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REPRODUCTIVE PERFORMANCE OF WILD STRAINS OF *Clarias gariepinus* BROODSTOCKS FROM NORTH-EAST NIGERIA

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ABSTRACT

Fish seed production of *Clarias gariepinus* has been successfully been carried out in Nigeria. Despite the success, most of the strains used in aquaculture have suffered from inbreeding and its consequences and there still exist a wide gap between fish seed demand and supply, this therefore necessitate the need to increase research. This study focused on intra-specific hybridization among and between wild *Clarias gariepinus* from four different lakes viz., lake Alau in Borno state, lake Dadin Kowa in Gombe state, lake Maladumba in Bauchi state and lake Mayo Ranewo in Taraba state in the North-East of Nigeria in other to evaluate their reproductive performances. Twenty pairs of live wild gravid broodstocks of *C. gariepinus* with a mean total length of 47.9±1.08cm and a mean total weight of 951.75±16.55g were randomly collected from each lake. The fish were conditioned, fed and spawned in the Hatchery complex, Department of Fisheries, University of Maiduguri, Nigeria. The broodstocks were mated in pure parental and reciprocal crosses generating sixteen mating combinations (generic crosses) duplicated in complete blocked randomized design. Reproductive performance parameters such as fecundity, fertilization rate, hatching rate, and survival were monitored and the data collected were analyzed using Analysis of Variance (ANOVA) at $p<0.05$ significant level. The result revealed that the mean highest fecundity (66208±120.12g) was recorded for female broodstocks collected from Lake Mayo Ranewo in Taraba state, crosses between Bauchi? and Taraba? had the highest values of fertilization rate (95.50±9.50%), hatching rate (93.28±2.00%) and survival rate (88.16±2.50%). Results clearly indicated that reproductive performances varied significantly among and between the pure lines and their reciprocal crosses. Water quality parameters including ammonia (mg/L), pH, water temperature (°C) and dissolved oxygen (mg/L) fell within the recommended range for the culture of fresh water fish. For better reproductive performance of wild strains of Clarias gariepinus, in the North-East of Nigeria, crosses should be encouraged between broodstocks from Bauchi and Taraba.

Keywords: *Clarias gariepinus*, reproductive performance, water quality, North-East lakes

INTRODUCTION

In Nigeria, aquaculture is a key economic tool used by both the federal and state government to improve means of livelihood especially among the unemployed citizens. On a global perspective, it is one of the fastest growing food producing sectors and fish is among the most traded food commodities (FAO, 2018). For aquaculture to be successful, a reliable and steady source of fingerlings must be assured throughout the year (Ovie and Ovie, 2014). This can only be guaranteed through artificial breeding. Artificial breeding has the advantage of increasing the genetic makeup of the fish via hybridization and selective breeding and ensures that fish with good genetic strain and vigor are delivered for rearing. Artificial propagation methods constitute the major practicable means of providing high quality fish seed for aquaculture (Charo *et al.,* 2000).

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One of the major factors that can determine the success or failure of artificial breeding is the choice and quality of broodstock. Also, biological factors such as broodstock size, age, strain and species and environmental factors such as dissolved oxygen, pH, temperature, stocking density, photoperiod, etc. could influence breeding success or failure (Ataguba *et al.,* 2012, Ataguba *et al.,* 2013). The broodstock requires specialized attention because the quality of the broodstock determines the quality of the offspring (Madu, 2016). Heavy reliance on broodstock from farms is not recommended for artificial propagation of fish seed. This is because, some unimpressive influence on broodstock as a result of dispersive processes (inbreeding and genetic drift) and systematic processes (mutation, migration and selection) can cause changes in allelic and genotypic frequencies leading to the proliferations of undesirable traits as well as reduction in general productivity of fish species (Madu, 2016). Also, fish caught from the wild have high genetic diversity than those farmed which enables them to withstand lots of factors (Eyo *et al*., 2020). The African Catfish *Clarias gariepinus* belonging to family Clariidae is one of the most important aquaculture species in Nigeria (Eyo *et al.,* 2014). *C. gariepinus* is endemic to Africa and its distribution ranges from North Africa, through the mid-Sahara and covering both East and West down to the South (Teugels, 1986). Its success in aquaculture could be attributed to its fast growth rate, high fecundity, acceptance of artificial feed, good meat quality, ease of induced breeding, disease resistance and hardiness (Eyo *et al.,* 2014; Eyo *et al.,* 2016; Eyo and Awom, 2016). According to Pillay (1990), their high reproductive potential and sturdy resistance to environmental variations contributes to their widespread distribution and natural spawning in different water bodies.

