FUDMA Journal of Sciences (FJS)
ISSN online: 2616-1370
ISSN print: 2645 - 2944
Vol. 10 No. 1, January, 2026, pp 362 – 369
DOI: https://doi.org/10.33003/fjs-2026-1001-4580

INTERACTION OF CROSSES AND STOCKING DENSITY ON BREEDING OF *Clarias Gariepinus* FROM THREE ECO-REGIONS IN NIGERIA: RIVER NIGER (N), RIVER BENUE (B) AND RIVER HADEJIA (H)

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ABSTRACT
This study determined the Interaction of crosses and stocking density on breeding of C. gariepinus from three eco-regions in Nigeria: River Niger (N), River Benue (B) and River hadejia (H). Interaction of cross and stocking density was significant ($p<0.05$) in determining the MFW of the progenies. Survival rates for progenies from the crosses irrespective of the stocking density was significantly different ($p<0.05$). The best survival rate (92.08%) was recorded for the cross ♀N×H♂ while the least (73.33%) was recorded for ♀H×H♂. The interaction of cross and stocking density shows that the highest mean breeding value for body depth was recorded from the cross ♀N×N♂ while the maximum breeding value for this trait at low stocking density was observed from the cross ♀H×H♂. The interaction of cross and stocking density indicates that at high stocking density, the highest mean breeding value occurred in the cross ♀B×N♂ while the maximum breeding value for this trait at low stocking density is shared between the cross ♀B×N♂ and its reciprocal ♀N×B♂. The production of fish in captivity necessitates the use of artificial means to propagate fish species. This ensures the continuous production of fish in the farm hence supply is guaranteed at any time. In captivity, fish may behave differently and gonadal development may be impaired or even cease completely. This brings the need for man to exercise some control over the reproductive process of captive fish. Induced maturation and coordinated spawning is a valuable tool for fish culturists.

Keywords: Fish, stocking density, breeding of *C. gariepinus*.: River Niger (N), River Benue (B), River Hadejia (H)

INTRODUCTION
The FAO (2014) reports that aquaculture production in Africa increased by 56 percent in volume and more than 100 percent in value between 2003 and 2007 attributing the growth to increasing prices for aquatic products along with the emergence and spread of small and medium enterprises, and to a significant investment in cage culture accompanied by the expansion of larger commercial ventures, some producing high-value commodities for overseas markets. However, according to the FAO (2007), the sub-Saharan Africa region is not a key player in aquaculture despite its natural potential. For instance, Nigeria being the top producer in the region produced 44,000 tonnes of catfish, tilapia and other freshwater fishes. Today, more than 1 billion people rely on fish as a source of animal protein. Fish supplies about 30% of the total protein intake for people in Asia, 20% in Africa and 10% in Latin America. In addition, two million people around the world depend on fish, either directly or indirectly for employment. Fish are also one of the most highly traded agricultural commodities with nearly 40% of fish production traded internationally (CGIAR, 2005). Natural fish populations have declined during the last several decades because of environmental degradation and over fishing. Though catches between 1950 and 1990 increased fivefold to some 100 million tons, they are now in slow decline, and as a result, prices have risen. Currently, researchers are working to determine ways to cope with increasing stock scarcity and price increases by developing methods to increase production through aquaculture and better stewardship of natural fisheries resources and the environment (CGIAR, 2005). This has resulted in an increased effort in the development of techniques for hatchery production of fish.

The Niger-Benue river system and the Chad systems are the two major hydrological systems in Nigeria and according to Goldface – Irokalibe (2008), Nigeria is divided into eight hydrological areas drained mainly by the River Niger and River Benue and their numerous minor tributaries as well as the Lake Chad and the Oguta Lake and the rivers that discharge into them.

