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Reproductive and Growth Performance of Backcross of Albino Hybrid and Parents *Clarias gariepinus*

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Abstract Backcrossing of Albino hybrid and parents *Clarias gariepinus* was conducted in the fish hatchery of Department of Fisheries, Teaching and Research farm, Modibbo Adama University of Technology Yola, Adamawa State, Nigeria, to study the reproductive and growth performance with the aim of determining the best in fertilization, hatchability, percentage survival and growth performance. Two pairs of brooders ♂NN + ♀NAlb and ♀NN + ♂NAlb were crossed. The results from the genetic cross ♂NAlb x ♀NAlb showed low performance in fertilization (75%), hatchability (61%) and survival (55%) while the highest was recorded in cross between ♂NN x ♀NN (95%, 82%, and 85%) respectively. The backcrossed ♂NAlb x ♀ NN), and reciprocal backcrossed ♂NN x ♀NAlb offspring reflected relatively intermediate fertilization (89% and 79%), hatchability (80% and 73%) and survival. (75% and 70%). However highest growth performance was recorded in backcross offspring (♂NAlb x ♀ NN) with final weight (57.100±1.5099), Weight gain (56.530±1.4430), Daily weight gain (1.009±0.0258), Length gain (4.5567±0.0173), Daily length gain (0.0814±0.0003) SGR(%/day) (3.58) and K factor (1.3) respectively. While high survival was found in parental cross (♂NN x ♀NN). It was concluded that crossing the albino hybrids gave low growth performance while backcrossing with the female parent gave good growth performance. It is therefore recommended that breeding albino should be between parents and offspring to obtain better growth performance.

Keywords: *backcross, albino hybrid, pigmented, growth, Clarias gariepinus*

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1. Introduction

Many species of fish have been tried in aquaculture. The African aquaculture has been dominated by the farming of the *Clariid* fishes of which the African sharptooth catfish (*Clarias gariepinus*) is the most popular and of great economic importance as food fish [1]. The species, *C. gariepinus* attracts good prices in Nigerian markets, due to its tasty flesh devoid of sharp bones [2]. It is hardy, exhibiting great tolerance for high stocking density even in low oxygen waters, good growth rate, efficient food conversion and excellent nutritional profile, and medicinally valuable [3].

Like many other vertebrates, the African sharptooth catfish (*C. gariepinus*), has a synonymous strain, albino *C. gariepinus* [4]. The albino has pinkish or yellowish body colouration, white belly and red eyes. There is no doubt that commercial breeding of catfish in captivity has increased the amount of Albino catfish available both in the aquarium trade and in the wild as a result of different restocking efforts. It should however be noted that Albino specimens of all catfish species including the Albino channel catfish is a natural occurring phenomena and that there has always been Albino catfish even if only a few survived to become adults. An albino specimen of any of the larger catfish species can be truly a magnificent sight, such as large albino wels catfish. Physiological and behavioural constraints hinder albino individuals [5].

Albinism is a genetic abnormality caused by an autosomal recessive gene in the homozygous state resulting in deficit melanin production [6]. According to these authors, it can also be induced artificially by exposing the eggs or brood stocks to heavy metals such as Arsenic, Cadmium, Copper, Mercury, Selenium, or Zinc. Three types of albinism have been identified namely: true (total or complete) albinism, marked by total absence of melanin, normal skin and eye pigmentation. Leucism, in which exists abnormal skin pigmentation but normal eye colour; and partial albinism recognized by restricted normal skin colour but normal eye colour [7]. While the other authors regarded leucism as partial albinism, Miller [7] classified them as distinct. There exist albino specimens of all Channel and African catfish species in the wild but the light coloration makes them easier to spot by predators and it is therefore uncommon with adult albino *C. gariepinus* or Channel catfish in the wild [4].

Albino African catfish is not common in the wild because the light coloration makes them easier to spot by

predators and it is therefore uncommon with adult albino Channel catfish in the wild [4], but occasionally could occur in artificial production of fingerlings in the hatcheries. It has therefore become necessary to multiply and evaluate the performance of available albino African catfish, *C. gariepinus.* The objectives of this study are to determine the percentage fertilization, hatchability, survival and growth performance and the ratio of albino and normal pigmented of normal-albino hybrids, (NAlb) backcrossed with the parents(NN) *C. gariepinus*.

