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Effects of thermal treatment on growth performance and survival rate of African catfish (*Clarias Gariepinus*) in Maiduguri, Nigeria

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Abstract
Effects of thermal treatment on growth performance and survival of African catfish fries was conducted in Maiduguri. The aim was to investigate the growth and survival of African catfish fries bred using eggs exposed to different thermal treatments. Five matured male and female *Clarias gariepinus* breeders with a total weight and length ranging from 700-900g and 26-31cm were procured from commercial fish farm within Maiduguri Metropolitan and transferred to fish hatchery complex of the Department of Fisheries, University of Maiduguri. The female brooders were injected with ovaprim at a dosage of 0.5ml/kg of their body weight and kept for latency period of 11hours. Milts from the males were collected and used to fertilize the eggs collected from the females. Three grams of the fertilized eggs were collected from each group and subjected to five (5) different thermal treatments (25, 30, 35, 40 and 45). The fertilized eggs were exposed to the thermal treatment for the period of 3 minutes in each of the group. After the thermal treatment, the treated eggs were placed on hatching substrates for incubation. Hatching, death and survival rate of the fries were recorded. Fifteen fries from each treatment were collected and reared for four (4) months to ascertain their growth performance. After the four month rearing, growth indices of the fish were estimated and calculated. The result revealed better growth performance in fish produced through eggs exposed to 30 ^{0}C in term of weight gain as 403.77g. The eggs exposed to 25 and 30 ^{0}C indicated higher percentage survival (73.33%). Growth and survival of fries can be improved through exposure of fertilized eggs to thermal treatments at 25 and 30 ^{0}C.

Keywords: Thermal, growth, survival, *Clarias gariepinus*, hatchlings

1. Introduction
The African catfish otherwise known as the *Clarias gariepinus* is valuable species of fish in Nigeria. It is one of the leading aquaculture products because of its high market value, tolerance to wide range of environmental factors such as low dissolved oxygen, low temperature, low pH and other water quality parameters. Nigeria is regarded as a larger producer of the African catfish through capture fisheries [1]. The African catfish is elongated and has cylindrical body that looks like eel fish. Its body coloration was dark grey or black on the back with whitish belly. The fish was reported to have a maximum length of 1.7m and a weight of 60kg [2]. The fish can be identify by its broad and flatten head, terminal mouth with four pairs of barbels. The species was adopted with accessory breathing organs which are sometimes regarded as supplementary lungs. Spiny fins are found only on the pectoral fins and can serve as a defense mechanism. *Clarias gariepinus* are found to inhibit most African countries except Maghreb, Upper and Lower Guinea as well as Cape provinces of South Africa [3]. According to [4] it is the most widely distributed fish species in Africa. [5] its natural distribution was as far as south Orange River system in the West and the Umtamvuna River in the East of South Africa. The fish seed can be obtained through artificial propagation in lakes, rivers, ponds and other confined body of water [6]. Genetically modified fish (GMF) are fish that their genetic makeup had been changed for certain reasons. The fish could be from any of the classes such as Agnatha (jawless fish including eel), Chondrichthyes (cartilaginous fish) and Osteichthyes (bony fish such as Clarias and tilapia). The reason for their modification is to improve the organism by eliminating undesired traits replacing with other traits from good performing species. The production, sales and consumption of genetically modified fish

(salmond) was first approved in 2015 by the US Food and Drugs Administration (FDA) making it the first GMF to be approved for human consumption [7]. The fish that have been modified genetically include; salmond [8], carps [9], tilapia and clarias [10]. Thermal treatment in improving performance of fish simply refers to heat treatment in imposing triploidy by subjecting fertilized eggs to heat shock shortly after fertilisation [11]. The treatment prevents the second meiotic division, resulting in sets of chromosome being contributed by the egg cell, and one set from the sperm cell. Success in inducing triploidy depends largely on three features. That is; time of initiation, duration of the treatment (heat) and the level of the treatment (temperature of the shock). Despite the effort on improving the African catfish for aquacultural purposes through hybridization, transgenesis, monoculture, selective breeding, a lot of issues has been highlighted. The use of some of these are time wasting and tedious while others especially the use of hormone are not encouraging because of health hazard. The use of thermal treatment can be used to induced stress resistance as well as to promote growth in the fish.