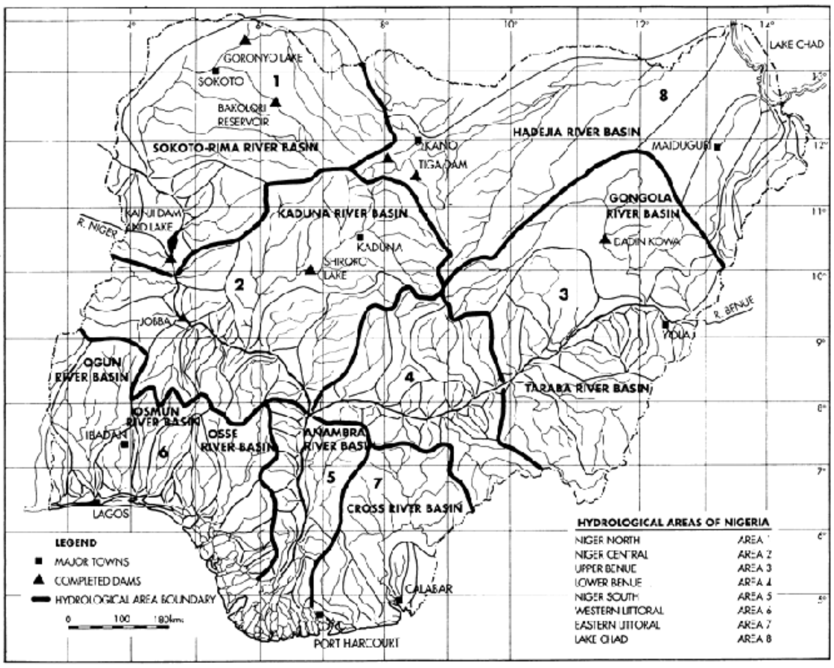


Figure 1: Hydrological Map of Nigeria (Source:Ita(1993)

The lower Niger basin enters Nigeria from Niger Republic about 162 km north of Kainji Lake. The Sokoto River joins the Niger approximately 75 km downstream of the Nigerian border and extends upstream with a broad floodplain for about 387 km (Hughes et al., 1992). There are many major tributaries including the Anambra, Sokoto, Rima, the Kaduna, the Gbako and the Gurara along the River Niger up to the confluence of the Benue at Lokoja; and the Gongola, the Taraba, the Donga, the Katsina-Ala and the Mada along the River Benue. The Hadejia-Jama'are floodplain in northern Nigeria forms where the Rivers Hadejia and Jama'are meet to form the River Yobe which flows on in the direction of Lake Chad (Thomas, 1996). In the lower Niger, 160 species have been inventoried in the Kainji Lake(Ita, 1993) among which 9 fish families are of economic importance. On the River Benue, 113 species were collected in the Mayo-kebbi (Blache et al., 1964) versus 128 in the Benue River (Stauch, 1966). Within the River Hadejia- Jama'are and their flood plains, species such as *Alestes* sp., *Clarias* sp., *Tilapia* sp. and larger predatory species like *Hydrocynusforskalii* and *Latesniloticus* are known to thrive (Thomas, 1996). Sixty fish species have been successfully identified within the floodplains of the rivers (Matthes, 1990).

The production of fish in captivity necessitates the use of artificial means to propagate fish species. This ensures the continuous production of fish in the farm hence supply is guaranteed at any time. In captivity, fish may behave differently and gonadal development may be impaired or even cease completely. This brings the need for man to exercise some control over the reproductive process of captive fish. Induced maturation and coordinated spawning is a valuable tool for fish culturists (Powell et al., 1998). Environmental and hormonal manipulation of ovulation in the fish have become of practical importance in the fish farming industry for two main reasons: (1) it is important to solve the problem of spawning asynchrony which necessitates frequent broodstock handling(Lin & Peter, 1996); (2) by accelerating or delaying gametogenesis in captive broodstock, spawning may be scheduled to yield fry whenever needed(Lam, 1983). Moreover, induced breeding makes possible hybridization between closely related species(Hayden et al., 2010; Lam, 1982; Park, Choi, et al., 1997).Artificial fertilization involves the collection of gametes from the male and female fish. To achieve this, hormones must be used to induce ovulation and spermiation. Various hormones have been used including human hormone analogues as well as fish and amphibian pituitary extracts. Doses of hormones are administered either once or twice in which case, the first dose is termed the priming dose and the second dose is called the resolving dose. The choice of hormone depends on many factors including efficacy, species, cost and availability, egg incubation or larval-rearing facilities, and training acquired by the breeder.Inducing breeding with hormones involves assessment of the maturity of breeders, as the success of the technology depends on accurate information about the state of the gonad. Gravid fish can be judged by considering the external appearance (large soft abdomen and a swollen gonad papilla). For the male fish of some species but not catfish, release of milt when abdomen is squeezed shows maturity of breeders. Nguenga et al. (2000) reported the use of more complex and time-consuming methods based on gonad biopsy and egg analysis. Success in induced spawning depends largely on knowledge of (i) the optimum dose of hormones to be used, and (ii) latency period, the time between injection of hormones and stripping of eggs. The aim of this study is to determine the Interaction of crosses and stocking density on breeding of C. gariepinus from three eco-regions in Nigeria: River Niger (N), River Benue (B) and River hadejia (H).

