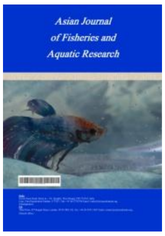

Asian Journal of Fisheries and Aquatic Research

17(5): 8-19, 2022; Article no.AJFAR.83538
ISSN: 2582-3760

A Comparative Study on the Gonadosomatic Index and Milt Volume of Four Populations of *Clarias gariepinus* (Burchell, 1822) Broodstock Strains from North-East Nigeria

Felix Eze [a*], Muhammad Yakubu Haruna [a] and Akosubo Oghenemarho Victory [b]

[a] *Department of Fisheries and Aquaculture, Nigeria Maritime University, Okerenkoko, Warri-South, Delta State, Nigeria.*
[b] *Department of Fisheries, University of Maiduguri, Borno State, Nigeria.*

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/AJFAR/2022/v17i530415

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/83538

Original Research Article

Received 08 December 2021
Accepted 16 February 2022
Published 31 May 2022

ABSTRACT

This study was carried out to compare and assess the Gonadosomatic Index (GSI) and Milt Volume of African catfish (*Clarias gariepinus*) from four population strains in the North-East of Nigeria. The broodstocks for the experiment were collected from lake Alau in Borno State, Lake Dadin Kowa in Gombe State, Lake Maladumba in Bauchi State and Lake Mayo Ranewo in Taraba State. The experiment was carried out at the hatchery complex of the Department of Fisheries, University of Maiduguri. A total of eighty *C. gariepinus*, twenty from each lake were collected. Standard methods were used to determine the gonadosomatic index and milt volume of the broodstock fish. The result obtained showed that the highest GSI value in males was 0.48±0.14 for fish caught from Lake Mayo Ranewo and the lowest GSI in males value was 0.28±0.01 for fish caught from Lake Maladumba. While the highest GSI value in females was 9.18±2.48 for fish caught from Lake Maladumba and the lowest GSI in females value was 4.06±0.65 for fish caught from Lake Dadin Kowa. There was a significant difference (*P<0.05*) on the GSI among the males and females fish broodstocks among Lakes The highest milt volume 2.66±0.16 was recorded for fish caught from Lake Mayo Ranewo and the lowest milt volume in males value was 2.32±0.11 and 2.32±0.11 for fish caught from Lake Alau and Lake Dadin Kowa respectively. The results obtained

**Corresponding author: Email: felixeze8@gmail.com, felixeze@nmu.edu.ng;*

in this study have increase our knowledge on the reproductive biology of wild *C. gariepinus* from the North-East of Nigeria and have also provided relevant information for fisheries and aquaculture management as well as breeding programmes.

Keywords: Clarias gariepinus; gonadosomatic Index; milt volume; North-East lakes.

1. INTRODUCTION

Fishes are the foremost various and diverse group of vertebrates, they have a wide diversity of regenerative methods and are found in freshwater, brackish and marine species [1]. The quick development of the fish farming division is a reason to focus on high-quality broodstocks for an increment within the generation of fish seeds and fertility control in broodstocks.

The African catfish *Clarias gariepinus* (Burchell, 1822) is mostly considered as one of the driving cultivated farmed fish in Nigeria and it is considered the foremost looked for fish species among fish farmers, consumers and researchers because it commands a great commercial and study value [2]. It can consume artificial feed, the high feed conversion rate is not susceptible to disease, high growth rate, resistance to a wide extent of environmental conditions, and ability to reproduce in captivity [3].

Gonadosomatic Index (GSI) is an index of reproduction [4]. The gonadosomatic index is the ratio of fish gonad weight to body weight. The GSI is especially valuable and supportive in recognizing the days and seasons of spawning. During spawning, the ovaries of the gravid females will quickly increase in size and weight [5]. Thus the GSI gives a valuable estimation of the producing potential of fish [6].

Reproduction is the foremost crucial arrangement within the life cycle of a species, which determines its survival and success. The Gonadosomatc Index could be a dependable marker of changes in the dietary and vitality condition of fish [7].

For effective domestication of fishes, the gonadosomatic index is an important biological aspect that needs to be understood, it moreover plays a critical role in assessing the maturity index [8], gonadal state as well as the reproductive potential of fish [9].

Male C*larias gariepinus* don’t discharge milt when stripped therefore they need to be sacrificed to obtain semen for induced breeding. Although, milt collection after killing a male fish is compelling for artificial breeding, in most cases fish produces high viscose milt which is little in volume [10].

Milt quantity (volume) and quality are vital components that impact the production of viable larvae during the artificial propagation of African catfish [11]. To create high-quality fingerlings, endeavors are made to get milt of the most noteworthy quality and subsequently to produce the highest possible numbers of good quality fingerlings [12,13]. Milt quality is vital for the generation of high-quality fish hatchlings and the economical utilization of hatcheries [14].

The capacity of milt to effectively fertilize an egg could be a degree of the milt quality, such ability usually depends on subjective parameters [15]. Common measures of gamete quality incorporate milt volume, the viability of spermatozoa, egg morphology and chemical profile of gametes and seminal fluid, hatchability of eggs and malformation rate of embryos and fry survival [16-18].

