Global Journal of Fisheries Science
Volume 6(4), pages 112-118, October 2024
Article Number: 7738760C4
ISSN: 2782-750X
https://doi.org/10.31248/GJFS2024.063
https://integrityresjournals.org/journal/GJFS

Full Length Research

Fecundity studies on *Clarias gariepinus* and *Heterobranchus longifilis* parent stocks

Robert, E. A.[1]*, Yisa, A.T.[2], Tsadu, S. M.[2] and Olayimika, S. A.[2]

[1]National Institute for Freshwater Fisheries Research (NIFFR), P.M.B 6006, New Bussa, Niger State, Nigeria.
[2]Federal University of Technology (FUTMINNA), P.M.B 65, Minna, Niger State, Nigeria.

*Corresponding author. Email: ememrobert@gmail.com; Tel: +234 8051251464.

Received 13th October 2024; Accepted 29th October 2024

ABSTRACT: Thirty-two (32) male and female parent stocks (eight males and eight females for *Clarias gariepinus;* eight males and eight females for *Heterobranchus longifilis*), were selected for induced breeding and fecundity studies from the Fish Breeding and Culture Program of the National Institute for Freshwater Fisheries Research, New Bussa. Fish weights ranged from 400 to 1800g. Percentage fertility, reported a higher percentage for *Heterobranchus longifilis* with 67.75%; and for *Clarias gariepinus* 66.68%. Percentage hatching values were also higher in *Heterobranchus longifilis* with 91.40%, than in *Clarias gariepinus* with reported values of 83.25%. Fecundity values in *Clarias gariepinus* were, however, higher with 433,720 eggs in this study. *Heterobranchus longifilis* reported lower fecundity values of 187,166 eggs. The Mean Gonadosomatic Index for *Clarias gariepinus* and *Heterobranchus longifilis* brood parent stocks reported the values 13.1±0.21 and 11.2±0.21, respectively. Hepatosomatic Index for *Clarias gariepinus* and *Heterobranchus longifilis*, also reported the values 1.69±0.01 and 1.45±0.02, respectively. This study purposed to add to knowledge on hatchability, survival rate and fecundity studies on *Clarias gariepinus* and *Heterobranchus longifilis* parent stocks and serve as a baseline for further research.

Keywords: *Clarias gariepinus,* fecundity, *Heterobranchus longifilis*, gonadosomatic index, hepatosomatic index.

INTRODUCTION

Fecundity refers to the number of eggs released from the ovary of a female fish. The eggs released are counted using a Geiger muller counter or by manual estimation (Opiyo *et al.,* 2017). The African walking mud catfish *Clarias gariepinus*, is the most successful culturable species in Nigeria. Culturing *Clarias gariepinus* from its early life stages (fry and post-fry) is very essential as these stages are critical to production. High mortality is usually the challenge for every fish farmer at these mentioned stages (Nwipie *et al.,* 2015). Productive aquaculture is hinged on adequate supply and management of fish seed to stock rearing tanks or enclosures. Therefore, it can be deduced that appropriate management practices are crucial to confront and tackle mortality challenges (Nwipie *et al.,* 2015). The Catfish *Heterobranchus longifilis* is regarded as one of the most suitable species for aquaculture in the region of West Africa. This species can attain a mean daily growth rate of 2.8g per day (growth per day) if conditions are favourable. Omnivorous feeding habits, a good acceptance of commercial feeding pelleted diets, resistance to diseases and pollutions of any kind and the ability to withstand poor water quality conditions make *Heterobranchus longifilis* marketable to consumers and fish farmers alike. The seeming challenge with this species of catfish is the high mortality rate due to cannibalism and predation during the early life stages in rearing systems (Ovie *et al.,* 2014). For optimal productivity, ease of fish losses, the growth and survival of *Clarias gariepinus* and *Heterobranchus longifilis,* proper stocking density and excellent management practices should be cultivated

(Nwipie *et al.,* 2015).