MATERIALS AND METHODS

Origin and Maintenance of Broodstock

This study was carried out in Makurdi, Benue State. Makurdi is located on latitude 7° 43' 55.92" N and 8° 32' 20.76" E. Makurdi town has two main seasons: the wet season usually between April and October and the dry season usually between November and March. Wild broodstock of *Clarias gariepinus* were obtained from artisanal fishermen along the River Hadejia and Jama’are (H) basin and flood plains, River Niger at Lokoja (N) and River Benue (B) at Makurdi. The mean broodstock weight was 1.001±0.02kg for females and

0.995±0.02kg for males. The breeding experiments were carried out at Korex Aquatic Farms, Makurdi

The Chemistry of Water Quality Parameters

Water obtained from a borehole was used for the hatchery and rearing experiments. The physicochemical parameters of water in the incubation tanks as well as the ponds used for rearing were analyzed as per standard methods by APHA (2005).

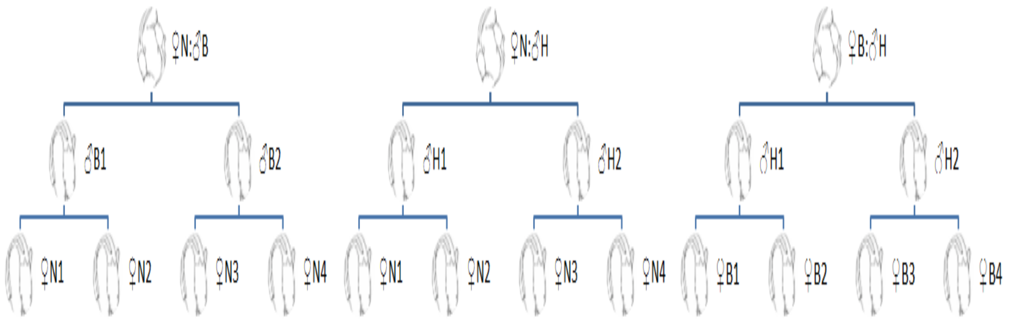
Temperature: The temperature of water in each tank was taken using mercury in glass thermometer (0-100^{0}C) every sampling morning.

Hydrogen ion concentration (pH): The pH of the water in the tanks was taken using an electronic pH meter - B. Bran Scientific pH-meter (Model pHS – 25).

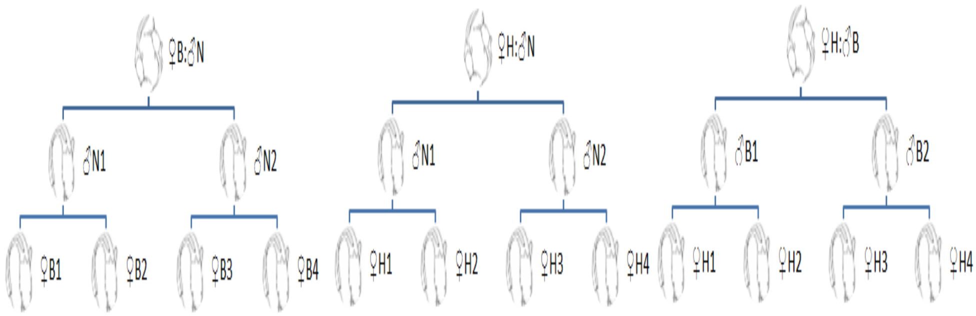
Dissolved Oxygen (DO): This was measured using Hanna Multiparameter Water Quality Probe Model HI-98129.

Experimental Design

Completely randomized design was adopted for the experiments. The Crosses served as treatment alongside tanks and hapas (replication).



F$_1$ Crosses



Reciprocal Crosses

Figure 2: Pedigree of Crosses Between three Ecotypes of *C. gariepinus*

Interaction of Crosses and Stocking Density on Breeding Values

Based on biological interpretation and relevance, individual breeding values were selected for five economic traits. The selection was based on statistical principles of the normal distribution such that the individuals were selected beginning from the first positive breeding value for traits that require positive values and the first negative breeding value for traits that require negative values or less quantity/size.