2. Materials and Method

2.1. Study of Area

The study was conducted in the Fish Hatchery of the Department of Fisheries, Teaching and Research Farm, Modibbo Adama University of Technology, Yola, Adamawa State, Nigeria. Adamawa State is in North East part of Nigeria and occupies land size of about 36,917 Km^2. It is bordered by the States of Borno to the Northwest, Gombe to the West and Taraba to the Southwest. Its East border forms the National Boundary with Cameroon. Adamawa is a mountainous land crossed by the large river valleys Benue and Gongola. It is located on latitude 9.20 – 9.33^{o}N, longitude 12.30 – 12.50°E and an altitude of 185.9m above sea level. It has an average annual rainfall of about 759mm with maximum temperature of 39.7°C. The rainy season runs from May through October, while the dry season commences in November and ends in April. The driest months of the year are January and February when the relative humidity drops to 13% [8].

2.2. Source of Broodstock

Male and female Albino hybrids and normal pigmented brood fish each weighing approximately 2 kg were obtained from the Department of Fisheries, Teaching and Research Farm, Modibbo Adama University of Technology Yola, Adamawa State, and Ministry of Agriculture and Water Resource Dadinkowa, Gombe State, Nigeria.

2.3. Broodstock Selection

Broodstock selection for the study was based on maturity. The female broodstock were gravid with swollen, well distended soft abdomen, round and reddish vent that freely oozed out eggs upon gentle pressure on the abdomen. The matured males possessed prominent reddish-coloured pointed genital papillae [9].

2.4. Experimental Design and Hormone Administration

At 8:30pm, 2 pairs of brooders normal pigmented male and albino female (♂NN and ♀NAlb) and normal pigmented female and albino male (♀NN and ♂NAlb) were induced with Ovaprim at 0.5ml/kg female fish and 0.25ml/kg male body weight. The temperature at the time of injection was 28^{o}C. The injection was given intramuscularly above the lateral line just below the dorsal fin. The point of injection was massaged lightly with finger in order to distribute the Ovaprim evenly throughout the muscle and to prevent backflow. The injected fish were kept in a net covered plastic basins to undergo latency period.

2.5. Collection of Milt

The milt was collected by sacrificing the male fishes using dissecting kits and the gonad (testes) removed and labeled (NN and NAlb). Prior to this action physiological solution was prepared by dissolving 9 grams of common salt (NaCl) in one litre of water. Incisions was made into the creamy coloured lobes of the testes and then squeezed and rinsed out of the testes sac with the physiological solution in to a labeled plastic bowl.

2.6. Stripping of Eggs

After the latency period of about 11 hours, the stripping commenced by 7:30am. The head of the female was covered with towel and handled by two laboratory assistants. The eggs were stripped into clean dry receptacle. The stripped egg from each fish was divided into two labeled plastic bowls.

2.7. Genetic Crosses

The stripped eggs were divided into 4 labeled plastic bowls thereafter, fertilized for 3 minute using the milt collected from the male fishes. The crosses were done as follows: Normal-albino male x Normal-albino female (♂NAlb x ♀NAlb), Normal-albino male x Normal female (♂NAlb x ♀ NN), Normal male x Normal-albino female (♂NN x ♀NAlb) and Normal male x Normal female (♂NN x ♀NN). The genetic crosses serve as the treatments, each with three replicates.

Table 1. Genetic Crossing.

	♀NAlb	♀NN
♂NAlb	NNAlb	NNAlb(NN)
♂NN	NN(NNAlb)	NN

2.8. Percentage Fertilization

Fifty fertilized eggs from each genetic cross was put into petri-dishes and observed for percentage fertilization. The unfertilized eggs turned white while the fertilized eggs maintained the pinkish green colour. Percentage fertilization was calculated as follows

$$\%\ Fertilization = \frac{\text{No. of fertilized eggs}}{\text{No of incubated eggs}} \times 100.$$

2.9. Hatchability

Percentage hatchability was calculated as the number of hatched larvae against the estimated number of eggs incubated. The formula used was;

$$\%\ Hatchability = \frac{\text{No. of hatchlings}}{\text{No of fertilized eggs}} \times 100.$$

2.10. Feeding of Hatchlings

Hatchlings were fed ad-libitum daily with Artemia diet, from day four when the yolk sac was completely absorbed to a period of two weeks before artificial feed.

2.11. Fry and Fingerlings Rearing

Thereafter, twenty (20) fishes from each genetic cross was randomly selected, weighed and stocked in well labeled 25 litre plastic basin with three replicates, and fed with starter Skretting feed. As their weight increased for six weeks, the feed quantity was adjusted based on the weekly random sampling of the weight of 5 fry from each treatment and multiplied to give the total weight of the fish as well as the quantity of feed required (5% body weight).

