PHENOTYPIC AND GENETIC PARAMETERS FOR REPRODUCTIVE TRAITS, GROWTH AND SURVIVAL IN AFRICAN CATFISH (*CLARIAS GARIEPINUS*) UNDER CONTROLLED HATCHERY CONDITIONS

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ABSTRACT
This study presents estimates of phenotypic and genetic parameters for fertility, hatchability and weight gain, Specific growth rate and survival in African catfish (*Clarias gariepinus*) under controlled hatchery conditions for two generations. Parents of each generation were stocked and separated in ponds by sex and fed 32% protein diet. For the analysis, 2400 fully pedigreed experimental fish from G0, G1 and G2 were used. Generations were discrete and therefore parameters were estimated separately for each year. The heritability estimates for fertility (0.1) and hatchability (0.1) traits were generally low while that of weight gain, specific growth rate, survival were higher (0.3), (0.5) and (0.5) respectively. The phenotypic correlations between fertility and hatchability, fertility and survival, hatchability and survival, weight gain and specific growth rate, were 0.997, 0.830, 0.869 and 0.991, respectively. While, genetic correlations between fertility and hatchability, fertility and survival, hatchability and survival, weight gain and specific growth rate, were 0.748, 0.623, 0.651 and 0.743, respectively. Results shows that there was a positive phenotypic and genetic correlation between fertility and hatchability, fertility and survival, hatchability and survival, weight gain and specific growth rate which allowed indirect selection of these traits to improve in reproduction, growth and survival in *C. gariepinus.*

Keywords: Phenotypic correlations, Genetic correlations, Reproductive traits, Growth, Survival, *Clarias gariepinus.*

INTRODUCTION
Growth rate and survival are the major technical constraints in hatcheries and grow-out systems for catfish *Clarias gariepinus* (Rezk, 2007). Maximizing growth and viability of the fish is the ultimate target of any production system (Nguyen and Ponzoni, 2007).
Unfortunately, genetic parameters for production traits in African catfish were not found in the formal literature. Charo-Karisa *et al.,* (2005), reported phenotypic and genetic parameters for growth and survival from an experiment in which Nile tilapia had been selected for body weight during two generations in fertilized ponds with no supplementary feed. Heritabilities for body weight were between 0.4 and 0.6, and for survival between 0.03 and 0.14. In the present study, we report on the analysis of fertility, hatchability, weight gain, and specific growth rate for improved growth and survival of *C. gariepinus*. Knowledge of the correlated changes that occur in other traits due to selection for growth and survival is important for the design of an efficient genetic improvement program (Falconer and Mackay, 1996). Phenotypic and genetic correlations between traits of *C. gariepinus* reared in indoor recirculation systems and under control hatchery condition are lacking.

MATERIALS AND METHODS
General. The physical environment, the fish involved, the indoor-rearing system, the records taken, and the statistical procedures used are described by Umar, (2019).
The experiment was conducted in fish hatchery of the Department of Biology, Ahmadu Bello University, Zaria, Kaduna State, Nigeria. Fish used for this study were the grandparental population (G_0) produced in 2018, the G_1 generation produced in 2019, and G_2 generation produced in 2020. G_1 and G_2 were the first and second generations of selection respectively.
The founder population (i.e. parents of the G_0 population) was established from four different Nigerian strains namely Eleyele, Oba, Argungu and Yauri. Fifty (50) sires and hundred (100) dams, selected at random from the founder stock, were subsequently used to produce the G_0. Artificial fertilization was used, each sire was mated to two dams and each dam mated to only one sire, thus generating full and half sib groups. Incubation and hatching of eggs were carried in six (8) aerated

tanks (50cm x 35cm x 30cm) in a water circulatory system under controlled indoor hatchery conditions.
As soon as a family reached suitable tagging size, 24 randomly chosen fry from each full-sib family were individually tagged with Floy® tags and returned into the hapas until stocking.

Estimation of heritability
The narrow sense heritability which is calculated directly from selection experiments is called "realized heritability". The realized heritability relates the mean of the original random-bred population, the mean of the individuals selected to be the parents, and the mean of the next generation.

$$\text{The realized heritability } (h^2) = \frac{\text{Selection Response (SR)}}{\text{Selection Differential (SD)}}$$

Where selection differential for a given trait is the difference between the mean for the population and the individuals selected to be parents of the next generation (i.e. selected animals –original population) for that trait and selection response is the difference between the offspring mean and the original population mean or the amount by which the population mean shifted due to selection (i.e. next generation – original population).

$$\text{Selection intensity } I = \frac{\text{Selection Differential (SD)}}{\text{Phenotypic standard deviation } (\sigma_p)}$$

Standardised Selection Response = h^2 x I x σ_p
Correlated response (CR) = I x r_g x h_a x h_bx square root of σ^2
Where
CRx = Correlated response in a trait x
I = Selection intensity for a trait x
h_a = heritability of a trait x in environment a
h_b = heritability of a trait x in environment b
r_g = genetic correlation of trait x between environment a and b
σ^2 = genetic variance for trait x.