2. Materials and Methods

2.1 Study area

The experiment was conducted at the teaching and research fish farm of Department of Fisheries, University of Maiduguri situated between latitude 11º 51 N and longitude 13º 051 E. Maiduguri is characterized by cold dry climate from January to March and on average, the warmest month is April. It has a mean annual rainfall of 800mm. The rainy season usually begins in June and ends in October with the relative humidity of 5-54.5% and atmospheric temperature ranging from 38-40^{0}C during the day which drops to 29-31^{0}C during the night [12].

2.3 Experimental Fish

Five matured each of male and female *Clarias gariepinus* broodsocks with a total weight and length ranging 700-900g and 26-31cm were used for the experiment. The broodstocks were procured from commercial fish farm within Maiduguri metropolitan (Garus fish farm) and transported to the hatchery unit of the Department of Fisheries, University of Maiduguri in 25L capacity Jerican half filled with fresh water. The fish were selected based on their external features for maturity, the males with reddish genital papillae and the females with rose colour uro-genital organ and distended abdomen. They were acclimating for 24 hours in 2 x 1m^2 concrete ponds and fed 35% crude protein diet at 5% of their body weight twice a day before the commencement of the experiment.

2.4 Experimental design

The female broodstocks were remove from their tanks and injected with ovaprim at a dosage of 0.5/ml of their body weight and kept separately for latency period for 11 hours. After the latency period, eggs were stripped out into a clean container separately. Males were sacrificed and milts were collected by dissecting their abdomen. The milt sacs were rinsed against blood and later squeezed onto the stripped eggs for fertilization. Three grams (3grams) of the fertilized eggs were collected in each of the group and subjected to five different thermal treatments in replicates (25, 30, 35, 40 and 45ºC) with 25ºC as the control temperature. The fertilized eggs were subjected to the thermal treatments for three minutes (3 minutes) in each of the group. The temperature was control using Vacuum flask to prevent temperature reduction during the subjection. Thermometer was used to determine the required temperature for each group. After the three minutes subjection, fertilized and unfertilized eggs were recorded before finally transferring the eggs into 25L plastic container containing 20L of water separately for incubation. After the incubation, hatching rate, death eggs and survival rate were recorded. The experiment was done in a complete randomized design manner (CRD).

2.5 Growth and survival of African catfish (*Clarias gariepinus*) fries Obtained by Thermal Treatments

After three (3) weeks of the incubation, fifteen (15) fries were collected in each of the group and stocked in a 2 x 2x 1m^3 hapa net in replicate and reared for four months out doors on commercial diets. After the four months rearing, the following growth parameters were recorded and calculated;

1. Weight gain (g) = $W_2 - W_1$, where W_2 and W_1 are the final and initial weight of fish, respectively [13].
2. Mean daily weight gain (MDWG) in gram = $W_2 - W_1 / N \times t$, Where = W_2 andW_1 are the final and initial weight of fish, respectively, n = number of fish and t = the culture period (days) [14].
3. Final length (mm) = $L_2 - L_1$, where L_2 and L_1 are the final and initial length of fish respectively [13].
4. Specific growth rate (SGR% per day) = $\log_e W_i - \log_e W_o /t \times 100$, where $\log_e W_i$= log of final weight, $\log_e W_o$= log of initial weight, $\log_e$ = logarism and t = culture period [14].
5. Feed conversion Ratio (FCR) = Dry weight of feed (g) / Weight gain of fish (g).
6. Condition factor (K) = W x100 / L^3, where W and L are the weight and length of the fish [15].
7. Percentage survival = $n_2 - n_1 / t$ 100, where n_2 and n_1 are the final and initial of the fish respectively, t= the culture period [15].

2.6 Data Analysis

Data obtained from the experiments on fertilization, hatching rate, survival and growth performance were subjected to one way analysis of variance (ANOVA). The differences between means were determined using Fisher's LSD (p = 0.05) with the aid of Statistic 8.0 as a package.