2.12. Growth Parameters

Before stocking the hatchlings in the experimental bowls, the weights and lengths were taken and recorded to evaluate their growth performance. At the end of the rearing period the final weight (g), length (mm) and feed consumed were recorded for each treatment. Analytical balance with precision of 0.01 g was used to record bodyweight. Growth indices were estimated using the following formulae:

2.13. Weight Gain

The weight gain (WG) was calculated as the difference between the mean final weight of the fish at the end of the experiment and the mean initial weight in grams [10].

$$WG = Final\ weight\ (g) - Initial\ weight\ (g).$$

Mean daily weight gain = Final weight – Initial weight/Culture period in days.

2.14. Specific Growth Rate

$$\text{Specific growth rate} = \frac{\text{Logwf} - \text{Logwi}}{\text{Times(days)}} \times 100$$

Where
W_f: Final mean body weight (g)
W_i: Initial mean body weight (g)
T: Culture period in days.

Condition factor (K) = W × 100/ L3, Where, W=weight of fish (mg), L=Length of fish (mm).

Feed conversion ratio (FCR) = Total feed intake (mg)/ weight gain (mg)

2.15. Survival Rate

The percentage survival was determined for each treatment using the formula:

$$Survival\% = \frac{\begin{pmatrix}\text{final number of fish}\\ \text{at the end of the experiment}\end{pmatrix}}{\begin{pmatrix}\text{initial number of fish at tne}\\ \text{begining of the experiment}\end{pmatrix}} X\,100$$

3. Statistical Analysis

Data obtained from hatchability, survival, growth, ratio of albino to normally pigmented offsprings; water quality parameters, weight and length of the treated bowl and the control were subjected to statistical analysis. One way analysis of variance (one way ANOVA), was used. The difference between the means was determined using Least Significant Difference (LSD) at 95% while means were compared for significant differences ($p<0.05$).

4. Results

4.1. Fertilization, Hatchability and Survival Rates

The fertilization in hybrids was lowest: 73% for (♂NAlb x ♀NAlb), 89% for (♂NAlb x ♀NN) and 79% for (♂NN x♀ NAlb) compared to pure breed (NN x NN) 95% as indicated in Table 2. The value for (♂NN x ♀NN) was significantly different ($p<0.05$) from all other crosses. Hatchability was also recorded high, 82% in (♂NN x ♀NN) and least in cross between Albino Hybrids strain (NAlb x NAlb) (61%). Survival varied between the crosses. The fertilization percentage was significantly different ($p<0.05$) and the highest was recorded in the cross between Normal pigmented strains (NNxNN) (95%), and the least in cross between Albino Hybrids strain (NAlb x NAlb) (73%).

The percentage hatchability was also recorded high (82%) in (NNxNN) as against the cross between Albino Hybrids (NAlb x NAlb) (61%). However, there is no statistical significant difference ($p>0.05$) in hatchability between the backcrossed (♂NAlb x ♀NN) and reciprocal backcrossed (♂NN x♀ NAlb) 82% and 80% respectively, as shown in Table 1.

The survival percentage in experimental plastic bowl was low (55%) for cross between the hybrid (NAlb x NAlb) as compared to the cross between normal pigmented strain (NN x NN) (85%). The different in survival percentage between the backcrossed (♂NAlb x ♀NN) and reciprocal backcrossed (♂NN x♀ NAlb) is not significant (75% and 70%) respectively

4.2. Phenotypic Ratio of Color

The progeny resulting from backcrossing Albino hybrid with Normal pigmented was observed to be in the ratio 3:1 pigmented and albino. This is in agreement with the finding of Bridges and von Limbah [11], who in a study on inheritance of albinism in rainbow trout, produced (74.8%) fish of the wild type colour in F2 and (25.2%) with albino coloration. According to Boris (2011), the colour of skin in fish is determined by the combination of colour pigments.

Table 2. Reproductive performances of backcrossed Normal and Albino hybrids *C. gariepinus*

	NAxNA	NAxNN	NNxNA	NNxNN
%Fertilization	73^{d}	89^{b}	79^{c}	95^{a}
%Hatchability	61^{d}	80^{a}	73^{c}	82^{a}
% Survival	55^{d}	75^{b}	70^{c}	85^{a}

Means with different superscripts are significantly different ($p<0.05$).

4.3. Growth Rates

The results of the growth parameters (main final weight, Main weight gain, Specific growth rate, Main final length, Main length gain, and Condition factor) of the parental line, Normal-Albino (NA) Hybrid and Normal pigmented (NN) *C. gariepinus* and their hybrids (♂NAlb x ♀NN) and (♂NN x ♀NAlb) reared for 56 days in plastic bowl in the hatchery is presented in Table 2.

