integrity Research Journals

Global Journal of Fisheries Science
Volume 3(3), pages 27-36, August 2021
Article Number: 399B8B5F2
ISSN: 2782-750X
https://doi.org/10.31248/GJFS2021.025
https://integrityresjournals.org/journal/GJFS

Full Length Research

Intra-specific hybridization and larval performance of two strains of wild African catfish *Clarias gariepinus* (*Burchell*, 1822) (*Siluriformes*: Clariidae) from Cameroon

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Received 24th June, 2021; Accepted 16th July, 2021

ABSTRACT: In Cameroon, wild strains of *Clarias gariepinus* (Burchell, 1822**)** are often used for artificial reproduction in hatchery facilities, but there is insufficient information on their reproductive capacity and progeny performance. The reproductive capacity of two strains of *C. gariepinus* from the Mezam and Mungo Rivers and the performance of their F1 larvae obtained following hybridization were assessed. Reproduction was carried out with four crosses as follows: Mezam (♂) x Mezam (♀) (T1), Mezam (♂) x Mungo (♀) (T2), Mungo (♂) x Mezam (♀) (T3) and Mungo (♂) x Mungo (♀) (T4). Thereafter, three days old larvae obtained following reproduction were subjected to a 30 day experimental trial with standard feeds. The performance of larvae obtained from T4 was not assessed since larvae obtained were too few for the experiment. Although the broodstock of the different strains did not differ significantly in size, Mezam stock had significantly ($p = 0.00$) bigger eggs when compared to Mungo stock. Fecundity of 52480 was recorded for Mezam stock compared to 32985 for Mungo stock. Fertilization and hatchability rates differed significantly ($p < 0.05$) among the crosses, with the highest (82.28 and 81.31%, respectively) in T1, followed by T3 (65.96 and 61.28%, respectively), and the least (38.61 and 2.81%, respectively) in T4. The best larval survival was recorded in T1 (37.17%) and the least in T2 (15.67%), meanwhile T3 recorded best growth after 30 days. In terms of fertilization and hatchability, T1 was more suitable for artificial reproduction, but T3 is more encouraged for aquaculture based on its reproductive capacity and larval performance.

Keywords: *Clarias gariepinus*, larval performance, Mezam River, Mungo Rivers, reproductive capacity, wild broodstock.

INTRODUCTION

The culture of clariid catfishes is gaining grounds globally due to their hardy and air-breathing characteristics, fast growth, high fecundity and rich and palatable flesh (Offem et al., 2010). The African catfish (*Clarias gariepinus*, Burchell, 1822) is the main cultured clariid species owing to the availability of vast research findings on its reproductive biology, broodstock nutrition, artificial spawning and other aspects of culture (Hecht, 1988; Dadebo, 2000; Brzuska, 2004; Ibim and Sikoki, 2014; Sikoki and Ibim, 2014).

Clarias gariepinus is being crossed with other clariid species to produce inter-generic or inter-species hybrids of improved quality (Owodeinde and Ndimele, 2011; Owodeinde et al., 2012; Yakubu et al., 2014; Oben et al., 2015) when compared to purebred *C. gariepinus*. However, the resulting progenies may have lower

reproductive performances or prolonged periods at which first sexual maturity is attained (Legendre et al., 1992). Although exotic stocks of this species which off course are very expensive are often used for artificial reproduction in hatcheries, the wild strains also have potentials for aquaculture and fish seed of better potential can be obtained if selective breeding is carried out (Megbowon et al., 2013; Sunarma et al., 2016).

In Cameroon, *C*. *gariepinus* is considered a good fish for aquaculture because of its high economic value (Oben et al., 2015). Different strains of this species are farmed in different parts of the nation (Ponzoni and Nguyen, 2008), but knowledge on the aquaculture potential of the different strains is limited. Mezam and Mungo Rivers constitute important fishing grounds for fish seeds (fingerlings and juveniles) and broodstock for artificial reproduction. Among the different strains of *C. gariepinus* studied in Cameroon, Nkongho et al. (2019) reported genetic variation between the Mungo and Mezam Rivers strains. Thus, the aim of this study was therefore to assess the reproduction capacity of these two strains of *C. gariepinus* and the performance of the resulting progenies. This is a novel study on the artificial reproduction and larval performance of wild broodstock obtained from Mezam and Mungo Rivers.

MATERIALS AND METHODS

Study sites

Broodstock were captured from the Mezam River basin (in the Lower Bafut, North West Region) and the Mungo River (in Muyuka, South West Region). Broodstock maintenance and spawning activities were carried out at the FAPA Hatchery Complex in Muea, Buea in the Mount Cameroon Region. Buea is characterised by relatively low temperatures ranging from 20 to 26^{o}C (Oben and Oben, 2003/2004).

Broodstock maintenance

After capture, broodstock were given a dip bath in potassium permanganate ($KMnO_4$) solution (75 mg/L) for 5 minutes in order to treat wounds and eliminate parasites. They were stocked in outdoor concrete tanks of 5.04 m^2 capacity at a density of at most 5 fish/m^2. Female and male broodstock from Mungo River (4 females and 4 males) ranged from 0.9 to 2.5 kg and 0.6 to 2.6 kg, respectively, while those from Mezam River (22 females and 26 males) ranged from 0.7 to 2.0 kg and 0.9 to 1.6 kg, respectively were used for the experiment. For both stocks, males and females were stocked separately. Aller Claria Float 6.00 mm feed (40% crude protein, 12% crude fat, 32% NFE, 3.1% Fibre, 5.1% Ash) was administered daily; at the rate of 1% wet body weight (Nguenga et al., 2004). Feeding was ocassionally supplemented with local fishery by-catch predominantly of small clupeids of the species *Pellonula miri* (Njanja motto) and *Ethmalosa fimbriata* (Bonga) at 3% wet body weight.

Broodstock were maintained in outdoor tanks with continual mixing of water through regular water renewal thereby aerating the water and stabilizing oxygen content. The water temperature (using a Boyu Glass Thermometer BT-01) and pH (using Newdy Digital pH Meter Tester X001FYDQ1B) were monitored daily. Tank water was completely drained fortnightly and the broodstock examined. The broodstock were maintained for six months prior to artificial propagation.