Fish breeding is an aspect of aquaculture which has experienced research and innovation for increased fish production. In Nigeria, the demand for high quality fish seed is very high which is attributed to increase in fish production through aquaculture driven by increase in demand for fish protein. As a result of this, several research has been conducted to improve hatchability and survival of catfish larvae in captivity. Despite all these researches, several hatcheries are still supplying poor quality fish seeds to farmers which consequently, impacts negatively on growth rate and weight gain of the fish and profit levels of farmers. However, the insufficiency of supply and relatively high cost of *C. gariepinus* fingerlings resulting from low output per breeding attempt (Ofor, 2007), indicates the need to widen the scope of factors affecting the low output. Seed collection from the wild is however unreliable and limited only to rainy seasons. However, under cultural conditions, ovulation of the wild *C. gariepinus* can be induced either by environmental manipulation and/or hormonal stimulation. This study aims to evaluate the reproductive performance of intra-specific hybridization among and between wild *Clarias gariepinus* from four different lakes in the North-East of Nigeria.

MATERIAL AND METHODS

Study area

The wild population of *Clarias gariepinus* strains were collected from Lake Alau, Borno State, Lake Maladumba in Bauchi State, and Lake Mayo Ranewo in Taraba State, Dadin kowa Dam in Gombe State.

Lake Alau is located between latitude 11°39" 4' N and 11° 40", 02' N and longitude 13°39" 92'E and 120m above the sea level. The total surface area of Lake Alau is 56 km^2 and a maximum depth is 10m with an effective storage capacity of 54,000ha. The climate in Lake Alau is Sahelian with two distinct seasons with a day temperature of 30^{0}C and night 29^{0}C (Idowu, 2004). As shown in Figure 1.

Lake Maladumba is located at Latitude 11^{0}13' 56" N and Longitude 10^0 21' 42" E with a surface elevation of 408m above sea level. The Lake is a natural, shallow (1-2m) depression Lake, situated in a structural guided long, counterclockwise and clockwise semi-circular channel occupied by the River Kuka that drains into the Lake Kari and River Kari that partially drains the Lake during high water and the Lake undergoes accelerated siltation (Ayeni, 2007). The climate is the Sudan type with two distinct seasons, a short (May to September) wet season and a longer (October - April) dry season. Mean annual rainfall is 800mm with a unimodal distribution during the rainy season. Mean temperature range from 26^{0}C during harmattan to 34^0 during the hot months (Abdullahi, 2012). As shown in Figure 2.

Dadin Kowa Dam is connecting the Gongola River located in Gombe State, Nigeria. The area lies between latitudes 10^0 19' N and latitude 10^0 32' N, and longitudes 11^0 48' E and longitude 11^0 54' E. The dam is situated about 35 kilometers to the east of Gombe town and provides drinking water for the town. The dam was built by the Federal Government in 1984, to provide irrigation and electricity for the planned Gongola sugar plantation project (Timawus, 2012). The reservoir has a capacity of 800 million cubic meters of water and a surface area of 300 square kilometers