Fecundity researches serve to enlighten all aquaculture stakeholders about its importance in fishery resource management and stock size assessment (Robert *et al.,* 2024a). This study aimed to add to previously existing knowledge on fecundity, gonadosomatic index and hepatosomatic index research on *Clarias gariepinus* and *Heterobranchus longifilis*, while acting as a baseline source of information for future research.

MATERIALS AND METHODS

Study area, source of experimental fish and water source

The study was carried out using the outdoor concrete tanks of the National Institute for Freshwater Fisheries Research (NIFFR), New Bussa, Niger state. New Bussa is located at 9°53′N 4°31′E coordinates (NIFFR Archives, 2023). Broodstocks were obtained from the Fish Breeding and Culture unit of NIFFR, New Bussa. NIFFR's Kigera Dam supplied water for this research.

Experimental procedure, fish selection

Selected female parent stocks of *Clarias gariepinus a*nd *Heterobranchus longifilis w*ere weighed one by one as seen in Table 1. The weights were recorded in grams. The quantity of ovaprim used was in accordance with the weights of the female *Clarias gariepinus a*nd *Heterobranchus longifilis* parent stocks following the recommended dosage of 0.5ml per Kg of female fish. This value was in agreement with Oguntuase and Adebayo (2014). Matured female fish were collected, and the fish were taken to the laboratory and stored in vats or holding receptacles with water, to acclimatize them without feeding them. After eight to nine hours, fish were injected with 0.5 ml of hormone (ovaprim), returned to the vats and brought out in 12 hours (Sahoo *et al.,* 2014; Olumuyiwa and Olatunde, 2021). Fish injection was carried out intraperitoneally and each fish was massaged gently with a finger to enhance the even distribution of the hormone into the fish muscle. Fish weights ranged from 400 to 1800 g. Female fish were ready for stripping in twelve hours also known as the latency period; and some had eggs oozing out from their genital opening even before pressure was applied. The abdomen of the females was pressed and the eggs were poured onto a transparent slide (Yisa *et al.,* 2014; Opiyo *et al.,* 2017; Olumuyiwa and Olatunde, 2021). Eggs were seen using a microscope and counted using a counter or manually by hand; which was very cumbersome (Opiyo *et al.,* 2017). In calculating gonadosomatic index, live, healthy and ripe male and female fish were collected. The total length and body weight of the fish were recorded. Male and female fish were dissected. The ripe ovaries and testes were taken out. Care was taken to get the ovaries and testes out in good form. The weight of the ovaries and the testes was obtained by weighing using a sensitive weighing balance, and the Gonadosomatic Index (GSI) value of the specimen was recorded (Jan and Ahmed, 2016). Hepatosomatic Index (HSI) was calculated by determining the weight of the hepatopancreas as a percentage of the total live weight of the fish (Jan and Ahmed, 2016). Male and female fish samples were obtained and cleaned with a dry towel. Then, their body weights were recorded. After weighing, male and female fish were dissected to remove the liver. Then, the weight of the liver was also weighed (Irawan *et al.*, 2023).

Calculations

The fecundity of fish was monitored using the formula below:

$\text{Fecundity} = \frac{\text{Ovary weight x number of eggs in the subsample}}{\text{Sub sample weight}}$ (Jan and Ahmed, 2016; Hasan *et al.,* 2020).

$\text{\% Fertility} = \frac{\text{Number of fertilized eggs}}{\text{Total Number of eggs counted or estimated}}\ x\ 100$ (Oyebola and Awodiran, 2015; Esa *et al.,* 2023 and Robert *et al.,* 2024b).

$\text{Percentage hatching} = \frac{\text{Number of hatched eggs}}{\text{Total Number of fertilized eggs}}\ x\ 100$ (Oguntuase and Adebayo, 2014; Esa *et al.,* 2023; Robert *et al.,* 2024b).

Survival Rate (SR) = number of fish stocked – number of mortalities (Okomoda *et al.,* 2017).

$\text{\% Survival} = \frac{\text{No.of survivors at the end of study}}{\text{No.of fry stocked at the beginning of the study}}\ x\ 100$ (Okomoda *et al.,* 2017).