Data Analysis

Data on interaction (6 months) was analysed using two-way ANOVA. Means from ANOVA were separated using Tukey's HSD ($p<0.05$).

RESULTS AND DISCUSSION

Interaction of Crosses and Stocking Density on Breeding Values

Based on biological interpretation and relevance, individual breeding values were selected for five economic traits. The selection was based on statistical principles of the normal distribution such that the individuals were selected beginning from the first positive breeding value for traits that require positive values and the first negative breeding value for traits that require negative values or less quantity/size.There was a significant effect ($p<0.05$) of stocking density and cross on the breeding values generated with a significant interaction ($p<0.05$) also occurring between the two factors with regards to final total length of progenies from the crosses of broodstock from the three eco-regions (Table 1). Between the stocking densities, the highest breeding value of 0.69 was recorded at high density. Regardless of the stocking density there was a significant difference in positive breeding values for final total length among the crosses. The highest (positive) breeding value for final total length among the crosses was recorded for the cross ♀N×B♂ (1.9955) but the highest mean value (0.70) was recorded for the cross ♀B×B♂. The interaction of stocking density and cross (Figure 3) shows that the cross ♀N×B♂ gave the highest mean positive breeding value for final total length at high stocking density and the cross ♀N×N♂ had the least. At low stocking density, the cross ♀B×B♂ had the highest mean positive breeding value for final total length while the cross ♀B×H♂ had the least.

Table 1: Effect of Stocking Density and Cross On Breeding Values (Positive) For Final Total Length (Cm) Among Progeny of Crosses of *C. Gariepinus* Broodstock from Three Eco-Regions

Treatment	N	Mean	Minimum	Q1	Median	Q3	Maximum
Density							
High	470	$0.69{\pm}0.02^{a}$	0.2360	0.2900	0.7817	0.9154	1.9955
Low	282	$0.29{\pm}0.01^{b}$	0.0044	0.1786	0.2606	0.4053	0.8729
p-value		0.000					
Cross							
♀N×N♂	83	$0.41{\pm}0.00^{de}$	0.4018	0.4036	0.4043	0.4275	0.4275
♀B×B♂	60	$0.70{\pm}0.02^{bc}$	0.2448	0.6909	0.7825	0.7826	0.7831
♀H×H♂	74	$0.67{\pm}0.04^{ab}$	0.2606	0.2606	0.9370	0.9385	0.9400
♀N×B♂	75	$0.66{\pm}0.08^{a}$	0.0577	0.0577	0.7520	0.9976	1.9955
♀N×H♂	80	$0.57{\pm}0.01^{c}$	0.4053	0.4053	0.6658	0.6658	0.6658
♀B×N♂	70	$0.68{\pm}0.03^{ab}$	0.3314	0.3314	0.9154	0.9154	0.9154
♀B×H♂	127	$0.30{\pm}0.03^{e}$	0.0044	0.2127	0.2378	0.2385	1.2354
♀H×N♂	75	$0.69{\pm}0.02^{ab}$	0.4004	0.4004	0.8273	0.8283	0.8293
♀H×B♂	108	$0.43{\pm}0.04^{d}$	0.1786	0.1786	0.2889	0.2897	1.2866
p-value		0.000					
Interaction: Density*Cross							
p-value		0.000					

Means in the same column of treatments followed by different superscripts differ significantly (p<0.05); Interaction level of significance: p<0.05