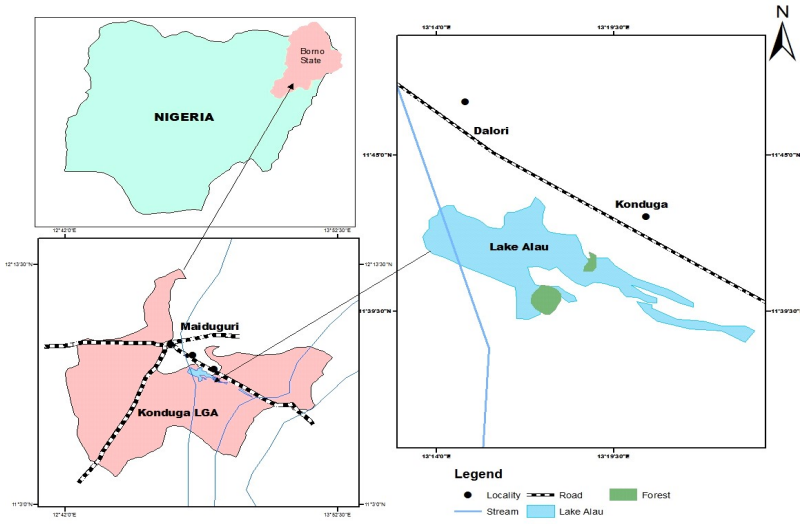

Figure 1. Lake Alau, Borno State

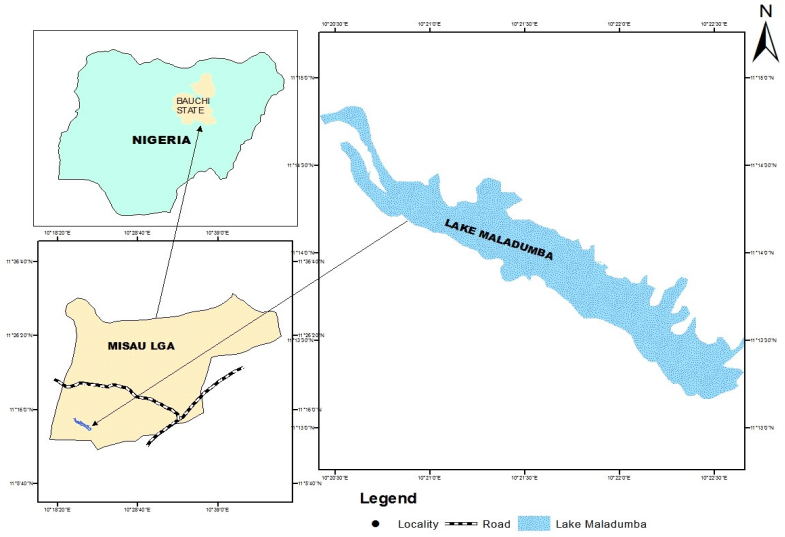

Figure 2. Lake Maladumba, Bauchi State

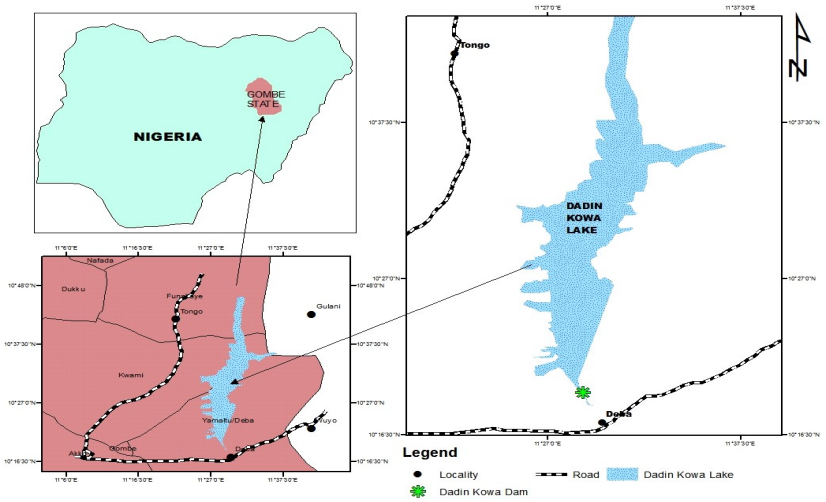

Figure 3. Dadin Kowa Dam, Gombe State

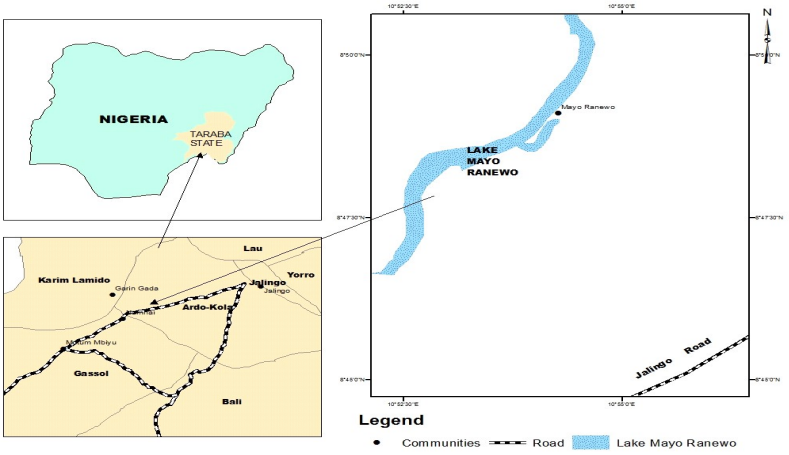

Figure 4. Lake Mayo Ranewo, Taraba State

Table 1. Geo-coordinates of the lakes where broodstocks were collected

S/N	Water bodies	States	Geo-Coordinates (Lat and Long)
1.	Lake Alau	Borno	11°39' N and 13°39' E
2.	Lake Maladumba	Bauchi	11°13' N and 10°21' E
3.	Dadin Kowa Dam	Gombe	10°19' N, and 11°48' E
4.	Lake Mayo Ranewa	Taraba	8°47' N and 10 ° 55' E

and has potential as a source of fish (Timawus, 2012). As shown in Figure 3.