The main weight gain was (56.530±1.443g) for the backcrossed (♂NAlb x ♀NN) and (55.55±3.182g) for reciprocal backcrossed (♂NN x ♀NA) were higher than pure Normal pigmented (♂NN x ♀NN) (55.00±2.605g) and pure Hybrid crosses (♂NAlb x ♀NAlb) (53.70±00g). Likewise, the value recorded for Main final weight was higher in backcross (♂NAlb x ♀NN) (57.100±1.509) and reciprocal backcross (♂NN x ♀NAlb) (56.033±3.759) than pure Hybrid crosses (♂NAlb x ♀NAb) (54.20±0.5774g) pure Normal pigmented (♂NN x ♀NN) (55.533±2.634g). The statistical analysis showed significant different ($p<0.05$) between the backcross and the two parental line crosses indicating weight increase in hybrids.

Fishes produced from all the genetic crosses increased in length during the rearing period. The backcross (♂NAlb x ♀NN) and reciprocal backcross (♂NN x ♀NAlb) showed the higher vae than the two parental crosses (♂NAlb x ♀NAlb and ♂NN x ♀NN) for length parameter. The maximum value for the main final length (6.063±0.02mm) and main length gain (4.56±0.02mm) were recorded in backcross (♂NAlb x ♀NN) whereas minimum size for main final length (5.667±0.09mm) and main length gain (4.27±0.09mm) were observed in (♂NAlb x ♀NAlb). Statistical analysis showed no significant different ($p>0.05$) in length, between Backcross and Reciprocal backcross offspring.

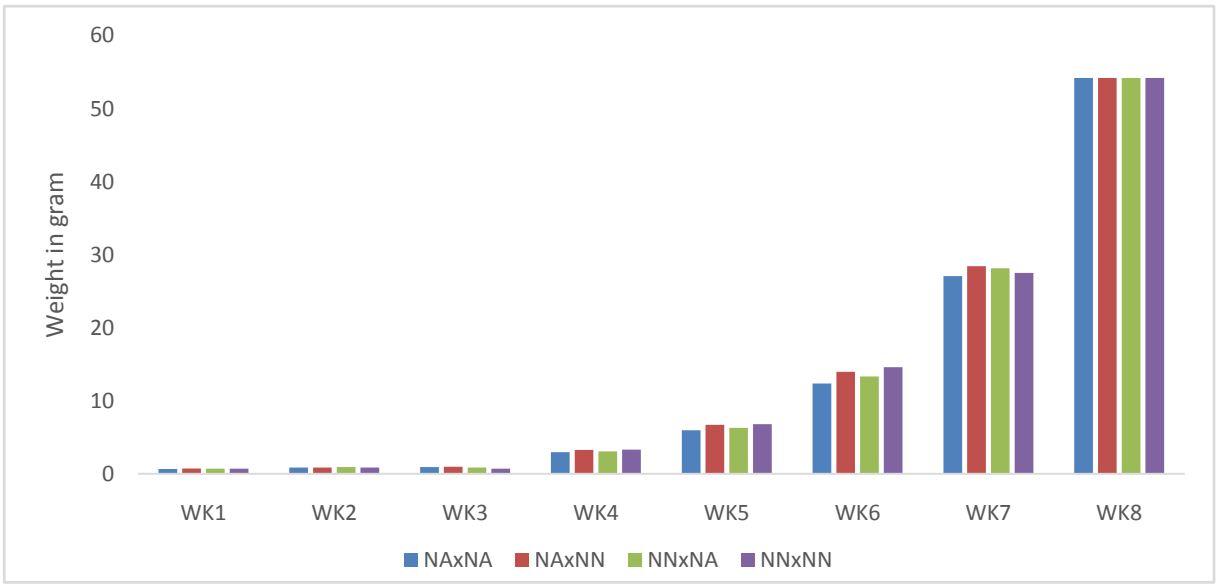

Figure 1. Growth Performance in weight of Hatchlings from Backcross of Albino Hybrid and Parent *C. gariepinus*