Gamete collection

Two mature females; one each from Mezam and Mungo River stocks weighing 2.6 and 2.7 kg, respectively were obtained after 24 hours of starvation. The broodstock were disinfected with 50 ppm 37% formalin bath for three hours. Thereafter, they were administered OVAPRIM and pituitary suspension intramuscularly into the dorsal muscle to induce final oocyte maturation and ovulation (Oben et al., 2015). OVAPRIM was administered at the rate of 0.5 mL/ kg wet body weight (WBW) and the pituitary suspension prepared by macerating pituitary gland of *C*. *gariepinus* in 2 mL physiological saline. The broodstock were then maintained indoors singly in circular plastic tanks for 12 hours at a temperature of 26 to 27ºC. Eggs were collected by gently pressing the abdomen of the females. Immediately after stripping, the females were stocked in 2mg/L KMnO4 (an analgesic) which was renewed daily to cure injuries and reduce stress/pain to fish. The weight of eggs was determined to the nearest 0.1 g using OHAUS Cs200 Cs Compact Portable balance. The eggs collected from each female were partitioned into two equal parts, each part fertilized with milt from within and without a stock.

Two mature males were selected; one each from Mezam and Mungo River weighing 2.1 and 2.2 kg respectively. They were disinfected following the procedure used for the female broodstock. Thereafter, they were also administered OVAPRIM and pituitary gland suspension (Oben et al., 2015), maintained as the female, sacrificed following standard protocol and testes collected.

Fecundity and egg diameter

To determine fecundity, the weight of stripped eggs was determined and three samples of 1 gram each were collected into petri dishes, physiological saline was added onto the eggs (Zango et al., 2015); this separated the eggs and harden them, thereby easing counting and diameter measurement. Egg diameter of 50 eggs per sample was measured to the nearest 0.01 mm using a Three-Button

Digital Caliper. Fecundity was then calculated according to Sahoo et al. (2005), as follows:

Total number of stripped eggs = Total weight of eggs × number of eggs in 1gram

Fertilization and egg incubation

Artificial reproduction was carried out with four combinations classified as follows: Mezam (♂) x Mezam (♀) (T1), Mezam (♂) x Mungo (♀) (T2), Mungo (♂) x Mezam (♀) (T3) and Mungo (♂) x Mungo (♀) (4). The testes were incised and milt squeezed directly onto the eggs and mixed using a sterile chicken flight feather for about one minute to thoroughly homogenize. Some physiological saline was added and mixed for about one minute. Finally, the eggs were washed 2-3 consecutive times with clean water and spread on the kakaban placed in culture tanks (Marimuthu et al., 2015) of water re-circulating systems and in 1 L bowls pre-set in water re-circulatory systems (Nguenga et al., 2004).
300W EHEIM JAGER aquarium thermostat heaters were used to maintain incubation temperature. Aeration was provided constantly using ACO-006 Electromagnetic Air Compressor aquarium air pump. The water re-circulating systems were equipped with UV light systems for microbial control. Water temperature, dissolved oxygen, pH and conductivity were monitored after every 6 hours.

Fertilization rate and hatchability

After 12 hours of incubation, a sample of eggs was collected from the centre of the kakaban placed in each of the three 1 L bowls, placed in a petri dish and observed under illumination for whitish (unfertilized) eggs (Nguenga et al., 2004). Fertilization rate and hatchability were computed according to Ataguba et al. (2012), as follows:

$$\%\ Fertilization\ = \frac{N-b}{N} x\ 100$$

$$b = \frac{Y}{X} N$$

Where N = the total number of eggs stripped, b = the number of whitish eggs, X = the number of eggs in three representative samples and Y = the number of whitish eggs counted in three representative samples.

Hatchability computed as follows:

$$\text{Hatchability} = \frac{\text{Number of larvae}}{\text{Total number of eggs incubated}} \times\ 100$$

Larval performance

After three days of culture without exogenous feeding, the larvae were measured for their initial total length and weight then randomly distributed in triplicate 80 L plastic tanks each holding 50 L of water at a stocking density of 4 larvae/liter of water (200 larvae per tank) and reared indoors for 30 days. Decapsulated *Artemia* cyst was administered for two weeks, then Neo-Supra GAMME CATFISH feed containing 58% crude protein, 13% lipid, 19% digestible energy, 0.5% crude fibre, 10% ash, 10% starch and 1.5% phosporous for sixteen additional days. Feed was administered 4 times daily; 9:00, 12:00, 15:00 and 18:00 at a rate of 5% total fish weight (Okunsebor and Sotolu, 2011).

The leftover feed and faeces was siphoned twice a day; before the first and the last rations of each day. Fifty percent (50%) of water was renewed after every two days (Saha and Saha, 2017). Aeration was continuous provided using ACO-006 Electromagnetic Air Compressor aquarium air pump. Water temperature (using a Boyu Glass Thermometer (BT-01)), dissolved oxygen (using a DO-5509- Dissolved Oxygen Meter), pH (using Newdy Digital pH Meter Tester (X001FYDQ1B)), conductivity (using YL - TDS2 - A Portable Digital TDS Tester Pen for Water Quality) were monitored twice a day; morning and evening and ammonia levels were monitored after every two days using a HANNA Ammonia Medium Range portable photometer (HI96715C).

Once a week, survivors were determined and 20 larvae per tank were randomly sampled for average weight determination in order to adjust food rations. At the end of the experiment, fry individual weight was measured to the nearest 0.01 g using the S. METTLER Electronic balance and the total length measured to the nearest 0.01 mm using a Three-Button Digital Caliper.