Lake Mayo Ranewo is located at Lat 8^0 47' to 8^0 53' and Longitude 10^0 55' E at the South-Western part of the Ardo Kola LGA in Taraba State. The Lake is located in the town of Mayo Ranewo which is located at the bank and Floodplain of the Benue River. The dominant ethnic groups are Fulani, Hausa, and Jukun Kona. The people of Mayo Ranewo are fish folks and Farmers. As shown in Figure 4.

Collection identification and transportation of *C. gariepinus* broodstock

Ten (10) females and ten (10) males of wild *C. gariepinus* broodstocks with a mean total length of 47.9 ± 1.08 cm and a mean total weight of 951.75 ± 16.55 g were collected from four lakes each in North East Nigeria. The lakes were Lake Alau in Borno State, Lake Dadin kowa in Gombe State, Lake Maladumba in Bauchi state, Lake Mayo Ranewo in Taraba state. Table 1 shows the geo-coordinates of the lakes where the broodstocks were collected from North-East, Nigeria. After collection, the experimental fish were identified using fish Identification keys given by Teugels (1986). Each female broodstock was examined for its readiness to spawn on the basis of external features and release of golden coloured eggs upon a gentle application of pressure on the abdomen following the method of Ayinla *et al*., (1984). For the female, the genital is round and pinkish red in coloration whereas the male has a long reddish genital papillae (Ayinla *et al*., 1994). After identification and examination, the fish were transported to the research fish farm of the Department of Fisheries, Faculty of Agriculture, University of Maiduguri, using a 200 litre plastic gallon.

Acclimatization of experimental fish

The broodstocks were acclimatized for 10 days in a 2 x 2 m^2 outdoor concrete tank separately and were fed with Coppens feed (42 % CP) at 2% of their body weight twice daily. Water in each tank was gradually replaced every 48 hours with fresh dechlorinated water.

Experimental design

The experiment was designed using Complete Blocked Randomized Design (CBRD). The experiment comprised of 16 groups conducted in duplicated (Table 2).

Hormonal Inducement and Stripping of Eggs

Female broodstocks were examined randomly before inducing. Each Female broodstock was selected and weighed using a spring weighing balance (Metlar 5000D). A slight pressure was applied on the abdominal part of the fish and eggs released were examined to confirm the stage of development (exogenenous vitellogenesis). The administration of

Table 2. Experimental Crosses

S/N	Groups	Female broodstock ♀	Male broodstock ♂	Code
1	Group 1	Borno (Lake Alau)	Borno (Lake Alau)	Bo♀ x Bo♂
2	Group 2	Bauchi (Lake Maladumba)	Bauchi (Lake Maladumba)	Ba ♀ x Ba♂
3	Group 3	Gombe (Lake Dadin Kowa)	Gombe (Lake Dadin Kowa)	Go♀ x Go♂
4	Group 4	Taraba (Lake Mayo Ranewa)	Taraba (Lake Mayo Ranewa)	Ta♀ x Ta♂
5	Group 5	Borno (Lake Alau)	Bauchi (Lake Maladumba)	Bo♀ x Ba♂
6	Group 6	Borno (Lake Alau)	Gombe (Lake Dadin Kowa)	Bo♀ x Go♂
7	Group 7	Borno (Lake Alau)	Taraba (Lake Mayo Ranewa)	Bo♀ x Ta♂
8	Group 8	Bauchi (Lake Maladumba)	Borno (Lake Alau)	Ba♀ x Bo♂
9	Group 9	Bauchi (Lake Maladumba)	Gombe (Lake Dadin Kowa)	Ba♀ x Go♂
10	Group 10	Bauchi (Lake Maladumba)	Taraba (Lake Mayo Ranewa)	Ba♀ x Ta♂
11	Group 11	Gombe (Lake Dadin Kowa)	Borno (Lake Alau)	Go♀ x Bo♂
12	Group 12	Gombe (Lake Dadin Kowa)	Bauchi (Lake Maladumba)	Go♀ x Ba♂
13	Group 13	Gombe (Lake Dadin Kowa)	Taraba (Lake Mayo Ranewa)	Go♀ x Ta♂
14	Group 14	Taraba (Lake Mayo Ranewa)	Taraba (Lake Mayo Ranewa)	Ta♀ x Bo♂
15	Group 15	Taraba (Lake Mayo Ranewa)	Bauchi (Lake Maladumba)	Ta♀ x Ba♂
16	Group 16	Taraba (Lake Mayo Ranewa)	Gombe (Lake Dadin Kowa)	Ta♀ x Go♂

the hormone (ovaprim) was done using 5mls hypodermic syringe with 0.6 gauge needle and the dosage was administered based on body weight according to the manufacturer guide. Ovaprim was administered intramuscularly into the dorsolateral region of the fish in a single dose (Haniffa and Sridhar, 2002) after cleaning the area to be injected with cotton swab. The needle was inserted gently towards the head at an angle of 45^0 to the body's longitudinal axis to a depth of about 1.5cm and injected slowly. Immediately after injecting the hormone, the point at which the hormone was injected was massaged with a cotton wool and checked for back flow of hormone (Haniffa and Sridhar, 2002). Each injected fish was returned into its tank. Within 8-9 hours (latency period) after administration of the hormone, the stripping of eggs commenced.