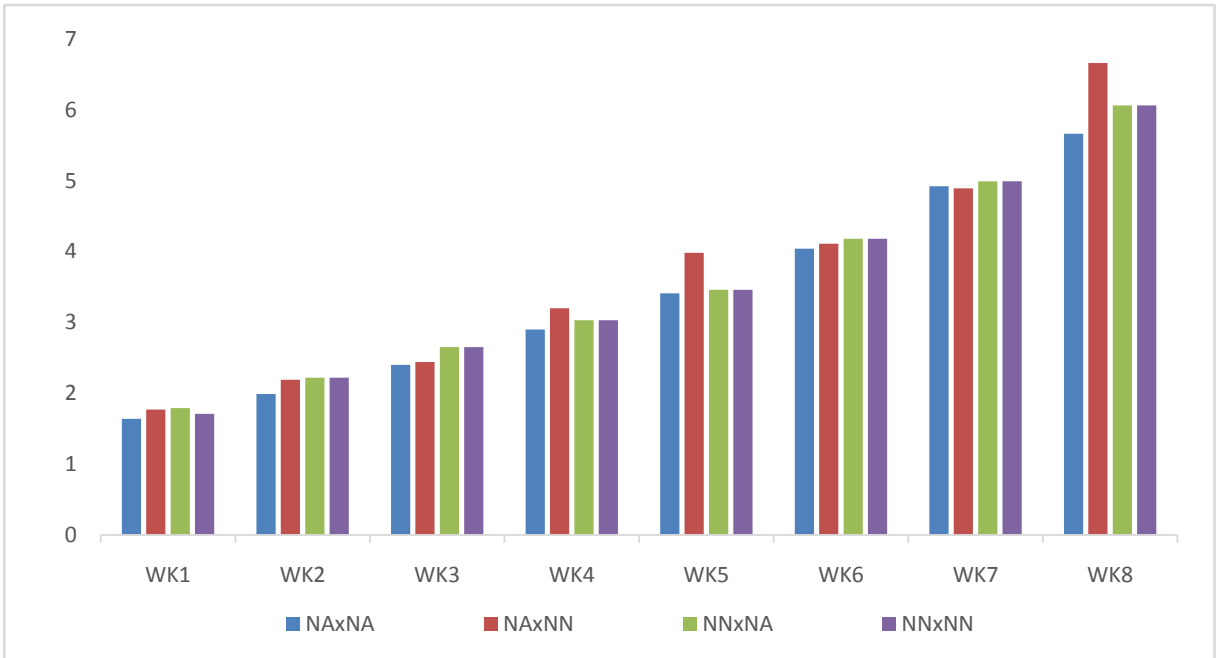

Figure 2. Growth performance in length of hatchlings of backcrossed Normal-Albino hybrids *C. gariepinus*

Table 3. Mean Growth Parameter of Hatchlings from Backcrossed Albino hybrids *C. gariepinus*

Weight gain	NAlbxNA	NAlbxNN	NNxNAlb	NNxNN
Initial weight(g)	0.50±0.05774	0.5667±0.0667	0.500±0.5774	0.533±0.0882
Final weight(g)	54.20±0.5774^{d}	57.100±1.5099^{a}	56.033±3.7596^{b}	55.533±2.634^{c}
Weight gain(g)	53.70±0.0000^{d}	56.530±1.4430^{a}	55.53±3.182^{b}	55.00±2.6052^{b}
Daily weight gain(g)	0.9589±0.000^{d}	1.009±0.0258^{a}	0.9916±0.056^{b}	0.982±0.0465^{b}
Initial length(cm)	1.4000±0.1079	1.5067±0.0291	1.5633±0.0491	1.5867±0.0296
Final length(cm)	5.667±0.2028^{d}	6.0633±0.02028^{a}	6.0633±0.1393^{a}	6.020±0.1429^{bc}
Length gain(cm)	4.267±0.095^{d}	4.5567±0.0173^{a}	4.50±0.0902^{a}	4.43±0.1133^{c}
Daily length gain(cm)	0.076±0.0002^{d}	0.0814±0.0003^{a}	0.0804±0.0002^{a}	0.0791±0.0002
SGR(%/day)	3.63^{a}	3.58^{d}	3.66^{a}	3.6^{a}
K	1.19^{d}	1.3^{a}	1.25^{a}	1.27^{a}

Means with different superscripts are significantly different ($p<0.05$).

Table 4: Mean Water Quality Parameter of Hatchlings from Backcrossed Albino hybrid *C. gariepinus*

Parameters	NAlbxNAlb	NAlbxNN	NNxNAlb	NNxNN
Temperature (°C)	30^{b}	30^{b}	30^{b}	31^{a}
Dissolve Oxygen(mg/l)	5.0^{c}	4.9^{d}	5.2^{a}	5.1^{b}
pH	7.5^{b}	7.4^{d}	7.8^{a}	7.2^{c}

Means with different superscripts is significantly different ($p<0.05$).

However, the backcrosse (♂NAlb x ♀NN) recorded greater value compare to that of its reciprocal backcross (♂NN x ♀NAlb). The main specific growth rate SGR (%/day) was also high (3.66) in (♂NN x ♀NAlb) followed (3.63) by (♂NAlb x ♀NAlb) the lowest value was recorded in (♀NAlb x ♂NN) (3.58) showing significant different compared to other crosses ($p<0.05$), while high survival was found in parental cross (♂NN x ♀NN). It is clear from the result that the backcrossed progeny performed better than the reciprocal backcrossed.