The growth and production indices namely: Average weight gain (WG); average daily growth (ADG); Condition factor (K); percentage weight gain (PWG) and specific growth rate (SGR) were computed.

$$\text{AWG} = \text{Final weight} - \text{Initial weight}$$

$$\text{ADG} = \frac{\text{Final weight} - \text{Initial weight (g)}}{\text{Period of experiment (days)}}$$

Fulton's Condition factor (K) = $100W/L^3$

Where W = whole body wet weight in grams and L = length in cm. The factor 100 is used to bring K close to unity.

$$\text{PWG} = \frac{\text{Final weight} - \text{Initial weight}}{\text{Initial weight}} \times 100$$

$$\text{SGR} = \frac{\text{In Final weight} - \ln \text{Initial weight}}{\text{Number of days}} \times 100$$

Statistical analysis

Data obtained was subjected to One Way Analysis of Variance (ANOVA). Differences between group means

were tested using Duncan's New Multiple Range Tests at a confidence interval of 95%. Regresion analysis was carried out to determine the weight-length relation of the larvae in the course of 30 days.

RESULTS AND DISCUSSION

Broodstock maintenance

Water temperature and pH recorded throughout broodstock maintenance are presented in Table1. There was no significant difference ($p > 0.05$) in both temperature and pH in the different tanks and they were within the desired range for catfish (Viveen et al., 1985). Daily feeding ration of 1% Body Weight (Nguenga et al., 2004) was adopted. Above this feeding level, there were high leftovers; which could degrade water quality thereby stressing the fish and in turn influencing certain physiological parameters (Contreras-Sinchez et al., 1998). However, Mungo River stock recorded high mortality during the maintenance period.

Fecundity and egg diameter

Fecundity for Mezam and Mungo was 52480 and 32985 eggs, respectively. The egg diameter was 1.63 ± 0.25 and 1.35 ± 0.23 mm for Mezam and Mungo stocks, respectively. Although females of the different stocks used for the experiment did not differ significantly in size (2.6 and 2.7 kg), the eggs of Mezam stock were significantly bigger ($p = 0.00$) when compared to those of Mungo stock.

Clarias gariepinus is highly fecund and its fecundity is known to strongly correlate with body weight (Ataguba et al., 2013; Absalom et al., 2017). The fecundity of 52480 and 32985 recorded for females of Mezam (2.6 kg) and Mungo (2.7 kg) stocks, respectively in this study was observed to be lower when compared to that reported by Ataguba et al. (2012), Ataguba et al. (2013) and Shinkafi and Ilesanmi (2014). This disparity could be attributed mainly to seasonal influence (Ayinla and Nwadukwe, 1990; Ikpi et al., 2012). However, the eggs diameter of 0.9 to 1.91 mm and 1.01 to 1.96 mm for Mungo and Mezam stocks, respectively recorded in this study was larger compared to that reported by Sule and Adikwu (2004) probably due to larger broodstock used in this study.

Fertilization and hatchability

Fertilization and hatching occurred in all the treatments, but at varying degrees. Fertilization rate differed significantly ($p < 0.05$) among some treatments; treatment 2 and treatment 4 were not significantly different ($p = 0.534$). The highest fertilization rate (82.28%) was recorded in treatment 1 (pure Mezam) and the least (38.61%) was recorded in treatment 4 (pure Mungo). First hatchlings were observed after 18 hours in all the treatments. Hatchability varied significantly ($p < 0.05$) among the treatments. However, the trend was the same as the fertilization rates; the highest hatchability of 81.31 ± 7.54 was observed in treatment 1 followed by treatment 3 and the least in treatment 4. Table 2 presents the fertilization and the hatchability.

Table 1. Mean ± SD and ranges of temperature and pH in broodstock tanks.

Stock	Temperature (°C)	pH
Mezam females	24.58 ± 1.28	7.61 ± 0.61
	(22.0 – 27.0)	(7.01 - 9.37)
Mezam males	24.60 ± 1.38	7.36 ± 0.40
	(22.0 – 27.0)	(7.02 - 8.66)
Mungo females	24.79 ± 1.46	7.31 ± 0.24
	(22.0 – 27.5)	(6.94 - 7.87)
Mungo males	24.84 ± 1.50	7.65 ± 0.64
	(22.0 – 27.5)	(7.77 - 8.99)

Both indices were highest in treatment 1, although the incubation conditions were not significantly different from those of other treatments. The findings are congruent with those of Ndeham et al. (2018). The highest fertilization and hatchability were recorded in treatment 1 (Mezam purebred), but contradictorily, the least fertilization and hatchability were recorded in treatment 4 (Mungo purebred). Very low hatchability of about 4% have also been reported for *C. gariepinus* (Macharia et al., 2005), where the cause was attributed to the type of incubation material used. The poor fertilization and hatchability recorded in treatment 4 could be attributed with genetic constitution as phylogenetic studies of Nkongho et al. (2019) revealed that the Mungo strain is more ancestral when compared to the other strain of *C. gariepinus* from Mezam River. However, the performance of cross between Mungo male and Mezame female was better. The indication is that Mezam ♀ x Mungo ♂ has a better aquaculture potential when compared to purebred Mungo. The general lower fertilization and hatchability recorded in this study could be attributed to seasonal influence (Ochokwu et al., 2016). However, the feasibility of breeding these two wild strains of *C. gariepinus* and producing their reciprocal hybrids was demonstrated in this study. The embryonic developmental period was similar to that of Olaniyi and Omitogun (2013).

Water quality of the incubation tanks

Water quality parameters namely dissolved oxygen (DO), temperature, pH and conductivity are presented in Table 3. There was no significant different ($p > 0.05$) among group means for all parameters. At the end of hatching,

Table 2. Mean±SD of percentage fertilization and hatchability.

Treatment	% Fertilization	% Hatchability
Treatment 1: Mezam ♀ x Mezam ♂	82.28 ± 8.01[a]	81.31 ± 7.54[a]
Treatment 2: Mungo ♀ x Mezam ♂	41.66 ± 2.34[c]	34.79 ± 5.72[c]
Treatment 3: Mezam ♀ x Mungo ♂	65.96 ± 1.24[b]	61.28 ± 3.54[b]
Treatment 4: Mungo ♀ and Mungo♂	38.61 ±2.98[c]	2.81 ± 1.78[d]

Means in a column with different superscripts are significantly different (p<0.05).