$\text{Gonadosomatic Index (GSI)} = \frac{\text{GW}}{\text{BW}}\ x\ 100$ (Jan and Ahmed, 2016)

Where: and BW refers to the body weight of the fishes.

$\text{Hepatosomatic Index (HIS)} = \frac{\text{LW}}{\text{BW}}\ x\ 100$ (Jan and Ahmed, 2016)

Where: GW = Gonad weight, LW = Liver weight, and BW = Body weight of the fishes.

Data analyses

Data from this experiment was computed using Microsoft excel (23 version) and exported to SPSS (statistical

Table 1. Parent stocks of *Clarias gariepinus and* *Heterobranchus longifilis* used for induced breeding.

Sex	Species	Weight (g)	Dosage (ml)
Female	*Clarias gariepinus*	1800	0.9
Female	*Clarias gariepinus*	1400	0.7
Female	*Clarias gariepinus*	1200	0.6
Female	*Clarias gariepinus*	1200	0.6
Female	*Clarias gariepinus*	700	0.35
Female	*Clarias gariepinus*	600	0.3
Female	*Clarias gariepinus*	600	0.3
Female	*Clarias gariepinus*	600	0.3
Female	*Heterobranchus longifilis*	500	0.5
Female	*Heterobranchus longifilis*	600	0.3
Female	*Heterobranchus longifilis*	500	0.25
Female	*Heterobranchus longifilis*	400	0.4
Female	*Heterobranchus longifilis*	800	0.3
Female	*Heterobranchus longifilis*	600	0.25
Female	*Heterobranchus longifilis*	400	0.2
Female	*Heterobranchus longifilis*	300	0.15

package for social sciences) version 2020 for statistical analysis.

RESULTS AND DISCUSSION

Percentage fertility, as shown in Table 2, reported a higher percentage for *Heterobranchus longifilis* with 67.75%; than *Clarias gariepinus* with 66.68%. Percentage hatching values were also higher in *Heterobranchus longifilis* with 91.40%, than in *Clarias gariepinus* with reported values of 83.25%. Fecundity values in *Clarias gariepinus* were higher with 433,720 eggs in this study while *Heterobranchus longifilis* reported lower fecundity values of 187,166 eggs.

Fertilization rate values in this study were not in agreement with a previous study carried out by Ataguba and Angela (2023) whose study on hybridization and growth performance of progeny from crosses between *Clarias gariepinus a*nd *Heterobranchus sp.* revealed fertilization rates of 80-90%. Lower fertilization rates could be a result of physical injury during the point of mixing with the milt. Furthermore, fish eggs that did not mix well with the milt, and then had water mixed therein tend to die faster. This is a result of the glycoprotein outer layer of the egg hydrating and causing an influx of water into the eggs due to an occurrence known as osmotic pressure (Rizzo and Bazzoli, 2020).

Hatching rates in this study were higher than the hatching rates obtained in a previous study by Tiogue *et al.* (2018) whose study revealed lower hatching rates of 68.07 to 72.82% in their study on reproductive performances of African Catfish (*Clarias gariepinus)* according to the type of hormones and substrates in recycled water in southern Cameroun. Lower hatching rates were also reported for *Clarias jaensis* in the range of 1.10 to 19.38%, where these species were induced with hCG (Human chorionic gonadotropin) and homoplastic pituitary extract (Zango *et al.,* 2016). Lower hatching rates are attributed to temperature differences, hormone differences and species differences (Ataguba and Angela, 2024).

Fecundity values were higher in *Clarias gariepinus* than there were in *Heterobranchus longifilis* parent stocks in this study as seen in Table 2. However, Hasan *et al.* (2020) reported the fecundity of *Clupisoma garua* in Bangladesh as ranging from 6,159 to 22,166 eggs. These values did not agree with the values reported in this study as the values in this study were higher for *Clarias gariepinus* with 433,720 eggs; followed by *Heterobranchus longifilis* with 187,166 eggs. There is a relationship between fecundity, total length, body weight and ovary weight. A previous study by Borthakur (2018) reported an increase in the number of eggs as being synonymous with an increase in total length, body weight and ovary weight. Robert *et al.* (2024a) in an earlier study reported fecundity results for *C. gariepinus a*s ranging from 7,000 to 34,000, and fecundity results for *H.longifilis* as ranging from 3,500 to 28,000. Lower fecundity rates in their study were attributed to the decrease of sGnRHa, which is essential for enhancing egg production in catfishes. Robert *et al.* (2024a) also opined that fecundity successes are achieved when fishes are given doses of 0.5 to 0.8ml/kg.