Milt collection and fertilization of the eggs

The male broodstocks were weighed according to treatments using Metlar MT5000D electronic scale and thereafter sacrificed to extracted the testes. Small incisions were made on the testes and a slight pressure was applied for milt to be extracted. The female broodstocks were stripped for eggs separately. The eggs were weighed according to treatments using Metlar MT5000D electronic scale and one hundred stripped eggs counted using a pipette (Eyo and Ekanem, 2011) were fertilized by pouring the milt on the stripped eggs and mixed thoroughly in a 2-litres size plastic bowl. Normal saline solution was also used to enhance fertilization of the eggs. This procedure was done separately for all the treatments.

Fertilization rate was calculated according to Muir and Robert (1985) as follows:

Fertilization rate (%) = Total number of fertilized eggs/ total number of eggs x 100

Incubation and Hatching of Fertilized Eggs

The fertilized eggs were incubated in an indoor incubating concrete tanks measuring 1 x 1 x 1 m^3 with a substrate or egg collectors (mosquito netting material). Hatching occurred between 24-30 hours of incubation at water temperature of 31ÚC. After hatching, the dead eggs and the egg collectors were removed. The hatched larvae fed on their yolk sac until it was completely absorbed within 2-3days before feeding the larva with artemia. Uneated feeds were siphoned to avoid water quality deterioration. Percentage hatchability was calculated according to Ayinla (1998) as follows:

Percentage hatchability = (Total number hatchlings/ Total number of fertilized eggs)* 100

Fecundity Estimation

Fecundity was calculated according to Viveen *et al*., (1985) as follows:

Fecundity (F) = Number of eggs per gram of egg mass * weight of the ovary'

Measurement of Water Quality Parameters

Water temperature, dissolved oxygen and pH were monitored every weekly to maintain the quality of water. Physicochemical parameters measured include temperature (°C), pH, dissolved oxygen (mg/l), and ammonia (mg/l). Temperature was measured using mercury in glass thermometer in °C, pH was measured with pH meter (pH Model SAEG $P^{H}S$ – 25C), dissolved oxygen was measured in mg/l using DO meter (MW600 Dissolved oxygen Milwaukee Smart DO meter) while ammonia in mg/l using ammonia test kit.

Statistical analysis

Analysis of variance (ANOVA) was used to analyze data obtained from the study for significance at P = 0.05. Version 18 of Predictive Analytical Software (PASW) was used in data analysis. Version 18.0. Analytical effect with a probability of P < 0.05) were considered significant. Means were separated using Least Significant Difference (LSD).

RESULTS AND DISCUSSION
Results

Mean fecundity and egg diameter (mm) of wild strains of female *C. gariepinus* broodstocks from Northeast Nigeria

For female *C. gariepinus* broodstock collected from Lake Alau (Borno State) as displayed in table 4, the mean total length was 48.5 ± 0.35 cm, mean body weight (956.00 ± 35.00 g), mean ovary weight (92.10 ± 2.10 g), mean fecundity (65420 ± 218.16 eggs), and mean egg diameter (1.50 ± 0.002 mm). For female *C. gariepinus* broodstock collected from Lake Maladunba (Bauchi State) as displayed in table 4, the mean total length was 46.3 ± 0.32 cm, mean body weight (944.00 ± 48.00 g), mean ovary weight (90.25 ± 2.10 g), mean fecundity (63429 ± 156.40 eggs), and mean egg diameter (1.51 ± 0.001 mm). In Lake Dadin Kowa (Gombe), female *C. gariepinus* broodstock as displayed in table 4 had a mean total length was 47.6 ± 0.43 cm, mean body weight (931.00 ± 51.00 g), mean ovary weight (89.18 ± 1.06 g), mean fecundity (62234 ± 109.25 eggs), and mean egg diameter (1.49 ± 0.002 mm). Female *C. gariepinus* broodstock collected from Lake Mayo Ranewa (Taraba State) as displayed in table 4 had a mean total length was 49.2 ± 0.41 cm, mean body weight (976.00 ±32.00 g), mean ovary weight (94.35 ± 1.65 g), mean fecundity (66208 ± 120.12 eggs), and mean egg diameter (1.52 ± 0.003 mm).