Estimation of phenotypic and genetic correlations
The phenotypic correlation (rP) between two traits (A_1, A_2) was calculated from the variance and covariance components as shown below:

$$\text{Phenotypic correlation (rP)} = \frac{\sigma A_1,\ A_2}{\sqrt{\sigma^2 A_1 * \sigma^2 A_2}}$$

Where $\boldsymbol{\sigma_{A1, A2}}$ are the variance between traits $\boldsymbol{A_1}$ and $\boldsymbol{A_2}$
$\boldsymbol{\sigma^2_{A1} * \sigma^2_{A2}}$ are covariance for traits $\boldsymbol{A_1}$ and $\boldsymbol{A_2}$, respectively

Genetic correlation (rG) was calculated from additive variance and covariance components as follows:

$$\text{Genetic correlation (rG)} = \frac{Cov\,(A_1,\ A_2)}{\sqrt{V_{A_1} * V_{A_2}}}$$

Where Cov ($\boldsymbol{A_1, A_2}$) is the additive covariance between traits $\boldsymbol{A_1}$ and $\boldsymbol{A_2}$
$\boldsymbol{V_{A1}}$ and $\boldsymbol{V_{A2}}$ are additive variance components for traits $\boldsymbol{A_1}$ and $\boldsymbol{A_2}$, respectively

RESULTS AND DISCUSSION
Results
Genetic parameters
Genetic parameters for fertility, hatchability, weight gain, specific growth rate and survival traits of African catfish *C. gariepinus* reared indoor for 56 days are shown in Table 1. The heritability for fertility (0.1) and hatchability (0.1) traits were generally low while that of weight gain, specific growth rate, survival were higher. The genetic gain for fertility, hatchability, weight gain, specific growth rate survival was 0.847, 0.822, 0.650, 0.547 and 6.365, respectively.

Table 1: Genetic parameters for fertility, hatchability, weight gain (WG), specific growth rate (SGR) and survival traits in African catfish (*C. gariepinus)* reared indoor for 56 days for G1

	Fertility (%)	Hatchability	Weight Gain	Specific Growth	Survival

		(%)	(g)	Rate (SGR)	(%)
Mean	80.533	73.773	4.151	9.735	92.693
σ_p	7.332	7.117	1.960	1.070	12.100
S.D.	8.468	8.220	2.165	1.094	12.735
I	1.155	1.555	1.105	1.022	1.052
h^2	0.100	0.100	0.300	0.500	0.500
Δ_G	0.847	0.822	0.650	0.547	6.365

Legend: σ_p, phenotypic standard deviation, SD, selection differencial, I, selection intensity, h^2 realised heritability, Δ_G, genetic gain

Phenotypic and genetic correlations

The phenotypic and genetic correlations for fertility, hatchability, weight gain, specific growth rate and survival traits of African catfish *C. gariepinus* reared indoor for 56 days are presented in Table 2. The phenotypic correlations between fertility and hatchability, fertility and survival, hatchability and survival, weight gain and specific growth rate, were 0.997, 0.830, 0.869 and 0.991, respectively. While, genetic correlations between fertility and hatchability, fertility and survival, hatchability and survival, weight gain and specific growth rate, were 0.748, 0.623, 0.651 and 0.743, respectively (Table 2).

Table 2: Phenotypic and Genetic correlations for fertility, hatchability, weight gain (WG), specific growth rate (SGR) and survival traits in African catfish *C. gariepinus* reared indoor for 56 days for G1

	Fertility (%)	Hatchability (%)	Weight Gain (g)	Specific Growth Rate (SGR)	Survival (%)
Fertility	****	+0.997	- 0.800	- 0.731	+0.830
Hatchability	+0.748	****	- 0.781	- 0.695	+0.869
Weight Gain	- 0.607	- 0.586	****	+0.991	- 0.472
SGR	- 0.549	- 0.521	+0.743	****	- 0.348
Survival	+0.623	+0.651	- 0.354	- 0.261	****

Legend: Phenotypic (above the diagonal) and genetic (below the diagonal) correlations
****, no relationship between same traits

DISCUSSION

Heritability for fertility (0.1) and hatchability (0.1) were generally low while, that for weight gain, specific growth rate, survival were higher. Results shows that there was a positive phenotypic and genetic correlation between fertility and hatchability, fertility and survival, hatchability and survival, weight gain and specific growth rate which allowed indirect selection of these traits to improve in reproduction, growth and survival in *C. gariepinus.*

When the correlated trait has a substantially higher heritability than the primary selection trait and the genetic correlation between the traits is high as in this study, indirect selection may be used (Falconer and Mackay, 1996).

CONCLUSION AND RECOMMENDATION

Our findings concluded that selection for fertility, hatchability and weight gain, Specific growth rate is good for survival and Specific growth rate respectively. Response to selections in different rearing systems was recommended.

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