Ovary and testes weights of *Clarias gariepinus* parent stocks revealed non-significant differences ($p>0.05$) in

Table 2. Percentage fertility, hatching, fecundity studies of parent stocks of *Clarias gariepinus* and *Heterobranchus longifilis*.

Species	Percentage fertility (%)	Percentage hatching (%)	Fecundity
Clarias gariepinus	66.68 ±0.50	83.25±0.60	433,720 ±7.07
Heterobranchus longifilis	67.75±0.62	91.40±1.15	187,166 ±10.81

Table 3. Ovary and testes weight of *Clarias gariepinus* parent stocks.

Name	Species	Sex	Weight of female (g)	Weight of male (g)	Weight of ovary (g)	Subsection weight (g)	Weight of testes (g)
PC_0	*Clarias gariepinus*	F	1800		1020	340.0	
	Clarias gariepinus	M		1200			10.5
	Clarias gariepinus	F	600		340	112.0	
	Clarias gariepinus	M		400			28.2
PC_1	*Clarias gariepinus*	F	1400		1200	40.0	
	Clarias gariepinus	M		800			18.1
	Clarias gariepinus	F	700		550	183.3	
	Clarias gariepinus	M		600			10.7
PC_2	*Clarias gariepinus*	F	1200		1193	397.7	
	Clarias gariepinus	M		1200			18.9
	Clarias gariepinus	F	600		350	116.7	
	Clarias gariepinus	M		1200			16.0

PC_0 (parent stocks of *Clarias gariepinus* ovary and testes), PC_1(parent stocks of *Clarias gariepinus* ovary and testes), PC_2(parent stocks of *Clarias gariepinus* ovary and testes).

Table 4. Ovary and testes weight of *Heterobranchus longifilis* parent stocks.

Name	Species	Sex	Weight of female (g)	Weight of male (g)	Weight of ovary (g)	Sub section Weight (g)	Weight of testes (g)
PH_0	*Heterobranchus longifilis*	F	500		93.9	31.3	
	Heterobranchus longifilis	M		400			6.2
	Heterobranchus longifilis	F	600		112.3	37.4	
	Heterobranchus longifilis	M		500			5.6
PH_1	*Heterobranchus longifilis*	F	500		113.4	37.8	
	Heterobranchus longifilis	M		500			6.9
	Heterobranchus longifilis	F	400		100.3	33.4	
	Heterobranchus longifilis	M		350			3.0
PH_2	*Heterobranchus longifilis*	F	800		80.2	26.7	
	Heterobranchus longifilis	M		500			7.5
	Heterobranchus longifilis	F	600		60.2	20.1	
	Heterobranchus longifilis	M		500			6.5

PH_0(parent stocks of *Heterobranchus longifilis* ovary and testes), PH_1(parent stocks of *Heterobranchus longifilis* ovary and testes), PH_2(parent stocks of *Heterobranchus longifilis* ovary and testes).

treatments PC_0, PC_1 and PC_2 as shown in Table 3 and Figure 1. Table 4 and Figure 2 reported ovary and testes weights of *Heterobranchus longifilis* parent stocks, showing significant differences ($p<0.05$) in treatments PH_0, PH_1 and PH_2, respectively. In August, when this study on Gonadosomatic Index (GSI) and Hepatosomatic Index (HSI) began, peak GSI and HSI values were obtained. This report agreed with Borthakur (2018) who reported peak GSI values as being at their maximum in July, and higher in June and August for freshwater fish *Xenontedon cancila.* The author further suggested that a decline in GSI values took effect from September to November. Therefore, it is