Table 3. Mean ± SD of water quality measurements during incubation.

Treatment	Water quality parameters			
	Temperature (°C)	pH	Dissolved oxygen (mg/L)	Conductivity (µS/cm)
Treatment1: Mezam ♀ x Mezam ♂	28.44±1.01	8.28±0 .13	7.48±1.21	335.50±21.38
Treatment 2: Mungo ♀ x Mezam ♂	28.48±1.10	8.28±0.06	7.00±1.59	328.33±16.10
Treatment 3: Mezam ♀ x Mungo ♂	28.67±1.00	8.24±0 .09	7.17±1.56	301.17±74.01
Treatment 4: Mungo ♀ x Mungo♂	28.72±0.57	8.33±0 .02	7.02±1.54	300.67±72.10

ammonia levels of 0.4, 0.09, 0.3 and 0.01 mg/L were recorded in treatments 1, 2, 3 and 4, respectively. Temperature is a very important abiotic factor controlling the rate of morphogenesis in fish (Kamler et al., 1994; Sapkale et al., 2011) and in this study; it did not differ significantly among the treatments and was within the optimal range for incubation of eggs of *C. gariepinus* (Viveen et al., 1985; Haylor and Mollah, 1995). The pH between 8.08 and 8.46 recorded was similar to that of Ochokwu et al. (2016), where up to 78% hatchability was recorded and was considered acceptable; Uzoka et al. (2011) reported median lethal hatching pH (ML50HpH) to be 4.45 and 9.40 for acidic and alkaline treatments, respectively. This means that although the pH recorded in this study was slightly higher when compared to the recommendation of Viveen et al. (1985), they likely did not have adverse effect on hatchability.

The dissolved oxygen (DO) levels of 7.48 ± 1.21, 7.00 ± 1.59, 7.17 ±1.56 and 7.02 ± 1.54 mg/L in treatments 1, 2, 3 and 4, respectively did not differ significantly ($p > 0.05$) and were within the acceptable range (Saha and Saha, 2017).

The conductivity in all the tanks did not differ significantly ($p > 0.05$) and was within the desirable range reported by Stone et al. (2013).

The mean ammonia levels of 0.4, 0.09, 0.3 and 0.01 mg/L for treatments 1, 2, 3 and 4, respectively was within the acceptable range reported by Onada and Ogunola (2017). According to Stone et al. (2013), warm water fishes are less sensitive to ammonia compared to temperate species like salmonids and trout.

Larval performance

Survival among the treatments was significantly different ($p > 0.05$); with highest (37.17%) in treatment 1 followed by treatment 3 (23.67%) and least (15.67%) in treatment 2. Treatment 3 had the highest weight gain and length gain while treatment 2 recorded the least. However, growth performance in treatment 1 and 3 did not differ significantly ($p > 0.05$). Change in length was highest in treatment 3, but it was not significantly different ($p = 0.968$) from that of treatment 1. Average weight gain, percentage weight gain and specific growth rate were highest in treatment 3, but were not significantly different ($p > 0.05$) from that in treatment 1. However, final condition factor was highest in treatment 2 followed by treatment 3 and least in treatment 1, but it was not significantly different ($p>0.05$) among treatments. Table 4 presents the different aspects of larval performance.

Only the percentage survival in treatment 1 was higher than that reported by Olurin et al. (2012). The significantly better survival recorded in treatment 1 when compared to the hybrids is congruent with the findings of Omeji et al. (2013) and Ndeham et al. (2018) and could be attributed to better heterosis for survival (Ndeham et al., 2018).

The performance of one of the hybrids (treatment 3) was better than the other (treatment 2), but the performance of the former was not significantly ($p > 0.05$) better than that of treatment 1. This finding is congruent with those of Diyaware and Onyila (2014), where hybridization resulted in better performance of the progenies of only one of the hybrids when compared to the purebred.

The length-weight relationships of the treatments showed exponent ('b') values of 1.46 to 2.99, revealing allometric growth as shown in Figures 1, 2 and 3. However treatment 2 showed a tendency towards isometric growth. The exponents, except in treatment 3 were within the expected range of 2.5 to 3.5 confirmed by Froese (2006). However, the exponents were significantly different from

Table 4. Larval performance for the different treatments in 30 days.

Parameter	Treatment 1 (Mezam ♂ x Mezam ♀)	Treatment 2 (Mezam ♂ x Mungo♀)	Treatment 3 (Mungo ♂ x Mezam ♀)
Duration of experiment (Days)	30	30	30
Initial number of fish	200	200	200
Final number of fish	73.00 ± 9.64[a]	31.33 ± .52[c]	47.33 ± 12.50[b]
Survival (%)	37.17 ± 5.97[a]	15.67 ± 1.26[c]	23.67 ± 6.25[b]
Initial weight (mg)	4.00	4.00	4.00
Final weight (mg)	65.60 ± 28.66[a]	44.8 ± 30.69[b]	71 ± 36.57[a]
Initial length (mm)	7.70± 0.37[a]	7.35 ± 0.49[b]	7.88 ± 0.38[a]
Final length (mm)	20.78± 3.31[a]	17.87 ± 3.12[b]	20.92 ± 3.80[a]
Average length gain	13.10 ± 0.99[a]	10.57 ± 0.45[b]	13.08 ± 0.80[a]
Average weight gain (mg)	60.00 ± 10.00[a]	40.00 ±10.00[b]	67.00 ± 1.00[a]
Average daily growth (mg/day)	2.12 ± 0.38[a]	1.38 ± 0.23[b]	2.23 ± 0.22[a]
Initial condition factor	0.88	1.01	0.82
Final Condition factor	0.73 ± 0.02[a]	0.79 ± 0.07[a]	0.77 ± 0.03[a]
Percentage weight gain	1558.33 ± 275.38[a]	1033.33 ± 170.17[b]	1675.00 ±163.94[a]
% Specific growth rate	9.33 ± 0.57[a]	8.06 ± 0.48[b]	9.58 ± 0.30[a]

Means in a row with the same superscript are not significantly different (p>0.05).