The condition factor (k-value) range from 1.19, 1.3, 1.25 and 1.27 for NAlb x NAlb, NAlb x NN, NN x NAlb and NN x NN respectively. At the end of the experiment the k-value of the 4 genetic crosses showed significant differences ($p<0.05$) and were greater than 1 due to their isometric growth pattern where weight increase more than the length. It is note-worthy to state that fish with isometric growth patterns often have k-value of greater than 1 which is in accordance with the equation ($100xW/L^{3}$) while NAlb x NN showed the highest k-value (1.3) because it displayed the highest weight gain (56.530±1.4430).

4.4. Water Quality Parameters

The water temperature, dissolved Oxygen and pH were checked every week to maintain the quality of the water. Main water temperature range was 30°C, main dissolve Oxygen ranged 5.1mg/l and main pH range 4.75 throughout the experimental period from larvae to fingerling stage and the value were within the recommended range for rearing cat fish.

5. Discussion

Many authors were successful in producing all male or all female population of fishes of different species or strains [12,13] while others also focused on improving the reproductive performances, growth and survival of fish [14,15]. This study achieved evaluation of reproductive and growth performance of backcrossing Albino Hybrid *C. gariepinus*.

The latency period and incubation time were noted 11 hours and 22 hours respectively which is in agreement with Viveen *et al.* [16]. In a similar way Onyia *et al.* [4] reported latency period of 10-12 hours for *C. gariepinus* using Ovaprim. Hatching time of hybrids was similar to that of pure cross, that agree with the report of Sahoo *at al*. [17].

Fertilization and hatching rates were found to be low in hybrid (NAlb xNAlb) compared to purebred. Although fertilization rate achieved in backcross was high (89% and 79%) for (♂NAlb x ♀NN) and reciprocal backcrossed (♂NN x♀ NAlb) respectively, it was lower than the normal pigmented crosses (NN x NN). The hatching rate also followed the same trend as fertilization rate. Similar variation between fertilization and hatching rate in hybrid and pure parental crosses were also made by various authors [18,19] recorded the least in hybrid (NAlb x NAlb).

At the end of the experiment the cross between male Hybrid (Normal-Albino) with the female parent (normal pigmented) showed highest performance in final weight gain, daily weight gain, length gain, daily length gained and condition factor. The study seems to be the first research that studied the performance of backcrossing African catfish especially of Albino Hybrid strain. The result might have been affected by heterosis (hybrid vigor) [20]. Consequently, the cross between male parent (normal pigmented and female hybrid (Normal Albino) showed lower number in term of growth parameters than the cross between male Hybrid (Normal-Albino) and female parent (normal pigmented) which may be caused by maternal effect of albinistic traits. Okumus *et al.* [21], reported that the differences in growth performance of albino and normal coloured specimen can be attributed to pigmentation and its possible pleiotropic effect. Females have stronger influence than males on the phenotypic expression of many traits of the offspring. The maternal effect may be due to mother's nuclear and extra nuclear gene and her environmental factors [22]. Ndimele *at al.* [23] reported that the reciprocal hybrid female *C. gariepinus*

cross with male *H. bidorsalis* had higher percentage in weight gain and specific growth rate than in cross between female hybrid *H. bidorsalis* and male *C. gariepinus*, the result indicated that maternal effect can be seen in the offspring. In the present result the cross between the male Hybrid (Normal-Albino) and the female parent (Normal pigment) showed higher result than the cross between male parent (Normal pigment) and female Hybrid (Normal-Albino). The results agree with the report by Rahman *et al*. [24] who found that hybrid from *C. batrachus* female crossed with *C. gariepinus* male showed better growth and survival rate than reciprocal and control offspring. Additionally, Hassan *et al*. [25] reported that hybrid of *P. hypophthalmus* male crossed with female *P. nasutusreveal* had shorter total length after hatching than the reciprocal cross. In this study, the control (NN x NN) offspring showed higher survival rate than the hybrid offspring (NAlb x NAlb), (NN x NAlb) and NAlb x NN. This may be that the fingerlings of hybrids are less aggressive compared to the most aggressive behaviour of the normal pigmented *C. gariepinus.* Moreover, the high sensitivity of the Albinos environment such as light and temperature might affect the survival rate even under hatchery condition. It was reported that, species with different levels of coloration display different levels of aggression [26] and that the level of aggression corresponds to different colour morphs [27, 28].