Reproductive performance of wild strains of *C. gariepinus* broodstocks from Northeast Nigeria

Results obtained showed that the number of fertilized eggs (Table 3) ranged from 71.50 ± 5.50 eggs in Group 12 (Go x Ba) to 95.50 ± 9.50 eggs in Group 10 (Ba x Ta). The number of unfertilized eggs ranged from 4.50 ± 9.50 eggs recorded for Group 10 (Ba x Ta) to 28.50 ± 5.50 eggs recorded for Group 12 (Go x Ba). Fertilization rate ranged from 71.50 ± 5.50 % recorded for Group 12 (Go x Ba) to 95.00 ± 9.50% recorded for Group 10 (Ba x Ta). Hatching rate ranged from 60.13±9.50 % recorded for Group 12 (Go x Ba) to 93.28±2.00 % recorded for Group 10 (Ba x Ta). The survival rate ranged from 62.18±4.00% in Group14 (Ta x Bo) to 88.16±2.50% in Group 10 (Ba x Ta)..

Physicochemical parameters

Mean physicochemical parameters of the incubating concrete tanks measured in this study including water temperature (ºC), pH, dissolved oxygen(mg/L) and ammonia level (mg/L) were within the recommended range for optimal growth and survival of freshwater fishes according to Boyd (1979).

Mean water temperature ranged between 27.15 ± 0.05(^{0}C) in Group 2 (Ba x Ba) to 28.90 ± 0.20(^{0}C) in Group 1 (Ba x Ba). Mean pH ranged between 7.06±0.26 in Group 10 (Ba x Ba) to 7.88±0.58 in Group 9 (Ba x Go). Mean dissolved oxygen ranged between 6.13±0.01 mg/l in Group 3 (Go x Go) to 6.65±0.15 mg/l in Group 8 (Ba x Bo). Mean ammonia ranged between 0.01 ± 0.001 mg/l in Group 4 (Ta x Ta) and Group 7 (Bo x Ta) to 0.01 ± 0.005 mg/l in Group 15 (Ta x Ba).

Table 3: Mean fecundity of wild strains of female *C. gariepinus* broodstocks from North-East Nigeria

Treatments	Total Length (cm)	Body Weight (g)	Ovary Weight (g)	Fecundity (No. of eggs)	Mean Egg Diameter (mn
Group 1 (Borno)	48.5 ± 0.35	956.00 ± 35.00	92.10± 2.10	65420 ± 218.16	1.50 ±0.002
Group 2 (Bauchi)	46.3 ± 0.32	944.00 ± 48.00	90.25 ± 1.25	63429 ± 156.40	1.51 ±0.001
Group 3 (Gombe)	47.6 ± 0.43	931.00 ± 51.00	89.18 ±1.06	62234 ± 109.25	1.49 ±0.002
Group 4 (Taraba)	49.2 ± 0.41	976.00 ± 32.00	94.35 ±1.65	66208 ± 120.12	1.52 ±0.003

Table 4. Reproductive performance of wild strains of *C. gariepinus* broodstocks from Northeast Nigeria

Groups	Total no. of eggs stripped	Number of fertilized eggs	Number of unfertilized eggs	Fertilization rate (%)	Hatching rate (%)	Survival rate (%)
Group 1 (Bo♀ x Bo♂)	100.00 ± 0.00	80.50 ± 2.50	19.50±2.50	90.50 ± 2.50	75.77±1.50	79.18±5.00
Group 2 (Ba♀ x Ba♂)	100.00 ± 0.00	87.50± 6.50	12.50±6.50	87.50± 6.50	85.71±3.50	77.00±2.50
Group 3 (Go♀ x Go♂)	100.00 ± 0.00	88.00±1.00	12.00±1.00	88.00±1.00	86.36±6.00	78.74±2.50
Group 4 (Ta♀ x Ta♂)	100.00 ± 0.00	89.00±10.00	11.00±10.00	89.00±10.00	87.64±6.00	77.59±1.00
Group 5 (Bo♀ x Ba♂)	100.00 ± 0.00	91.50±6.50	8.50±6.50	91.50±6.50	90.71±3.00	77.16±2.50
Group 6 (Bo♀ x Go♂)	100.00 ± 0.00	82.50±16.50	17.50±16.50	82.50±16.50	78.78±16.00	76.16±3.50
Group 7 (Bo♀ x Ta♂)	100.00 ± 0.00	73.50±1.50	26.50±1.50	73.50±1.50	63.94±1.00	62.55±3.50
Group 8 (Ba♀ x Bo♂)	100.00 ± 0.00	88.50±6.50	11.50±6.50	88.50±6.50	87.00±2.50	82.75±3.00
Group 9 (Ba♀ x Go♂)	100.00 ± 0.00	76.50±8.50	23.50±8.50	76.50±8.50	69.28±5.00	85.16±7.50
Group 10 (Ba♀ x Ta♂)	100.00 ± 0.00	95.50±9.50	4.50±9.50	95.50±9.50	93.28±2.00	88.16±2.50
Group 11 (Go♀ x Bo♂)	100.00 ± 0.00	88.50±4.50	11.50±4.50	88.50±4.50	87.00±0.50	80.45±3.50
Group 12 (Go♀ x Ba♂)	100.00 ± 0.00	71.50±5.50	28.50±5.50	71.50±5.50	60.13±9.50	66.52±3.00
Group 13 (Go♀ x Ta♂)	100.00 ± 0.00	76.00±5.00	24.00±5.00	76.00±5.00	68.42±8.00	65.77±1.00
Group 14 (Ta♀ x Bo♂)	100.00 ± 0.00	72.00±5.00	28.00±5.00	72.00±5.00	61.11±8.50	62.18±4.00
Group 15 (Ta♀ x Ba♂)	100.00 ± 0.00	82.50±14.50	17.50±14.50	82.50±14.50	78.78±12.50	63.46±2.50
Group 16 (Ta♀ x Go♂)	100.00 ± 0.00	87.50±9.50	12.50±9.50	87.50±9.50	85.71±17.00	79.33±5.00