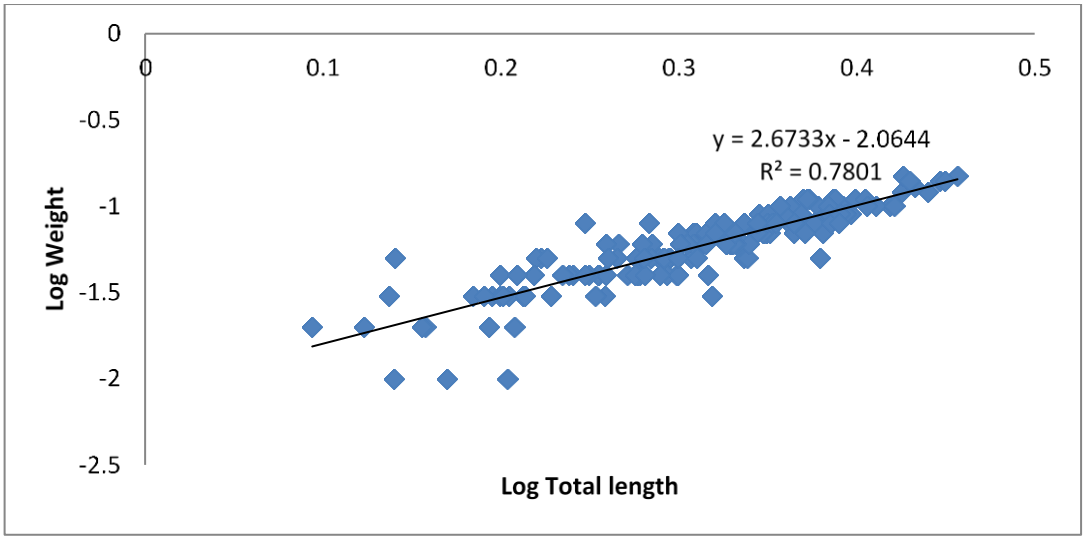

Figure 1. The length-weight relationship of larvae in treatment 1(Mezam ♂ x Mezam ♀).

the value of 2.58 reported for *C. gariepinus* by Okomoda et al. (2018). This disparity in the growth pattern could be attributed mainly to the growth phase of the fish Gaspar et al. (2012) and Okomoda et al. (2018).

Water quality in larval experimental tanks

The water quality parameters among treatments were fairly similar as shown in Table 5. Mean temperature was not significantly different (p = 0.746). The pH in treatments 2 and 3 did not differ significantly (p = 0.174), but differed significantly (p < 0.05) from that in treatment 1. Dissolved oxygen levels among the treatments did not significantly differ (p = 0.088). Also, conductivity (p = 0.095) and ammonia (p = 0.055) in the tanks were not significantly different. The water quality parameters recorded were within the desirable range for fish (Viveen et al., 1985). Although the pH of the different treatments differed significantly, it was within the optimal range reported by Ndubuisi et al. (2015). According to Viveen et al. (1985), the desirable level of ammonia is less than 0.05 mg/L since ammonia especially the unionized form is very toxic to fish, but Onada and Ogunola, (2017) and Nahar et al. (2000)

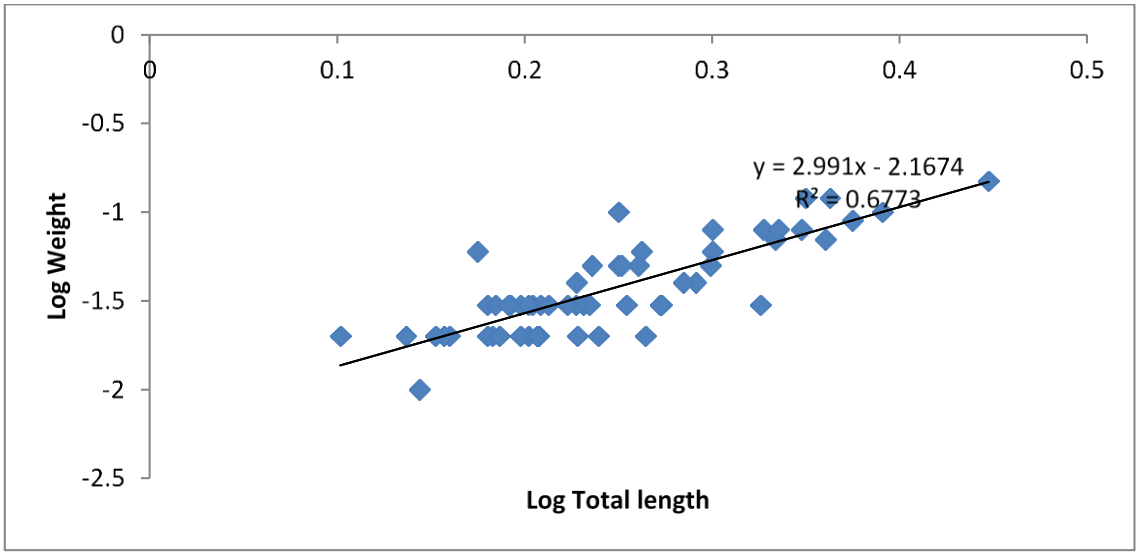

Figure 2. The length-weight relationship of larvae in treatment 2 (Mezam ♂ x Mungo♀).