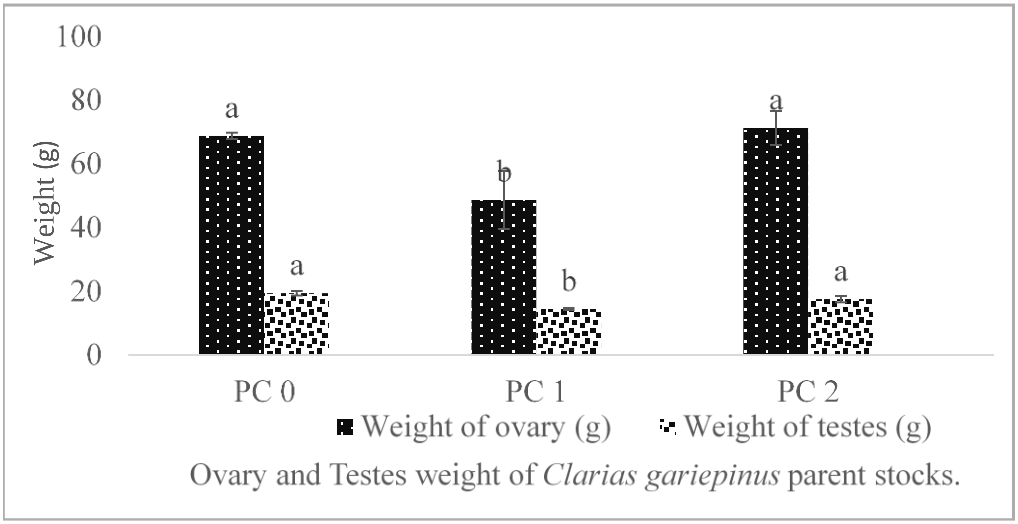

Figure 1. Mean ovary and testes weights of *Clarias gariepinus* parent stocks. Means in the same column (for each section) with different superscript are statistically different (p<0.05).

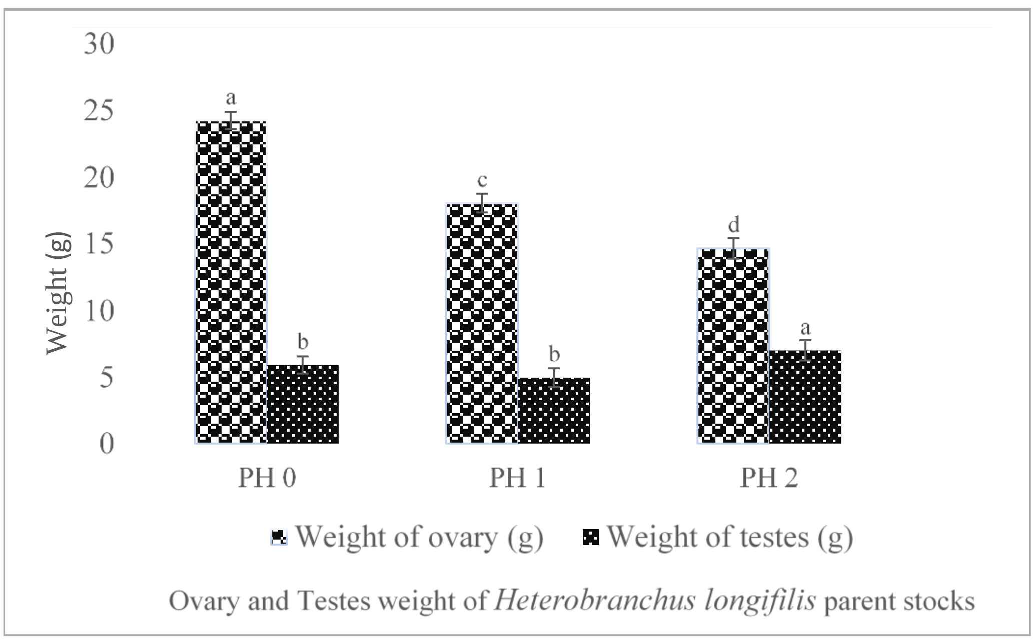

Figure 2. Mean ovary and testes weights of *Heterobranchus longifilis* parent stocks. Means in the same column (for each section) with different superscript are statistically different (p<0.05).

suggested that high metabolic activity was observed in August, during this study, as when GSI and HSI studies commenced in accordance with Borthakur (2018) report.