At the end of the experiment the k-value of the 4 genetic crosses showed significant differences ($p<0.05$) and were greater than 1 due to their isometric growth pattern where weight increased more than the length. It is note-worthy to state that fish with isometric growth patterns often have k-value of greater than 1 which is in accordance with the equation ($100xW/L^3$) while NAxNN showed the highest k-value (1.3) because it displayed the highest weight gain (56.530±1.4430). Besides, the k-value showed that fish were above average condition or higher than 1 during the experiment which indicated good health condition during the study [29].

In fish, as in other animals, the hereditary variability in body colour results from mutations of genes controlling the synthesis of pigments or the structure and distribution of pigment cells. The absence decreased or increased amount of some pigment in the skin result in changes in body colour, i.e. appearance of colour morphs. This study revealed the ratio of Albino to Normal pigmented offspring as 1:3. The colour of skin in fish is determined by the combination of colour pigments. There are several types of specialized pigment-containing cells (chromatophores) in fish skin. Each type of chromatophores contains a certain kind of pigment. Melanophores contain the black pigment melanin. Erythrophores and xanthophores accumulate red and yellow pigments, respectively. Iridophores contain crystals of colourless pigment guanine, which refracts and reflects light giving fish their typical metallic appearance [30].

6. Conclusion

Based on the result of this study, the cross breeding of Albino hybrids gave low reproductive and growth performance than pure line crosses. This might likely be due to inbreeding. However, backcrossing Albino hybrid with the female parent gave best growth performance, this may be due to heterosis. The only set back in reproductive performance, in that, fertilization and hatchability was reduced as compared to pure line crossing. It is therefore recommended that albino hybrids should crossed with normal female to produce better offspring with better performance.

References

[1] Diyaware M.Y., Haruna A.B., Abubakar, K.A. Determination of testes regeneration period for catfish (*Clarias gariepinus*) after milt collection through ablation. *Current Research Journal of Biological Sciences*, 2010, 2(6): 375-379.

[2] Oladosu G.A, Ayinla OA, Adeyemo A, Yakubu EF, Ajani AA. Comparative stud the reproductive capacity of the African catfish species, *Heterobranchus bidorsalis* (Geoffery), *Clarias gariepinus* (Burchell, 1822) and their Hybrid "Heteroclarias" *Nigerian Institute of Oceanography and Marine Research Technical Paper*, 1993; 92: 1-23.

[3] Debnath S. *Clarias batrachus*, the medicinal fish: An excellent candidate for aquaculture and employment generation. *Proceedings of the International Conference on Asia Agriculture an Animal*. Hong Kong, 2011. Available on: http://www.ipcbee. com/ vol13/7-A10002.pdf.

[4] Onyia U. L, Ochokwu I. J, Akume C. Growth and Survival of Normal Coloured and Albino *Clarias gariepinus* and their Reciprocal Hybrids. *Nigerian. Journal of Fisheries and Aquaculture*, 4(1): 22-27.

[5] Hupfeld D, and Hoffmann KP. (2006). Motion perception in rats (Rattus norvegicus sp.): deficits in albino Wistar rats compared to pigmented Long-Evans rats. *Behav Brain Res*.; 2016, 170: 29-33. pmid:16563528.

[6] Oliveira C, Foresti F. Albinism in the banded knifefish, *Gymnotus carapo*. *Tropical Fish Hobbyist.* 1996; 44(12): 92-96.

[7] Miller J. All about albinism. Available from 2010 https://mdc.mo .gov/conmag /2005 /06/all-about-albinism.

[8] C-GIDD, (Canback Global Income Distribution Database), Canback Dangel 2014. Retrieved on 29, May 2016.

[9] Olaniyi, W.A.and Omitogun, O.G. Stages in the early and larval development of the African catfish *Clarias gariepinus* (Teleostei, Clariidae) *Zygote*. 2013, 22:314-330.

[10] Jimoh, W. and Aroyehun, H.T. (2011). Evaluation of cooked and mechanically defatted sesame (*Sesamun indicum*) seed meal as a replacer for soya meal in the diet of African cat fish (*Clarias gariepiun*). *Turkish Journal of Fisheries and Aquatic Sciences*, 2011, 11:185-190.

[11] Bridges, W.R. and von Limbach, B. (1972). Inheritance of Albinism in Rainbow Trout. *Journal of Heridity* 1972, 63: 152-153.

[12] Rosenstein S. and Hulala G. Sex reversal in the genus *Oreochromis*: optimization of feminization protocol, *Aquaculture and Fisheries Management*,1994, 25: 329-339.

[13] El-zaeem S.Y. and Salam G.M. Production of genetically male Tilapia through interspecific hybridization between *Oreochromis niloticus and Oreochromis aureus. Iranian Journal of Fisheries Science* 2013, 12(4): 802-812d.