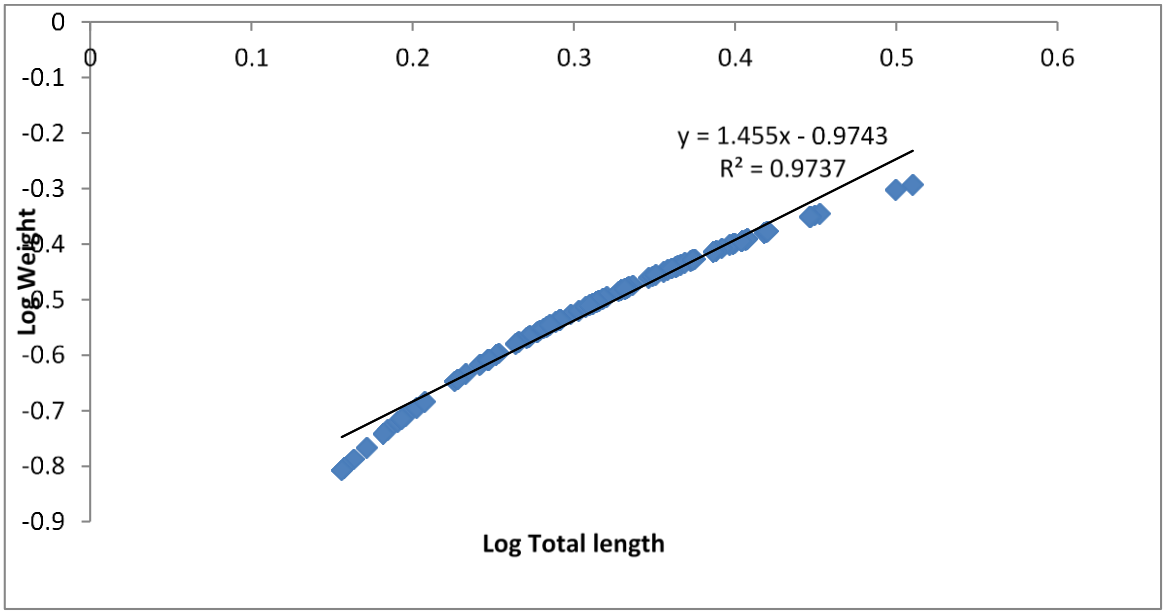

Figure 3. The length-weight relationship of larvae in treatment 3 (Mezam ♀ x Mungo ♂).

Table 5. Mean±SD of water quality parameters in experimental tanks.

Parameter	Treatment 1 (Mezam ♂ x Mezam♀)	Treatment 2 (Mezam ♂ x Mungo ♀)	Treatment 3 (Mungo ♂ x Mezam ♀)
Temperature (ºC)	24.30 ± 0.95[a]	24.29 ± 0.96[a]	24.25 ± 0.95[a]
pH	7.76 ± 0.25[a]	7.90 ± 0.17[b]	7.94 ± 0.14[b]
Dissolved oxygen (mg/L)	6.69 ± 0.85[a]	6.65 ± 0.85[a]	6.59 ± 0.81[a]
Ammonia (mg/L)	0.15 ± 0.20[a]	0.05 ± 0.10[a]	0.10 ± 0.15[a]
Conductivity (µS/cm)	239.13 ± 7.10[a]	237.24 ± 8.07[a]	237.46 ± 8.15[a]

Means in a row with the same superscript are not significantly different (p>0.05).

report ammonia levels of up to 0.5 mg/L to be acceptable in fish culture. In this study, the mean ammonia levels ranged from 0.05 mg/L in treatment 2 with the least survival of 15.5% to 0.15 mg/L in treatment 1 with the highest percent survival of 36.5%. It therefore implied that the high mortality in treatment 2 may not be associated with levels of ammonia, but genetic traits. The mean temperature of 24.3^{o}C recorded in this study was not optimal for *C. gariepinus* larvae (Viveen et al., 1985; Britz and Hecht, 1987) and was considered the growth limiting factor in this experiment. Temperature is therefore a limiting factor to the larviculture of *C. gariepinus* in Buea and the Mount Cameroon Region in general which is characterized by very low temperatures.

Conclusion

This study revealed the feasibility of reproducing *C. gariepinus* from Mezam and Mungo Rivers in captivity. Hybridization improved the fertilization and hatchability. Larvae obtained from a cross between Mezam female and Mungo male had best growth performance. *Clarias gariepinus* from Mezam River was a preferred wild stock for aquaculture when compared to the Mungo, since the former was more resistant with no mortality recorded during broodstock maintenance, the reproductive capacity was better and larval performance was good. However, for more profitable aquaculture, a cross between Mezam female and Mungo male is more recommended.

CONFLICT OF INTEREST

Authors declare that they have no conflicts of interest.

ACKNOWLEDGEMENTS

We are deeply thankful to the FAPA Hatchery Complex in Muea, Buea for providing working space, equipment, broodstock from Mungo River and reagents used for this study. We are also grateful to the CORAF/WECARD project and the Faculty of Agriculture and Veterinary Medicine, University of Buea for providing some materials for this study.

REFERENCES

Ataguba, G. A., Okomoda, V. T., & Onwuka, M. C. (2013). Relationship between broodstock weight combination and spawning success in African catfish (*Clarias gariepinus*). *Croatian Journal of Fisheries*, 71,176-181.

Ataguba, G. A., Solomon, S. G., & Onwuka, M. C. (2012). Broodstock size combination in artificial spawning of cultured *Clarias gariepinus*. *Livestock Research for Rural Development*, 24(12), 1-7.

Ayinla, O. A., & Nwadukwe, F. O. (1990). Effect of season on controlled propagation of the African Catfish, *Clarias gariepinus* (Burchell, 1822). Tcehnical paper No. 62, 1-15.

Britz, P. J., & Hecht, T. (1987). Temperature preferences and optimum temperature for growth of African Sharptooth Catfish (*Clarias gariepinus*) larvae and postlarvae. *Aquaculture*, 63,205-214.

Brzuska, E. (2004). Artificial propagation of African catfish (*Clarias gariepinus*): the application of a single dose of pellets containing D-Ala^{6}, Pro^{9} NEt-mGnRH and dopamine inhibitor metoclopramide. *Czech Journal of Animal Science* 49(7), 289-296.

Contreras-Sinchez, W. M., Schreck, C. B., Fitzpatrick, M. S., & Pereira, C. B. (1998). Effects of stress on the reproductive performance of rainbow trout (*Oncorhynchus mykiss*). *Biology of Reproduction*, 58,439-447.