According to Singh and Srivastava (2017) in their study of *Heteropneustes fossilis,* GSI values reportedly increase from January (the resting phase or the developing phase). From September to November reveals another phase (the post-spawning phase). Their study therefore suggested that the maximum increase in GSI during July to August results in maximum gonadal growth. Kaur *et al.* (2018) provided GSI ranges for female fishes in August as 11.03±0.85 to 35.73±1.03 which are in the ranges of the GSI values obtained in this study.

HSI recorded the lowest values for *Heteropneustes fossilis* females in September through to December. Higher HS I values, however, were evidenced in May to

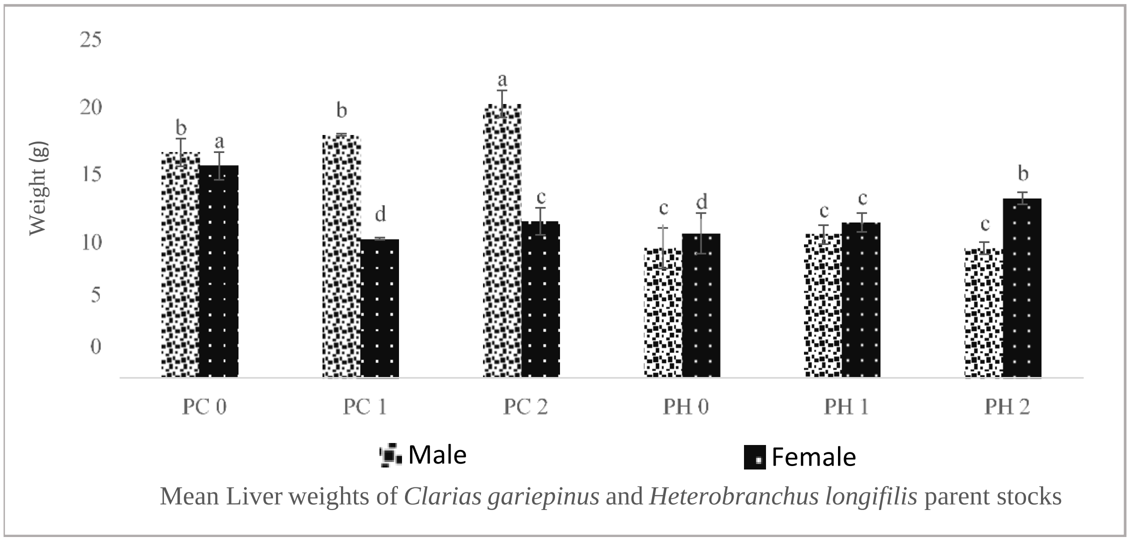

Figure 3. Mean liver weights of *Clarias gariepinus* and *Heterobranchus longifilis* parent stocks. Means in the same column (for each section) with different superscript are statistically different (p<0.05).

Table 5. Random liver weights of *Clarias gariepinus* and *Heterobranchus longifilis* parent stocks.

Name	Species	Liver weights (g)
PC_0	M	16.7
	F	15.7
PC_1	M	18
	F	10.3
PC_2	M	20.3
	F	11.6
PH_0	M	9.6
	F	10.7
PH_1	M	10.6
	F	11.5
PH_2	M	9.6
	F	13.3

June (also known as the pre-spawning phase or the developing phase). However, HSI values decreased in (the post-spawning phase) which was September to November; and showed further increase in December to January which was denoted as (the resting phase) (Singh and Srivastava, 2017). Findings from their study on GSI and HSI greatly support the findings in this study. Dambo *et al.* (2021) further provided HSI ranges as 1.52±0.13 to 3.08±0.45. Their HSI ranges also agree with the HSI values in this study.