3. Results and Discussion

3.1 Effect of thermal treatments on hatchability and survival of fry

The hatchability and survival of fry exposed to different thermal treatments are presented in table 1. Number of eggs used for the experiment was higher 722.00 in eggs subjected to 30 ºC followed by eggs subjected to 40ºC as 690.00. Eggs exposed to 35 and 40 ºC presented the value of 683.33 each. The least value (654.67) of eggs used in the experiment was in 25 ºC thermal treatment. Eggs subjected to 25ºC differ significantly ($P< 0.05$) with those number of eggs exposed to 30 ºC. However, the number of eggs subjected to 25 and 30ºC did not differ statistically (P>0.05) with those number of eggs treated with 35, 40 and 45ºC. The number of eggs used for the present experiment was higher than the number of eggs used by Bukar [16] as 204.00 when worked on the effects of different water quantity on hatchability and survival of African catfish. The difference in the number of eggs used could be due to the differences in size of the broodstocks used. The number of fertilized eggs was revealed to be higher

(308.33) in eggs exposed to 30 ºC thermal treatment followed by those eggs subjected to 40 ºC thermal treatment (249.33). The values of 238.33, 227.67 and 210.00 were found to be in eggs exposed to 35, 25, and 45 ^{0}C. Eggs exposed to 25 and 35 ºC differ statistically (P<0.05) with each other but did not differ statistically (P>0.05) with treatment 3 and 4 (35 and 40 ºC thermal treatments). Treatment 1 (25 ºC thermal treatment) did not differ (P>0.05) with treatment 5 (45 ºC thermal treatment). Number of fertilized eggs (308.33) obtained from the present work was higher than the finding of Kareem *et al*. [17] who presented the mean fertilized eggs of 91.84 in his work on the effects of different fertilization and eggs de-adhesion methods on hatching and survival of fry for the period of 60 days. Number of death eggs found in this research was higher (473.33) in eggs exposed to 45 ºC thermal treatment while the values of 445.00 and 440.67 were seen in the eggs exposed to 35 and 40 ºC thermal treatment. The least value was observed in eggs exposed to 30 ºC thermal treatment. There was no statistical variations (P>0.05) seen throughout the entire treatments. The number of death eggs recorded in this research is similar to the result documented by Bukar [16]. The hatching rate observed from this study was better (185.33) in eggs subjected to 35 ºC thermal treatment followed by treatment 5, 4, 1 and 2 (45, 40, 25, and 30ºC thermal treatment) with the values of (166.67, 164.33, 135.67 and 120.00) respectively. Eggs exposed to 35 ºC thermal treatment differ (P< 0.05) with those eggs subjected to 25 and 30 ºC thermal treatment. However, the eggs exposed to 35 ºC did not differ statistically (P>0.05) with those eggs subjected to 40 and 45 ºC thermal treatment. Eggs exposed to 45 ºC also differ statistically (P<0.05) with eggs treated with 25 and 30ºC thermal treatment but did not differ with the eggs used in 40ºC thermal treatment. The hatching rates of fry secured from this study (185.33) was higher than the number of hatchling documented by Tsadu *et al*. [18] as 30.33 after working on the effect of MS (methylated spirit) as a disinfection and anti sticking agent on hatchability of eggs and survival of hatchlings. The higher value of hatchlings recorded in this work may be attributed to the experimental materials used. The survival rate of the hatchlings was revealed to be higher (106.00) in eggs subjected to 25 ºC thermal treatment, while eggs exposed to 35 ºC shows the value of 103.33. Eggs used in 30 and 40ºC show the values of 95.33 and 52.00 respectively. The lower value of survival of the hatching was reported in eggs treated in 45 ºC thermal treatment. Eggs treated in 20, 30 and 35 ºC shows no any statistical variation (P>0.05) but they differ greatly (P< 0.05) with those eggs exposed to 40 and 45 ºC. However, the eggs treated 40 and 45 ºC did not differ statistically (P>0.05) among themselves. The survival of the fries in the current work was higher than the survival rate laid down by Alain *et al*. [19] as 74.4 after working on the growth performance and survival of larvae fed with varying inclusion of beef brain meal.

