even though Lesser Snow Gees egg size increased with the size of gees, smaller gees produced more eggs.

Contrary to the findings of this study are those of Ataguba *et al.* (2012) that fecundity of *Clarias gariepinus* generally increased as the female weight increased with values ranging from 20,500 in female from (200-300g) group to 74,100 from (800-900g) group. The female's average ages were 15months but were not established to be full-sib as in this study. Bromage and Roberts (1995), also earlier reported that the fecundity of fish is directly proportional to its body weight, therefore fecundity increases with size. Again, whether the broodstock was full-sib was not mentioned. Only the weight of stripped eggs followed this trend in this study. Ataguba *et al.* (2012) used volumetric methods to determine fecundity, without recourse to variation in egg diameter with varying female size. In this study eggs from the different sizes, categories were counted separately to account for the egg size differences. Fecundity was measured in the present work according to Bagenal (1978) as the number of vitellogenic oocytes in mature females before the next spawning season (only the ripe spawn able eggs > 1.0 mm in the ovary of the fish). Oyelese (2006), observed that the total weight of eggs stripped from a female is dependent on the number of eggs ovulated at the time of stripping hence not a true representation of the total quantity of eggs obtained from a female spawner. The present study had results that were low compared to results from authors like Onada and Ogunola (2017), who considered fecundity to encompass all available eggs in the ovary of the broodstock and thus, reported 800-900 g total body weight (TBW) fecundity of as much as 235,345. In this study, stripping was stopped as soon as blood was observed from the vent to avoid damaging the internal organs

of the broodstock. In assisted reproductive technologies, administered hormones only have the potency to induce final oocyte maturation and ovulation, and not increase the number of eggs in the ovary of an induced broodstock. The number of vitellogenic oocytes in mature females before the next spawning season, which are likely to be ovulated after induction, should be used as a more appropriate parameter in induced breeding studies rather than the total number of eggs in the female's ovary in support of Bagenal (1978), Zadmajid and Butts (2018), and Zadmajid *et al*., (2019).

The latency period (minutes)

The result of this study showed that the latency period increased with broodstock size**.** The treatment I (Small size) ovulated a little earlier (548.3min= 9.13 hours), than both Treatment II (Medium size) and Treatment III (Large size) which ovulated on the 10th and 10.22hours respectively. This significantly lower ($p<0.05$) latency period for Treatment I could be attributed to the small size (average 1kg) compared to both Treatment II (average 1.5kg) and III (average 2.5kg) as other possible causes of variation in latency period (FAO 1992), like water temperature, and hormone type and dosage were all maintained at the same level for all treatments. The sufficient action of the hormonal treatment leading to final oocyte maturation and ovulation was faster in the smaller fish owing to smaller somatic weight. However, the latency periods in all treatments were all desirable in this study as obtained temperatures coincided with native conditions. **In support of these results generally,** Agbebi *et al* (2013) reported that a latency period of 10 hours is unarguably the best latency period for *Clarias gariepinus* at 29.50C. At a period lower than that, there will be insufficient action of the hormonal treatment leading to failed ovulation. Also in supporting these results is the **recommendation of** Hogendoorn and Vismans (1980) **for** *C. gariepinus* **of a latency period, at the ambient temperature (**average **28^{0}C), of 7-12 hours**.

Percentage fertilization

The result of percentage fertilization showed that Treatment III (80.63a) had significantly ($P > 0.05$) higher values. There was no significant ($P > 0.05$) difference in the percentage fertilization between Treatments II (72.00b) and I (70.9 b). It appears that bigger eggs have higher fertilization values. The significant values could be attributed to egg quality, as larvae where obtained through *in vitro* fertilization using milt from the same male. This difference in egg quality is due to different maternal energy investment in the production of fish eggs. Bigger females invest more energy in egg production thus having bigger eggs compared to smaller female (Diego *et al*. 2018), bigger eggs means bigger yolk. The mean percentage fertilization recorded in this study is also an indication of the efficacy of Ovaprim in induced breeding of *C. gariepinus* regardless of the size of broodstock used. Adebayo and Popoola (2004) also recorded high fertilization of 84.50% of eggs of *C. gariepinus* using Ovaprim, while Haniffa and Sridhar (2002) reported fertilization of 70% for spotted murrel (*Channa punctatus*) by the administration of this same hormone.