Liver weights in Table 5 and Figure 3 showed significant differences ($p<0.05$) in parent stock treatments PC_0, PC_1, PC_2, PH_0 and PH_2. However, there was no significant difference ($p>0.05$) in parent stock treatment PH_2. In an earlier documented research, comparatively studying ovarian development in wild and captive-reared long-whiskered *Sperata aor,* the liver showed no significant differences ($p>0.05$) in more of the wild test fish groups. But, further observations showed a significant difference ($p<0.05$) in very few of the captive-reared test fish groups (Kabir *et al.,* 2023). Their result agrees with the findings of this study.

Conclusion and Recommendation

It is concluded that percentage fertility in this study reported a higher percentage for *Heterobranchus longifilis*; than *Clarias gariepinus*. Percentage hatching values were also higher in *Heterobranchus longifilis*, than in *Clarias gariepinus*. Fecundity values in *Clarias gariepinus* were higher in this study. *Heterobranchus longifilis* reported lower fecundity values.

Peak GSI and HSI values were observed in August, during this study, which was when GSI and HSI studies commenced. This study recommends further works on fecundity, to compare results and observations.

CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

REFERENCES

Ataguba, G. A., & Angela, A. (2023). Hybridization and growth performance of progeny from crosses between *Clarias* *gariepinus* and *Heterobranchus sp. Aquaculture Studies*, 24(1), AQUAST1154.

Borthakur, D. M. K. (2018). Study of gonadosomatic index and fecundity of freshwater fish *Xenontedon cancila. Journal of Entomology and Zoology Studies*, *6*(3), 42-46.

Dambo, A., Solomon, S. G., Ayuba, V. O., & Okayi, R. G. (2021). Study on condition factor and hepatosomatic index of *Bagrus bayad* (FORSSKAL, 1775) and *Synodontis nigrita* (VALENCIENNES, 1840) from Kangimi reservoir, Kaduna state, Nigeria. *Bayero Journal of Pure and Applied Sciences, 14*(2), 192-197.

Esa, Y. B., Dadile, A. M., Syukri, F., Christianus, A., & Diyaware, M. Y. (2023). Evaluation of fecundity, fertilization, hatching and gonadosomatic index of exotic *Clarias gariepinus* (Burchell, 1822) and native *Clarias macromystax* (Gunther, 1864) under semi-arid conditions of Nigeria. *Animals* (Basel), *13*(1723), 1-10.

Hasan, M., Hafiz All Hosen, Md., Idris Miah, Md., Chhanda, Z. M. S. & Shahriar, S. I. Md. (2020). Fecundity, length at maturity and gonadal development indices of river catfish (*Clupisoma garua*) of the old Brahmaputra River in Bangladesh. *The Egyptian Journal of Aquatic Research, 46*(3), 259-263.

Irawan, R., Muslim, M., Karolina, A., & Afriansyah, A. (2023). Gonadosomatic index and hepatosomatic index of Bonylip Barb (*Ostechilus vittatus*) from Lebak Kalong Floodplain, Ogan Komering Ilir, South Sumatra, Indonesia. *International Journal of Science and Research Archive, 10*(02), 174-180.

Jan, M., & Ahmed, I. (2016). Assessment of fecundity, gonadosomatic index and hepatosomatic index of snow trout, *Schizothorax plagiostomas* in river Lidder, from Kashmir Himalaya, India. *International Journal of Fisheries and Aquatic Studies, 4*(2), 370-375.

Kabir, M. A., Iqbal, M. M., Nandi, S. K., Khanam, M., Sumon, M. A. A., Tahiluddin, A. B., Kari, Z. A., Wei, L. S. & Tellez-Isaias, G. (2023). Comparative study of ovarian development in wild and captive-reared long-whiskered *Sperata aor* (Hamilton, 1822). *BioMed Central Zoology, 8*(10), 1-11.

Kaur, S., Singh, P., & Hassan, S. S. (2018). Studies on Gonadosomatic Index (GSI) of selected fishes of River Sutlej, Punjab. *Journal of Entomology and Zoology Studies, 6*(2), 1274-1279.