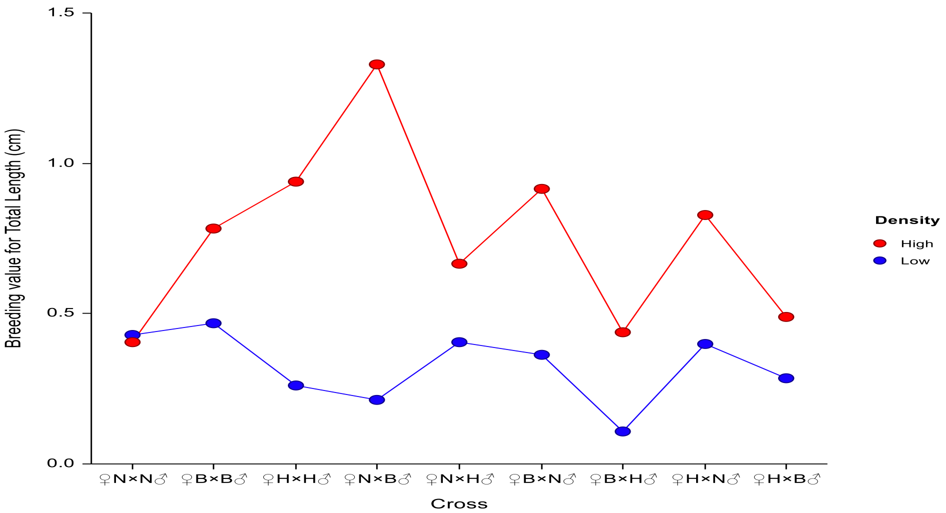


Figure 3: Interaction Plot for Effect of Cross and Stocking Density on Positive Breeding Values for Final Total Length (cm) in Progeny from Crosses of *C. gariepinus* Broodstock from Three Eco-regions

Head length is a trait that requires low values in order to make room for more flesh. To this end, only individuals with negative breeding values were analysed. There was a significant effect of stocking density (p<0.05) on this trait with the lowest mean breeding value of –0.18 being recorded for high stocking density. However, the best individual value was –0.80372 and it was observed in individuals reared at high stocking density regardless of cross. Among the crosses and without regard to stocking density, the lowest mean breeding value for the phenotype of head length was recorded in the cross ♀H×B♂ (–0.28). The least breeding value of –0.8037 occurred in the cross ♀H×B♂. There was a significant interaction (p<0.05) between stocking density and the desirable negative breeding values for head length. At high stocking density, the least breeding value for head length was observed for the cross ♀H×B♂ while at low stocking density, the least breeding value for this trait was observed in the cross ♀H×N♂ (Figure 4).

Table 2: Effect of Stocking Density and Cross On Breeding Values (Negative) For Final Head Length (Cm) Among Progeny of Crosses of *C. Gariepinus* Broodstock from Three Eco-Regions

Treatment	N	Mean	Minimum	Q1	Median	Q3	Maximum
Density							
High	443	$-0.18{\pm}0.01^{b}$	–0.80372	–0.19756	–0.13262	–0.05790	–0.00049
Low	270	$-0.08{\pm}0.00^{a}$	–0.18627	–0.11506	–0.06903	–0.03664	–0.00713
p-value		0.000					
Cross							
♀N×N♂	90	$-0.17{\pm}0.01^{d}$	–0.32828	–0.18103	–0.14954	–0.14690	–0.00713

Treatment	N	Mean	Minimum	Q1	Median	Q3	Maximum
♀B×B♂	100	–0.17±0.01^{cd}	–0.33040	–0.18848	–0.17789	–0.13460	–0.04385
♀H×H♂	75	–0.09±0.01^{a}	–0.21326	–0.07248	–0.06542	–0.04686	–0.00049
♀N×B♂	90	–0.09±0.01^{a}	–0.19530	–0.11153	–0.10074	–0.02775	–0.02775
♀N×H♂	55	–0.10±0.01^{bc}	–0.13636	–0.13262	–0.13262	–0.06515	–0.04885
♀B×N♂	87	–0.07±0.00^{ab}	–0.15343	–0.06965	–0.06965	–0.03664	–0.03664
♀B×H♂	68	–0.24±0.03^{e}	–0.51380	–0.49170	–0.09840	–0.02710	–0.02710
♀H×N♂	95	–0.15±0.02^{d}	–0.68730	–0.10660	–0.10660	–0.03910	–0.03060
♀H×B♂	53	–0.28±0.04^{f}	–0.80370	–0.78080	–0.05750	–0.05750	–0.00120
p-value		0.000					
Interaction: Density*Cross							
p-value		0.000					

Means in the same column of treatments followed by different superscripts differ significantly (p<0.05); Interaction level of significance: p<0.05