Table 1: Effect of thermal treatments on hatchability and survival of fry

	Treatments					
Parameters	**25ºC**	**30ºC**	**35ºC**	**40ºC**	**45ºC**	**SEM**
No of eggs used	654.67^{b}	722.00^{a}	683.33^{ab}	690.00^{ab}	683.33^{ab}	30.21*
No of fertilized eggs	227.67^{b}	308.33^{a}	238.33^{ab}	249.33^{ab}	210.00^{b}	34.50*
No of death eggs	427.00a	413.67^{a}	445.00^{a}	440.67^{a}	473.33^{a}	39.87^{ns}
Hatching rate	135.67^{c}	120.00^{c}	185.33^{a}	164.33^{abc}	166.67^{ab}	20.94*
Survival rate fry	106.00^{a}	95.33^{a}	103.33^{a}	52.00^{b}	35.67^{b}	9.14*
Death rate of fry	29.67^{b}	24.67^{b}	82.00^{b}	112.33^{a}	97.67^{a}	30.28*

Means within the same row having similar superscripts are not significantly different (P>0.005)

3.2 Growth Performance of Fry Exposed to Thermal Treatments

The growth performance of *Clarias gariepinus* fingerlings exposed to different thermal treatments were presented in table 2. Weight gain was higher (403.77g) in eggs exposed to 30 ºC followed by those fingerlings obtained using eggs exposed to 35 ^{0}C as 373.50g. Fingerlings obtained using eggs exposed to 25 and 40 ^{0}C thermal treatments show the values of 290.40 and 211.33g. The least value of the weight gain was in fingerlings secured using eggs introduced to 45 ^{0}C thermal treatment as 164.33g. No statistical variation (P>0.05) were seen throughout entire treatments. The weight gain value obtained in the present experiment was higher than the result of Ndirmbita [20] that got 0.56g after treating *Oreochromis niloticus* at ratio 1:1 feed/testes for sex reversal. The variation in the weight gain could be attributed to the effect of thermal treatment which has influence on the growth. The final weight of the fingerlings acquired using eggs exposed to 30 ^{0}C thermal treatments indicates better results as 441.60g, fingerlings gained using eggs introduced to 35, 25 and 40 ^{0}C presented the values of 414.63, 323.30 and 246.13g respectively. Least value was presented in fingerlings bred using eggs exposed to 45 ^{0}C as 210.33g. No statistical variations was presented (P>0.05) throughout the entire treatments. The final weight of the fries obtained (441.60g) was lower than the value reported by Mohammed *et al*. [21]. The differences could be due to the thermal treatment and feeding periods. Final length value of 91.17cm was revealed to be higher in fingerlings acquired using eggs introduced to 35 ^{0}C. Treatment 1, 3, 4 and 5 presented the final length values of, 85.33, 74.60 63.60 and 35.73cm respectively. Fingerlings bred using eggs subjected to 25, 30, 35 and 40 show no statistical variation (P>0.05) but treatment 1 and 2 (25 and 30 ^{0}C thermal treatment) differ (P<0.05) with treatment 5 (45 ^{0}C thermal treatment). However, treatment 5 show no any statistical variation (P>0.05) with the fingerlings secured using eggs exposed to 40 ^{0}C thermal treatment. The final length gotten from this work was higher than the final length presented by Idowu and Afolayan [22]. Feed conversion ratio (FCR) revealed in this study was higher (4.29) in fingerlings acquired using eggs treated with 45 ^{0}C thermal treatment followed by fingerlings bred using eggs introduced to 40, 25 and 35 ^{0}C thermal treatments as 3.73, 2.43 and 2.22 respectively. The least value was 2.08 in fingerlings exposed to 30 ^{0}C thermal treatment. No statistical variation (P>0.05) was observed throughout the entire treatments. Specific growth rate of the fingerlings obtained using eggs introduced to 35 ^{0}C thermal treatment show higher value of 2.85g while treatment 2, 1 and 4 show the values of 2.81, 2.75 and 2.62g respectively. Least value was presented in fingerlings gained using eggs placed in 45 ^{0}C (2.56g) thermal treatment. There was no statistical variation (P>0.05) in all the treatment.