Percentage hatchability

The results of this experiment showed that Treatment III (80.63a) was significant ($P > 0.05$) different in the percentage hatchability from Treatment II (72.00b) and Treatment I (70.9 b). There was no significant ($P > 0.05$) difference in the percentage hatchability between Treatments II (72.00b) and I (70.9 b). Also, this can be attributed to egg quality; bigger eggs had higher hatchability values. A similar trend was observed for the size of eggs shown in the weight of 10ml of eggs and fertilization rates obtained from each treatment. Different maternal energy investment in the production of fish eggs resulted in a difference in egg quality. Bigger females invest more energy in egg production thus having bigger eggs compared to smaller females, bigger eggs mean bigger yolk (Diego *et al*., 2018). The fertilization rate obtained in this study is supported by Yisa *et al*. (2010), who reported a 71 % percentage hatching rate for non-infected fish while studying the effect of nematode infection on the breeding potential of *Clarias gariepinus*. Maradu *et al*.,(2018) reported high larval hatchability of 88.70%, 80.58%, and 84.54% in a three treatments study indicate an overall good egg quality and effectiveness of the hormone used in the study of African catfish.

Survival rate to 4 days old (fry)

The yolk sac was absorbed for three days in this species. Similarly, yolk sac absorption was completed on the third day in *Hemibagrus nemurus*. *Pangasius sutchi, Mystus montanus, and Mystus macropterus* (Bleeker) (Marimuthu and Haniffa, 2007). Some fish species could take longer time to absorb the yolk sac. *I. punctatus* might take up to ten days for completion of yolk sac absorption. *R. quelen* completed yolk sac absorption in 5 days (De Amorim *et al*., 2009). Some fish species may additionally absorb the yolk sac in less than three days. This was observed in the *H. longifilis* where yolk sac absorption occurred at 55 h post-hatching (Ogunji and Rahe (1999).

There was no significant difference ($p>0.05$) among the Treatments in the survival of the fry to the fourth day of life suggesting that the yolk was sufficient to survive the endogenous feeding stage in all treatments. This is because all the females used in this study were mature and thus

produced fully ripe eggs. Gunder and Fink (2004) reported that *Clarias* species mature at about 8 months old.

Weight of 4 days old fry

Four days old fry of Treatment III (0.2165 g) were significantly ($p<0.05$) larger than those of Treatment II (0.1068g) which is, in turn, larger than the larvae of Treatment 1 (0.0850g). The significant values could be attributed to egg quality, as a similar trend was observed for the size of eggs shown in the weight of 10ml of eggs, fertilization and hatching rates obtained from each treatment. This difference in maternal weight is also known as genetic variability of the broodstocks, with larger broodstocks producing larger larvae. Breidy *et al.* (2017) reported that egg quality and larvae development are affected by the genetic variability of broodstocks of *Oreochromis niloticus*. Also, Phu *et al.* (2015) observed variability in the quality of tilapia progeny when females from different sources were fed the same diet, suggesting that variability is partly attributed to differences in the genetic characteristics of females. Size ranges similar to the values recorded in this study where earlier reported by Omer *et al*., (2016), in newly hatched larvae of *Clarias* spp that weighed 0.50 – 0.6 mg (average 0.53 ± 0.06 mg) and measured 3.71 – 3.77 mm total body length (average 3.74 ± 0.03 mm). They added that the larvae size after yolk sac absorption weighed 0.84 – 0.96 mg (average 0.90 ± 0.06 mg) and measured 4.69 – 5.80 mm total body length (average 5.18 ± 0.60 mm).

CONCLUSION

All spawning parameters increased with increased female broodstock size including hatchlings which had higher initial sizes, except for fecundity which was highest in the small female broodstock. Small size broodstocks are, however, useful for studies involving fish fecundity.

It can be concluded that spawning performance in terms of egg density and therefore the size of an egg, fertilization, hatchability, and size of fry at 4 days old increased with increasing size of broodstock. Larger sized broodstock may yield better spawning performance if carefully selected. Thus, it is recommended that hatchery operators procure female broodstock of 2.5 kg to achieve better yield in their production cycle.

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