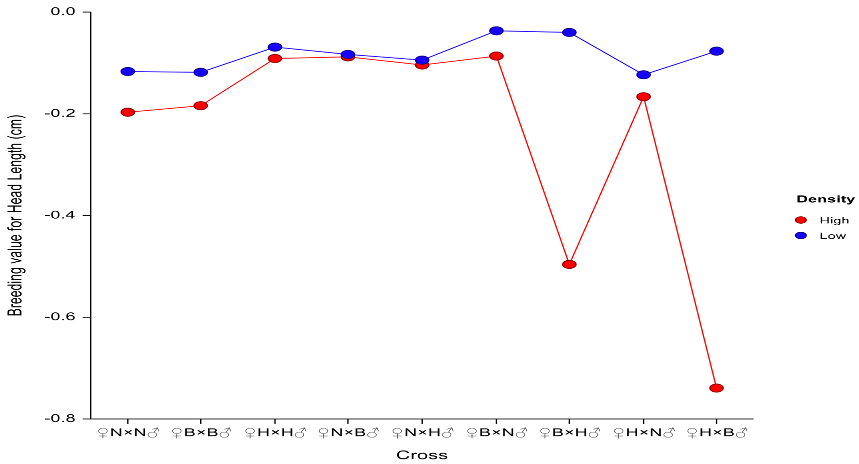


Figure 4: Interaction Plot for Effect of Cross and Stocking Density On Negative Breeding Values for Final Head Length (Cm) In Progeny from Crosses of *C. Gariepinus* Broodstock from Three Eco-Regions

The breeding values for body depth (Table 3) was significantly impacted by both stocking density and cross (p<0.05) with a significant interaction (p<0.05) between them to shape the breeding values (Figure 5). With regard to stocking density, the mean breeding value for body depth is higher at high stocking density (0.10). The maximum individual breeding value for this trait occurred under high stocking density (0.28256). Regardless of the stocking density, there was a significant difference in mean positive breeding values for the trait of body depth among the crosses. The highest mean breeding value for body depth was recorded from the cross ♀H×H♂ (0.16) and the same cross holds the individual with the maximum breeding value for this trait (0.28256). The interaction of cross and stocking density (Figure 5) shows that the highest mean breeding value for body depth was recorded from the cross ♀N×N♂ while the maximum breeding value for this trait at low stocking density was observed from the cross ♀H×H♂.

Table 3: Effect of Stocking Density and Cross On Breeding Values (Positive) For Final Body Depth (Cm) Among Progeny of Crosses of *C. Gariepinus* Broodstock from Three Eco-Regions

Treatment	N	Mean	Minimum	Q1	Median	Q3	Maximum
Density							
High	450	0.10±0.00^{a}	0.00013	0.05743	0.09097	0.11848	0.28256
Low	309	0.06±0.00^{b}	0.00872	0.02122	0.03325	0.09389	0.23421
p-value		0.000					
Cross							
♀N×N♂	97	0.12±0.01^{b}	0.03182	0.03182	0.11762	0.21350	0.21574
♀B×B♂	82	0.05±0.00^{cd}	0.02122	0.02122	0.06291	0.06344	0.10154
♀H×H♂	90	0.16±0.01^{a}	0.07356	0.08338	0.15388	0.19652	0.28256
♀N×B♂	85	0.07±0.01^{c}	0.03325	0.03325	0.05743	0.05743	0.15603
♀N×H♂	75	0.12±0.01^{b}	0.01357	0.03293	0.09389	0.23013	0.23013
♀B×N♂	110	0.06±0.00^{cd}	0.00013	0.00013	0.08061	0.09873	0.16094
♀B×H♂	112	0.05±0.00^{d}	0.01249	0.01644	0.03132	0.11405	0.11636
♀H×N♂	45	0.06±0.01^{cd}	0.01385	0.01385	0.09417	0.09417	0.09717
♀H×B♂	63	0.07±0.01^{c}	0.00872	0.00872	0.08936	0.09048	0.16937
p-value		0.000					

Interaction: Density*Cross	
p-value	0.000

Means in the same column of treatments followed by different superscripts differ significantly (p<0.05); Interaction level of significance: p<0.05