Table 5: Physicochemical parameters

Groups	Temperature (^{0}C)	pH	Dissolved oxygen (mg/l)	Ammonia (mg/l)
Group 1 (Bo x Bo)	28.90±0.20	7.48±0.15	6.21±0.04	0.01 ± 0.003
Group 2 (Ba x Ba)	27.15±0.05	7.44±0.04	6.15±0.15	0.01 ± 0.002
Group 3 (Go x Go)	27.95±0.15	7.34±0.55	6.13±0.01	0.01 ± 0.002
Group 4 (Ta x Ta)	28.25±0.15	7.51±0.07	6.17±0.75	0.01 ± 0.001
Group 5 (Bo x Ba)	27.80±0.40	7.61±0.01	6.18±0.40	0.01 ± 0.002
Group 6 (Bo x Go)	28.20±0.20	7.35±0.14	6.13±0.35	0.01 ± 0.004
Group 7 (Bo x Ta)	27.75±0.35	7.55±0.07	6.06±0.65	0.01 ± 0.001
Group 8 (Ba x Bo)	27.75±0.65	7.60±0.09	6.65±0.15	0.01 ± 0.004
Group 9 (Ba x Go)	28.45±0.15	7.88±0.58	6.57±0.32	0.01 ± 0.002
Group 10 (Ba x Ta)	27.95±0.55	7.06±0.26	6.25±0.45	0.01 ± 0.003
Group 11 (Go x Bo)	27.80±0.70	7.49±0.85	6.51±0.29	0.01 ± 0.002
Group 12 (Go x Ba)	28.10±0.20	7.42±0.40	6.13±0.35	0.01 ± 0.004
Group 13 (Go x Ta)	27.10±0.00	7.54±0.80	6.20±0.01	0.01 ± 0.002
Group 14 (Ta x Bo)	28.00±0.10	7.38±0.09	6.18±0.03	0.01 ± 0.002
Group 15 (Ta x Ba)	27.65±0.25	7.51±0.11	6.15±0.01	0.01 ± 0.005
Group 16 (Ta x Go)	27.25±0.15	7.47±0.10	6.27±0.25	0.01 ± 0.004

Discussion

The findings from this study revealed that the offsprings of *Clarias gariepinus* strains from the North-East of Nigeria had significantly (*p>0.05*) highest values for fertilization, hatchability, and survival than the parent broodstocks. This artificial propagation through intraspecific reciprocal mating will facilitate the production of the superior strain of the Clariid catfish which could be attributed to improved hybrid vigor and improved adaptability, dominance, and epistasis gene effect. This is in agreement with the findings of earlier reports which indicated that hybrids in most cases were superior to the parental strains (Madu *et al*., 1993; Salami et. al., 1993), Akankali *et al*. (2011) who detailed that apart from being able to obtain quality seed, the artificial propagation technique can also be used to develop strains superior to their ancestors by the methods of selective breeding and hybridization and Tilahun *et al*., (2016) for the hybrids of female *Clarias batrachus* (Cb ♀ x Cg ♂) that achieved better than the pure batrachus in India. The performance of pure line strains may be attributed to the degree of inbreeding depression found in catfish in Nigeria.