NIFFR (2023). National Institute for Freshwater Fisheries Research (NIFFR) Archives, with researcher's modification.

Nwipie, G. N., Erondu, E. S., & Zabbey, N. (2015). Influence of Stocking Density on Growth and Survival of Post Fry of the African Mud Catfish, *Clarias gariepinus*. *Fisheries and Aquaculture Journal, 6*(1), 1-4.

Oguntuase, B. G., & Adebayo, O. T. (2014). Sperm quality and reproductive performance of male *Clarias gariepinus* induced with synthetic hormones (Ovatide and Ovaprim). *International Journal of Fisheries and Aquaculture, 6*(1), 9-15.

Olumuyiwa, O. A., & Olatunde O. F. (2021). Aspects of reproductive indices and enteroparasitic infestation of *Clarias gariepinus* (Burchell, 1822) in a tropical reservoir. *International Journal of Fisheries and Aquaculture,* 13*(*1), 15-26.

Opiyo, M. A., Orina, P., & Charo-Karisa, H. (2017). Fecundity, growth parameters and survival rate of three African Catfish (*Clarias gariepinus*) strains under hatchery conditions. *Journal of Aquaculture Engineering and Fisheries Research, 3*(2), 75-81.

Ovie, S. O., Ovie, S. I., Wonah, C., Ekundayo, T., Offor, C. C., Maradun, H. F., Ibrahim, J. Z., Robert, E., & Abdullahi, U. B. (2014). The effect of fertilization on the growth of Heteroclarias fry in outdoor concrete tanks. *Best Journal, 11*(2), 141-146.

Rizzo, E., & Bazzoli, N. (2020). Reproduction and Embryogenesis. In: B. Baldisserotto, E. C. Urbinati & J. E. P. Cyrino (Eds.), *Biology and Physiology of Freshwater Neotropical Fish* (pp. 287-313), Academic Press.

Robert, E. A., Binyotubo, O. I., Ogbuebunu, K. E. & Eze, J. (2024a). Ovulation stimulation and fecundity of *Clarias gariepinus* and *Heterobranchus longifilis* given Ovaprim doses. *Nigerian Journal of Fisheries Science and Technology, 3*(1),10-16.

Robert, E. A., Binyotubo, O. I., Ogbuebunu, K. E., & Eze, J. (2024b). Embryonic Developmental Stages of the Catfish *Heterobranchus longifilis* in New Bussa, Niger state, Nigeria. *Nigerian Journal of Fisheries Science and Technology, 3*(1),73-78.

Sahoo, S. K., Giri, S. S., Paramanik, M. & Ferosekhan, S. (2014). Preliminary observation on the induced breeding and hatchery rearing of an endangered catfish, *Horabagrus brachysoma* (Gunther). *International Journal of Fisheries and Aquatic Studies,* 1(5), 117-120.

Singh, S., & Srivastava, A. K. (2017). Variations in Hepatosomatic Index (HSI) and Gonadosomatic Index (GSI) in fish *Heteropneustes fossillis* exposed to higher sub-lethal concentrations to arsenic and copper. *Journal of Ecophysiology and Occupational Health, 15*(3-4), 89-93.

Tiogue, C. T., Ambela, D. A. E., Nana, P., & Tomebi-Tabi, M. E. (2018). Reproductive performances of African Catfish according to the type of hormones and substrates in recycled water in southern Cameroon. *Asian Journal of Fisheries and Aquatic Research, 2*(1), 1-10.

Yisa, T. A., Lamai, S. L., Tsadu, S. M. & Kolo, R. J. (2014). Induced breeding of *Clarias gariepinus* using non-conventional method of abdominal incision. *International Journal of Biochemistry and Biotechnology, 2*(7), 484-489.

Zango, P., Tomedi, M. T. E., Efole, T. E., Tiogue, C. T., Nguenga, D., Kamanke, S. M. K., Mikolasek, O., & Tchoumboue, J. (2016). Reproductive performances of indigenous catfish of Cameroon *Clarias jaensis* (Boulenger, 1909) in captivity. *International Journal of Biological and Chemical Sciences, 10*(2), 533-542.