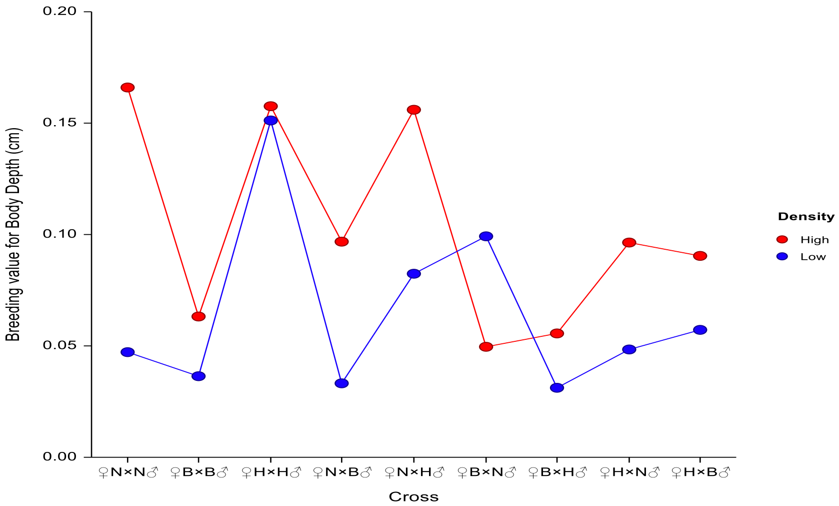


Figure 5: Interaction Plot for Effect of Cross and Stocking Density On Positive Breeding Values for Final Body Depth (Cm) In Progeny from Crosses of *C. Gariepinus* Broodstock from Three Eco-Regions

Breeding values for final weight (Table 4) was significantly influenced by the stocking density and crosses carried out (p<0.05) with a significant interaction between the stocking density and crosses in determining the breeding values. The maximum breeding value for final weight (60.811) was observed at high stocking density. Among the crosses, the individual with the best breeding value as recorded from the foregoing (60.811) comes from the cross ♀B×N♂.

The interaction of cross and stocking density (Figure 6) indicates that at high stocking density, the highest mean breeding value occurred in the cross ♀B×N♂ while the maximum breeding value for this trait at low stocking density is shared between the cross ♀B×N♂ and its reciprocal ♀N×B♂.

Table 4: Effect of Stocking Density and Cross On Breeding Values (Positive) For Final Weight (G) Among Progeny of Crosses of *C. Gariepinus* Broodstock from Three Eco-Regions

Treatment	N	Mean	Minimum	Q1	Median	Q3	Maximum
Density							
High	542	10.30 ± 0.45^{a}	0.003	2.540	6.919	14.014	60.811
Low	271	4.59 ± 0.23^{b}	0.031	1.482	3.471	7.137	16.970
p-value		0.000					
Cross							
♀N×N♂	88	4.95 ± 0.41^{d}	0.094	1.424	3.838	7.917	15.938
♀B×B♂	80	3.35 ± 0.31^{de}	0.156	1.157	2.584	5.398	12.021
♀H×H♂	92	2.62 ± 0.25^{e}	0.031	0.851	1.877	3.651	11.842
♀N×B♂	89	10.41 ± 0.81^{bc}	0.273	4.633	9.753	13.841	36.592
♀N×H♂	92	9.85 ± 0.89^{bc}	0.117	2.957	7.649	13.615	34.199
♀B×N♂	91	17.69 ± 1.42^{a}	0.630	6.820	12.94	27.15	60.810
♀B×H♂	96	11.69 ± 1.16^{b}	0.000	3.400	8.280	16.88	49.000
♀H×N♂	96	9.09 ± 0.90^{c}	0.101	2.457	5.483	13.575	42.008
♀H×B♂	89	5.02 ± 0.42^{d}	0.015	2.059	4.359	7.029	22.435
p-value		0.000					
Interaction: Density*Cross							
p-value		0.000					

Means in the same column of treatments followed by different superscripts differ significantly (p<0.05); Interaction level of significance: p<0.05