Dadebo, E. (2000). Reproductive biology and feeding habits of the catfish *C. gariepinus* (Bruchell) (Pisces: Clariidae) in Lake Awassa, Ethiopia. *SINET: Ethiopia Journal of Science*, 23(2), 231-246.

Diyaware, M. Y., & Onyila, L. U. (2014). Growth and survival of intergeneric hybrids of *Clarias anguillaris* and *Heterobranchus bidorsalis* in semi-arid zone of Nigeria. *Journal of Fisheries and Aquatic Science*, 9(5), 398-406.

Froese, R. (2006). Cube law, condition factor and weight–length relationships: history, meta-analysis and recommendations. *Journal of Applied Ichthyology*, 22, 241–253.

Gaspar, S., Tobes, I., Miranda, R., Leunda, P. M., & Peláez, M. (2012). Length–weight relationships of sixteen freshwater fishes from the Hacha River and its tributaries (Amazon Basin, Caquetá, Colombia). *Journal of Applied Ichthyology*, 28(4), 667-670.

Haylor, G. S., & Mollah, M. F. A. (1995). Controlled hatchery production of African catfish, *Clarias gariepinus*: the influence of temperature on early development. *Aquatic Living Resour*ces, 8, 431-438.

Hecht, T., Uys, W., & Britz, P. J. (1988). The culture of sharptooth catfish, *Clarias gariepinus* in Southern Africa. South African national scientific programme report No. 153, p. 143.

Ibim, A. T., & Sikoki, F. D. (2014). Effect of protein level on gonadal development of the African Catfish. *Journal of Biology, Agriculture and Healthcare*, 4(1), 51-56.

Ikpi, G. U., Jenyo-Oni, A., & Offem, B. O. (2012). Effect of season on catch rate, diet and aspects of reproduction of *Clarias gariepinus* (Teleostei: Clariidae) in a tropical waterfalls. *Advances in Life Sciences*, 2(3), 68-74.

Kamler, E., Szlaminska, M., Kuczynski, M., Hamackova, J., Kouri, J., & Dabrowski, R. (1994). Temperature induced changes of early development and yolk utilization in the African catfish *Clarias gariepinus*. *Journal of Fish Biology*, 44, 311-326.

Legendre, M., Teugels, G. G., Cauty, C., & Jalabert, B. (1992). A comparative study on morphology, growth rate and reproduction of *Carias gariepinus* (Burchell, 1822), *Heterobranchus longifilis* Valenciennes, 1840, and their reciprocal hybrids (Pisces, Clariidae). *Journal of Fish Biology*, 40, 59-79.

Macharia, S. K., Ngugi, C. C., & Rasowo, J. (2005). Comparative study of hatching rates of African Catfish (*Clarias gariepinus* Burchell 1822) eggs on different substrates. NAGA, *World Fish Center Quarterly*, 28(3- 4), 23-26.

Marimuthu, K., Satthiyasilan, N., Rahman, M. A., Arshad, A., Raj, M. G., & Arockiaraj, J. (2015). Induced ovulation and spawning of African catfish *Clarias gariepinus* (Bloch) using ovaprim. *Journal of Environment and Biotechnology Research*, 1(1), 2-9.

Megbowon, I., Fashina-Bombata, H. A., Akinwale, M. M.-A.,

Hammed, A.M., Okunade, O. A., & Mojekwu T. O. (2013). Breeding performance of *Clarias gariepinus* obtained from Nigerian Waters. *Journal of Agriculture and Veterinary Science*, 6(3), 6-9.

Nahar, Z., Shah, A. K. M. A., Bhandari, R. K., Ali, M. H., & Dewan, S. (2000). Effect of different feeds on growth, survival and production of African catfish (*Clarias gariepinus* Burchell). *Bangladesh Journal of Fisery Resources*, 4(2), 121-126.

Ndeham, V. R., Ladu, B. M. B., & Onyia, L.U. (2018). Comparison of fertiliztion, hatchability, growth and survival of *Clarias gariepinus* from Adamawa and Katsina States. *Advances in Life Science and Technology,* 63, 1-7.

Ndubuisi, U. C., Chimezie, A. J., Chinedu, U. C., Chikwem, I. C., & Alexander, U. (2015). Effect of pH on the growth performance and survival rate of *Clarias gariepinus* fry. *International Journal of Research in Biosciences*, 4(3), 14-20.

Nguenga, D., Teugels, G. G., Legendre, M., & Ollevier, F. (2004). Influence of tropical seasonal changes on oocyte diameter, responses to hormonal induction and hatching quality in two strains of the catfish, *Heterobranchus longifilis* Val. (Clariidae). *Aquaculture Research*, 35(14), 1349-1357.

Nkongho, G. O., Oben, B. O., Sanni, M. T., Agbebi, O. T., Obie, A. E., Makombu, J. G., Narika, A. F., Arrey, M. A., & Oben, P. M. (2019). Morphological and molecular characterization of some wild and cultured *Clarias* (Clariidae, Siluriformes) fish species from Cameroon. *International Journal of Research Studies in Biosciences*, *7*(3), 16-26.

Oben, P. M., & Oben, B. O. (2003/2004). Preliminary study on the domestication of brood stock of an ornamental aquarium fish, *Synodontis obesus* (Teleostei: Mochokidae) in concrete tanks. *Tropical Freshwater Biology*, 12/13, 137-153.

Oben, P. M., Oben, B. O., Akoachere, R., & Joseph, E. (2015). Induced spawning, survival and growth of an African catfish hybrid (female *Clarias gariepinus* and male *Clarias anguillaris*) fingerlings relative to their parental species in the Mount Cameroon Region. *Tropical Freshwater Biology*, 24, 63-88.

Ochokwu, I. J., Bichi, A. H., & Onyia, L. U. (2016). Intra-specific Hybridization between Two Strains of *Clarias gariepinus* from SouthWest and North Western Nigeria. *Nigerian Journal of Fisheries and Aquaculture*, 4(1), 34-41.

Offem, B. O., Akegbejo-Samsons, Y., & Omoniyi, I. T. (2010). Aspects of ecology of *Clarias anguillaris* (Teleostei: Clariidae) in the Cross River, Nigeria. *Turkish Journal of Fisheries and Aquatic Sciences*, 10, 101-110.