Specific growth rate of the fries obtained was higher (3.88g) than the value reported by Olvera *et al*. [23] who reported the specific growth rate of 1.75g when fed diet with different level of crude protein to *Clarias gariepinus*. The percentage survival of the fingerlings secured using eggs treated with 25 and 30 ^{0}C thermal treatment revealed the higher value with each having 73.33% followed by fingerlings bred using eggs exposed to 35 ^{0}C as 60.00%. The value of 53.33% was obtained in fingerlings exposed to 40 ^{0}C while the least value was presented in fingerlings bred using 45 ^{0}C as 26.67%. Treatment 1, 2, 3 and 4 show no statistical variation (P>0.05) between them. However, treatment 1, 2 and 3 differ statistically (P<0.05) with treatment 5. Subsequently, treatment 4 and 5 did not differ greatly (P>0.05) among themselves. The survival rate of the fries obtained from this study (73.33%) was lower when compared with the work of Koumi *et al*. [24] who revealed the percentage survival of 76.00% when worked on fish fed diet containing soy bean at different level. Condition factor of the fingerlings obtained from the eggs exposed to 30 ^{0}C revealed higher value of 0.53 while treatments 3, 1, 4 and 5 reveals the values in a sequence of 0.50, 0.39, 0.30 and 0.25 respectively. No statistical variation was observed throughout the treatments. Condition factor secured from this work (0.53) was lower than the condition factor value produced by Soliman *et al*. [25] as 3.35 for *Clarias gariepinus*. The difference in the condition factor could be due to the stocking density of the fry during the experiment.

Table 2: Effect of thermal treatments on growth performance of African catfish fry

Parameters	Treatments					
	25 ºC	**30 ºC**	**35 ºC**	**40 ºC**	**45 ºC**	**SEM**
IW(g)	32.90^a	37.83^{bc}	40.97^{ab}	34.80^{bc}	46.00^a	2.91*
IL (cm)	32.20^c	37.20^{ab}	38.90^{ab}	36.50^b	39.83^a	1.48*
FW (g)	323.30^a	441.60^a	414.63^a	246.13^a	210.33^a	127.92^{ns}
FL (cm)	85.33^a	91.17^a	74.60^{ab}	63.60^{ab}	35.73^b	18.93^{ns}
WG (g)	290.40^a	403.77^a	373.50^a	211.33^a	164.33^a	127.02^{ns}
FCR	2.43^a	2.08^a	2.22^a	3.73^a	4.29^a	1.01^{ns}
MDWG (g)	0.87^a	1.19^a	1.27^a	0.75^a	1.57^a	0.42^{ns}
SGR (g)	2.75^a	2.81^a	2.85^a	2.62^a	2.56^a	0.20^{ns}
SURVIVAL (%)	73.33^a	73.33^a	60.00^a	53.33^{ab}	26.67^b	13.33*
CF	0.39^a	0.53^a	0.50^a	0.30^a	0.25^a	0.15^{ns}

Means within the same row having the same superscript are not significantly different (P>0.005)

Key: IW = Initial weight, IL= Initial Length, FW=Final Weight, FL=Final Length, WG=Weight Gain, FCR: Feed Conversion Ratio, MDWG= Mean Daily Weight Gain, SGR = Specific Growth Rate, Survival (%) = Percentage Survival, CF= Condition Factor.

4. Conclusion

It was concluded that thermal treatment has effect on the hatchability and growth of fry bred using eggs exposed to thermal treatment. The survival of the fry obtained from eggs exposed to thermal treatment at 40 ^{0}C was less which signifies that, thermal treatment at higher level can affect the survival of the fries.

5. Recommendation

It is recommended that fish eggs should be expose to thermal treatment in order to produce fast growing and higher percentage survival fish for profitable farming. Further studies should be carried out on the thermal treatment on other species such as Tilapia and Heterobranchus, so as to know the effect of thermal treatment on their growth.

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