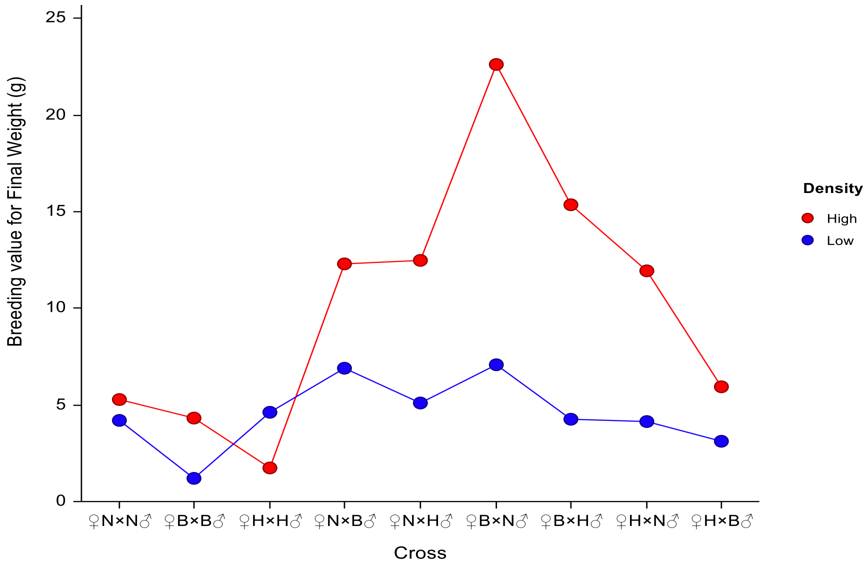


Figure 6: Interaction Plot for Effect of Cross and Stocking Density On Positive Breeding Values for Final Weight (G) In Progeny from Crosses of *C. Gariepinus* Broodstock from Three Eco-Regions

Discussion

The selection was based on statistical principles of the normal distribution such that the individuals were selected beginning from the first positive breeding value for traits that require positive values and the first negative breeding value for traits that require negative values or less quantity/size. There was a significant effect of stocking density and cross on the breeding values generated with a significant interaction also occurring between the two factors with regards to final total length of progenies from the crosses of brood stock from the three eco-regions. Between the stocking densities, the highest breeding value of 0.69 was recorded at high density. Regardless of the stocking density there was a significant difference in positive breeding values for final total length among the crosses. The highest (positive) breeding value for final total length among the crosses was recorded for the cross ♀N×B♂ (1.9955) but the highest mean value (0.70) was recorded for the cross ♀B×B♂. The interaction of stocking density and cross shows that the cross ♀N×B♂ gave the highest mean positive breeding value for final total length at high stocking density and the cross ♀N×N♂ had the least. At low stocking density, the cross ♀B×B♂ had the highest mean positive breeding value for final total length while the cross ♀B×H♂ had the least. Head length is a trait that requires low values in order to make room for more flesh. To this end, only individuals with negative breeding values were analysed. There was a significant effect of stocking density on this trait with the lowest mean breeding value of –0.18 being recorded for high stocking density. However, the best individual value was –0.80372 and it was observed in individuals reared at high stocking density regardless of cross. Among the crosses and without regard to stocking density, the lowest mean breeding value for the phenotype of head length was recorded in the cross ♀H×B♂ (–0.28). The least breeding value of –0.8037 occurred in the cross ♀H×B♂. There was a significant interaction between stocking density and the desirable negative breeding values for head length. At high stocking density, the least breeding value for head length was observed for the cross ♀H×B♂ while at low stocking density, the least breeding value for this trait was observed in the cross ♀H×N♂.

The breeding values for body depth was significantly impacted by both stocking density and cross ($p<0.05$) with a significant interaction between them to shape the breeding values (Figure 5). With regard to stocking density, the mean breeding value for body depth is higher at high stocking density (0.10). The maximum individual breeding value for this trait occurred under high stocking density (0.28256). Regardless of the stocking density, there was a significant difference in mean positive breeding values for the trait of body depth among the crosses. The highest mean breeding value for body depth was recorded from the cross ♀H×H♂ (0.16) and the same cross holds the individual with the maximum breeding value for this trait (0.28256). The interaction of cross and stocking density shows that the highest mean breeding value for body depth was recorded from the cross ♀N×N♂ while the maximum breeding value for this trait at low stocking density was observed from the cross ♀H×H♂.

CONCLUSION

Interaction of cross and stocking density was significant ($p<0.05$) in determining the MFW of the progenies. Survival rates for progenies from the crosses irrespective of the stocking density was significantly different ($p<0.05$). The best survival rate (92.08%) was recorded for the cross ♀N×H♂ while the least (73.33%) was recorded for ♀H×H♂. The interaction of cross and stocking density shows that the highest mean breeding value for body depth was recorded from the cross ♀N×N♂ while the maximum breeding value for this trait at low stocking density was observed from the cross ♀H×H♂. The interaction of cross and stocking density indicates that at high stocking density, the highest mean breeding value occurred in the cross ♀B×N♂ while the maximum breeding value for this trait at low stocking density is shared between the cross ♀B×N♂ and its reciprocal ♀N×B♂.

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