Okomoda, V. T., Koh, I. C. C., Hassan, A., Amornsakun, T., & Shahreza, S. M. (2018). Length-weight relationship and condition factor of the progenies of pure and reciprocal crosses of *Pangasianodon hypophthalmus* and *Clarias gariepinus*. *Aquaculture, Aquarium, Conservation and Legislation-Bioflux*, 11(4), 980-987.

Okunsebor, S. A. and Sotolu, A. O. (2011). Growth performance and survival rate of *Clarias gariepinus* fry fed on live feeds *Brachionus calyciflorus, Ceriodaphnia reticulata* and shell free *Artemia*. *Production, Agriculture and Technology*, 7(2), 108-115.

Olaniyi, W. A., & Omitogun, O. G. (2014). Stages in the early and larval development of the African catfish *Clarias gariepinus* (Teleostei, Clariidae). *Zygote*, 22(3), 314-330.

Olurin, K. B., Iwuchukwu, P. O., & Oladapo, O. (2012). Larval rearing of African catfish, *Clarias gariepinus* fed decapsulated *Artemia*, wild copepods or commercial starter diet. *African Journal of Food Science and Technology*, 3(8), 182-185.

Omeji, S., Obande, R. A., & Oyaje, J. (2013). Intra-specific hybridization of local and exotic *Clarias gariepinus*. *International Journal of Modern Biology*, 1, 35-41.

Onada, O. A., & Ogunola, O. S. (2017). Effects of Catfish (*Clarias gariepinus*) Brood-stocks Egg combination on hatchability and survival of fish larvae. *Journal of Aquactic Resource Development*, S2, 014.

Owodeinde, F. G., & Ndimele, P. E. (2011). Survival, growth and feed utilization of two clariid catfish (*Clarias gariepinus*, Burchell 1822 and *Heterobranchus bidorsalis*, Geoffroy, 1809) and their reciprocal hybrids. *Journal of Applied Ichthyology*, 27(5), 1249-1253.

Owodeinde, F. G., Fakoya, K. A., & Anetekhai, M. A. (2012). Growth performance of hybrid catfish (*Clarias gariepinus* X *Heterobranchus bidorsalis*) in earthen ponds. *Asian Journal of Biological Science*, 5(4),192-200.

Ponzoni, R. W., & Nguyen, N. H. (eds). (2008). Proceedings of a workshop on the development of a genetic improvement program for African catfish *Clarias gariepinus*. *World Fish Center conference proceedings No. 1889*. The WorldFish Center, Penang, Malaysia. 130p.

Saha, R. K., & Saha, H. (2017). Hybridization of *Clarias* spp. and *Heteropneustes fossilis* in Tripura, India. *Advances in Research*, 9(6), 1-13.

Sahoo, S. K., Giri, S. S., Chandra, S., & Mohapatra, B. C. (2008). Evaluation of breeding performance of Asian Catfish *Clarias batrachus* at different doses of HCG and latency period combinations. *Turkish Journal of Fisheries and Aquatic Sciences*, 8, 249-251.

Sapkale, P. H., Singh, R. K., & Desai, A. S. (2011). Optimal water temperature and pH for development of eggs and growth of spawn of common carp (*Cyprinus carpio*). *Journal of Applied Animal Research*, 39(4), 339-345.

Shinkafi, B. A., & Ilesanmi, B. D. (2014). Effect of varying doses of ovatide on the breeding performance of African catfish (Clarias gariepinus Burchell, 1822) in Sokoto, North-western Nigeria. *Asian Journal of Animal Sciences*, 8(2), 56-64.

Sikoki, F. D., & Ibim, A. T. (2014). The Effect of environmental and nutritional manipulation on year-round gonadal development, spawning and recrudescence of female *Clarias gariepinus* broodfish. *Advances in Life Science and Technology*, 16, 1-9.

Stone, N., Shelton, J. L., Haggard, B. E., & Thomforde, H. K. (2013). Interpretation of water analysis reports for fish culture. Southern Regional Aquaculture Center, No. 4606: 12p.

Sule, O. D., & Adikwu, U. I. (2004). Embryonic development in *Clarias gariepinus* (Buchell, 1822) under laboratory conditions. *Animal Research International,* 1(2),81-85.

Sunarma, A., Carman, O., Zairin, Jr. M., & Alimuddin, A. (2016). Interpopulation crossbreeding of farmed and wild African catfish *Clarias gariepinus* (Burchell 1822) in Indonesia at the nursing stage. *Aquatic Living Resources*, 29(3), Article Number 303.

Uzoka, C. N., Mgbeahuruike, L. O., & Nwodu, J. A. (2011). Influence of various pH regimes on hatching success and hatching time of *Clarias gariepinus* (Butchell 1822) eggs. *Journal of Research in Biology*, 7, 513-517.

Viveen, W. J. A. R., Riditer, J. J. C., Oordrot, P. G. w. I., Jansen, J. A. L., & Huisman, E. A. (1985). Practical manual for the culture of the African catfish, *Clarias gariepinus*. Directorate General for International Cooperation, The Hague, The Netherlands. 94pp.

Yakubu, A. F., Nwogu, N. A., Olaji, E. D., Ajiboye, O. O., Apochi, J. O., Adams, T. E., Obule, E. E., & Eke, M. (2014). A comparative study on growth performance and survival of

Clarias gariepinus Burchell. 1822 and *Heterobranchus longifilis* Valenciesnnes, 1840 under water recirculation system. *Agriculture, Forestory and Fisheries*, 3(1), 30-33.

Zango, P., Tomedi, M. T. E., Oben, M. L., Tchoumboue, J., Efole, T. E., Pouomogne, V. Nguenga, D., & Mikolasek, O. (2015). Comparing reproductive characteristics of two catfish species *Clarias gariepinus* and *Clarias jaensis* in the natural environment of the western region of Cameroon. *Journal of Multidisciplinary Engineering Science and Technology*, 2(12), 3437-3441.