The higher fecundity rate (66208 ± 120.12) recorded in this study is higher than that obtained by Hirpo, (2013) and Eyo *et al*., 2016 and is in line with the result recorded by Shinkafi and Ipinjolu, (2012) who reported higher fecundity in most of the larger fishes than the smaller fishes. He further stated that the lower the number of eggs in the species, the larger the size of eggs. However, Fecundity was also dependent on the size of fish and thus, the larger the fish, the higher its egg number and this may be due to more available visceral volume for holding the eggs.

The highest fertilization rates (95.50%) obtained in this study is higher than 75.49%, 77.10% and 89.8% obtained from a similar studies reported by Islam and Shah (2007), Tilahun *et al.* (2016) and Megbowon, 2013 respectively. And similar to the findings of Nguenga *et al* (2000), and Iwalewa *et al*., 2017 respectively who both reported a high fertilization rates of 95.2%. The reason for the higher fertilization rate in the crosses of pure lines can be due to differences in their population strains.

The hatching rates were higher in all genetic types (60.13 to 93.28%) compared to those obtained by (Agn'ese *et al*.,1995; Iwalewa *et al.,* 2017; Tiogu´e *et al*. 2018b) for *C. gariepinus.* while Macharia *et al* (2005) reported a rate as low as 4% for *C. gariepinus*. Similar variation between fertilization and hatching rates in hybrids and pure parental crosses were also made by various authors (Chaudhuri, 1961; Alikunhi and Chaudhuri, 1959; Tarnchalanukit, 1985; Adebayo, 2006; Morni, 2003). It is however important to acknowledge that differences that arise from breeding history, age and water quality can affect hatching rates. Variations in seasons can also lead to differences in hatching rates, as rightly observed by Shah *et al*., (2011) and Ochokwu *et al*., (2015).

Apart from the genetic factors, the non-genetic factors like the culture system and condition like water temperature, salinity, pH and alkalinity also plays a major role in the success of hybridization (Rahman *et al*. 2012). Similar suggestion was given by Ndimele and Owodeinde (2012), who described that the cross breeds tolerate more stress than the pure lines.

The survival rates of the progeny of the intergeneric crosses were similar to those of the pure breeds after rearing for 21 days. On the survival rates aspect, our results ranged (62.18 to 88.16%) are lower than the result obtained from (Nguenga *et al*. 2000; Iwalewa *et al*., 2017; Megbowon *et al*., 2013).

Meanwhile temperature, Dissolve Oxygen, pH and ammonia during the breeding process, agrees with the findings of Onyia *et al*. (2015). And the values were within the recommended range for rearing catfishes (Ayokanmi, 1999).

This research also indicates that the reproductive indices of the pure lines population is lower than that of the intra-specific reciprocal mating. The implication of the breeding potentials of Clarias geriepinus strain is that if several selective breeding of *Clarias gariepinus* from Ba ♀ x Ta ♂ (for high fertilization), Ta ♀ x Go ♂ (for high hatching) and Go ♀ x Ba ♀ (for high survival) strains are carried out reciprocally, we are likely to obtain fish seed of better reproductive potential in terms of fertilization, hatchability, survival, fecundity and better growth performance. Such intra specific hybridization will lead to improved production as a result of combination of these production traits.

The aquaculture implication of this research lies in the reliality that breeding exercises should not only focus on pure breeds catfishes but also on intra-specific mating combination with the view of accomplishing a greater survival and better growth rates of fry up to stocking stage and facilitate the production of superior strain of the Clariid catfish. This is in agreement with Akankali *et al*. (2011) who reported that apart from being able to obtain quality seed, the artificial propagation technique can also be used to develop strains superior to their ancestors by the methods of selective breeding and hybridization. There is therefore the need to explore the natural populations for genetic development through selective breeding, hybridization and gene transfer.

This result should therefore be used as baseline information that is extended to hatchery operators and growth out farms. Further improvement for the poor survival of the larvae is required to produce sufficient seed for grow-out culture to exploit the potential of the hybrids in aquaculture. Finally, application of selective breeding for the genetic improvement of this wild *C. gariepinus* from Bauchi, Taraba and Gombe is also recommended.

CONCLUSION

This study highlights the differential performance of reproductive parameters of wild *Clarias gariepinus* populations from four lakes in the North-East of Nigeria indicating better reproductive capacity of brooders from lake Maladumba and Lake Mayo Ranewo. The knowledge generated will be of use in choosing wild broodstocks of *Clarias gariepinus* with superior

reproductive traits from the North-East of Nigeria. Aquaculture production will be improved as a result of this mating combinations. Further research is needed to evaluate the growth of offspring from both the parent and the reciprocal crosses between the different strains of *C. gariepinus* in North-East Nigeria and also, there is a need to carry out protein and gene profiling of these natural populace *C. gariepinus* to identify the proteins and gene responsible for this variation in breeding performances if variations are traceable to genetic factors.

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