[14] Salim,M,. Shahzadi,T,. and A. Barlas. Growth performance and feed conversion ratio in Hybrid fish (Catlaq *catla* and *Labeo rohita*) feed on wheat bran, rice broken and blood meal, *Parkistan Veterinary Journal*. 2009, 29: 55-58.

[15] Onyia, L.U., B.M.B Ladu and Olufeagba S.O. Evaluation of hatchability, survival and Growth of *Clarias anguillaris. World Journal of Biotechnology*. 2010, 11(1): 1662-1667.

[16] Viveen. W.J.A., Richter C.J.J., Van Oordt, P.G., Janseen, J.A.L. and Huisman,E.A., Practical manual for the culture of African catfish (*Clarias gariepinus*).Directorate General International Cooperation of the Ministryof Foreign Affairs. The Hague, The Netherlands, 1986, 121 pp.

[17] Sahoo, S.K., Giri, S. S., Sahoo, A.K. and Ayyappan,S. Experimental Hybridization between catfish *Clarias batracus* x *Clarias gariepinus* and performance of the offspring in rearing operation. *Asian Fish. Sci.* 2003, 16:157-166.

[18] Adebayo, O.T. Reproductive performance and heterosis in reciprocal *Clarias hybrids* between *Clarias gariepinus* and *Clarias anguillaris. Journal Fish. Int.*, 2006, 6(3): 67-70.

[19] Morni, M.M. Study on Cross Breeding Between Asian and African Catfish (*Clarias macrocephalus and Clarias gariepinus*) and some aspects of the Hybrid Larvae Development and Rearing. Koleg University of Science and Technology Malaysia, Master of Science Thesis 2003, 137p.

[20] Burnside, E. B. To successfully crossbreed, it is essential to utilize breeds that is competitive and superior for individual straits. Article for crossbreeding for profit. November, 2004. Twoplus Norwegia.

[21] Okumus, I., Degirmenci, A., Bascinar, N and Celikkale, M. S. Comparative, Approximate Biochemical composition and consumer preference of Albino and Normally pigmented varieties of Rainbow Trout (*Oncorhynchus mykiss*) Turkish *Journal of Fisheries and Aquatic Science* 2011, 1: 23-2.

[22] Heath, D. D. and D.M. Blouw Are maternal effect in fish adaptive or Merely physiological Side effect? In: Maternal effect as Adaptations Mousseau, T.A. and C.W. fox (Ed.) Oxford University press, New York, 1998, 178-201pp.

[23] Ndimele, P.E., Owodeinde, F.G., Kumolu Johnson C.A., Jimoh A.A., Whenu O.O. and Onyenania O.B. Growth performance of the reciprocal hybrids of *Clarias gariepinus* (Buchell, 1822) and *Heterobranchus bidorsalis*(valenciensis 1840). *J. Biol. Sci.*, 2011, 12: 619-626.

[24] Rahman, M.A., Bhadra, A., Begun, N.,Aslam, M. S., Hussain, M.G. Production of Hybrid vigor through cross breeding between *Clarias batrachus* lin and *Clarias gariepinus* Bur., *Aquaculture* 1995, 138 (1-4): 125-130.

[25] Hassan, A., Ambak, M.A., and Samad, A.A. Crossbreeding of *Pangasianodon hypopthalmus* (Sauvage, 1878) and *Pangasius nasutusI* (Bleeker, 1863) and their larval development. *Aquaculture*. 2011, 74:1-10

[26] Pryke S.R, Griffith SC. Red dominants black: agonistic signaling among head morphs in the colour polymorphic Gouldina finch. Proceedings of the Royal Society of London Series 11/9/2017 How does agonistic behaviour differ in albino and pigmented fish? https://www.ncbi.nlm.nih. gov/pmc/articles/PMC 4841223/12/13 B. 2006; 273: 949-957.

[27] Pryke S.R. Is red an innate or learned signal of aggression and intimidation? *Animal Behaviour*. 2009; 78: 393-398.

[28] Dijkstra P.D., Hemelrijk C.K., Seehausen O, Groothius T.G.G. Colour polymorphism reduces intrasexual selection in assemblages of cichlid fish. *Behaviour Ecology*. 2009; 20: 138-144.

[29] Ayoade, A. A. Length-weight Relationship and diet of African Carp *Labeo ogunensis* (Boulenger, 1910) in Asijire lake southwestern Nigeria. *J. fish.Aquat. sci.* 2011, 6:472-478.

[30] Boris Gomelsky. Fish genetic theory and practice VMD Verlag Muller GmbH and co. KG Dubweiler landstr. 99, 66123 Saarbruken Germany. 2011, Isbn: 978-3639-2805-9.