One of the most sensitive baseline and endline for estimating the reproductive wellness of a fish populace in any environment is the degree of gamete quality [19]. The quality of sperm is exceedingly variable and depends on various external factors such as feeding regime, the quality of the feed, and the rearing temperature of the fish [20]. It is vital to utilize high-quality gametes with high milt volume from wild broodstocks in other to guarantee the production of valuable and profitable offspring that can withstand various factors for aquaculture [21].

Several researchers have researched the GSI, fecundity and egg size of distinctive fish species from Nigerian waters and these incorporate; [22-29]. Several studies have depicted semen characteristics in *C. gariepinus* including semen density and seminal plasma pH [30], sperm ultrastructure, motility, viability [31] and sperm metabolism [32]. According to [15], any measurable physical parameter that directly correlates with the fertilization rate of sperm could be potentially used as a measure of sperm quality. In a past study, [33] distinguished two types of testicular semen in African catfish depending on the maturation grade of the testes. [34,35], reported that variations between individual ages of the fish are also factors that determine the quality of egg and milt. Hajirezace et al. (2010), opined that feed conversion ratio, environmental conditions, and season of the year could influence milt quality respectively.

In the last two decades, one of the major advancements in fish culture is captive breeding. Agreeing to [36], the fish farming industry in Nigeria shows up to be more concerned around the quality and quantity of eggs rather than that of sperm, indeed even though the sperm quantity and quality of male broodstock affect significantly the production of healthy and inexhaustible hatchlings. It has appeared that in most commercial hatcheries where African catfish seeds are being propagated, semen is regularly insufficient both in terms of quantity (volume) and quality and does not always give fruitful fertilization in artificial breeding [15]. When male broodstock is limited, it is particularly imperative to guarantee that sperm quality sweet sufficient to attain a high percentage of fertilization. Artificial reproduction under more controlled conditions including stripping of eggs, collection of sperms, followed by fertilization of eggs has been developed. To ensure high fry survival and reproductive success there is a need to assess the milt quantity.

Milt volume has incredible variability among distinctive male individuals kept under the same conditions [33]. In foreseeing the reproductive results of broodstocks, knowledge of the Gonadosomatic Index is critical. Whereas information on some sperm quality is an important factor to be considered in spawning, fertilization, hatching, and development of offspring [36,12]. It is, hence, fundamental to have adequate knowledge of the Gonadosomatic Index and Milt volume in other to achieve high success in any breeding activity. This study was aimed at comparing and assessing the Gonadosomatic index and milt volume of wild *Clarias gariepinus* from North-East Nigeria.

2. MATERIALS AND METHODS

2.1 Study Area

The wild population of *Clarias gariepinus* strains were collected from Lake Alau, Borno State, Lake Maladumba in Bauchi State, and Lake Mayo Ranewo in Taraba State, Dadin kowa Dam in Gombe State, River Benue in Adamawa State, Komadugu Lake in Yobe State.

Lake Alau is located between latitude 11°39" 4' N and 11°40", 02' N and longitude 13°39" 92' E and 120m above the sea level. The total surface area of Lake Alau is 56 km^2 and a maximum depth is 10m with an effective storage capacity of 54, 000ha [37]. The climate in Lake Alau is Sahelian with two distinct seasons with a day temperature of 30°C and night 29°C [38].

Lake Maladumba is located at Latitude 11°13' 56" N and Longitude 10°21' 42" E with a surface elevation of 408m above sea level. The Lake is a natural, shallow (1-2m) depression Lake, situated in a structural guided long, counterclockwise and clockwise semi-circular channel occupied by the River Kuka that drains into the Lake Kari and River Kari that partially drains the Lake during high water and the Lake undergoes accelerated siltation [39]. The climate is the Sudan type with two distinct seasons, a short (May to September) wet season and a longer (October - April) dry season. Mean annual rainfall is 800mm with a unimodal distribution during the rainy season. Mean temperature range from 26°C during harmattan to 34° during the hot months [40].

Dadin Kowa Dam is connecting the Gongola River located in Gombe State, Nigeria. The area lies between latitudes 10°19' N and latitude 10°32' N, and longitudes 11°48' E and longitude 11°54' E. The dam is situated about 35 kilometers to the east of Gombe town and provides drinking water for the town. The dam was built by the Federal Government in 1984, to provide irrigation and electricity for the planned Gongola sugar plantation project [41]. The reservoir has a capacity of 800 million cubic meters of water and a surface area of 300 square kilometers and has potential as a source of fish [41].

Lake Mayo Ranewo is located at Lat 8°47' to 8°53' and Longitude 10°55' E at the South-Western part of the Ardo Kola LGA in Taraba State. The Lake is located in the town of Mayo Ranewo which is located at the bank and Floodplain of the Benue River. The dominant ethnic groups are Fulani, Hausa, and Jukun Kona. The people of Mayo Ranewo are fish folks and Farmers.

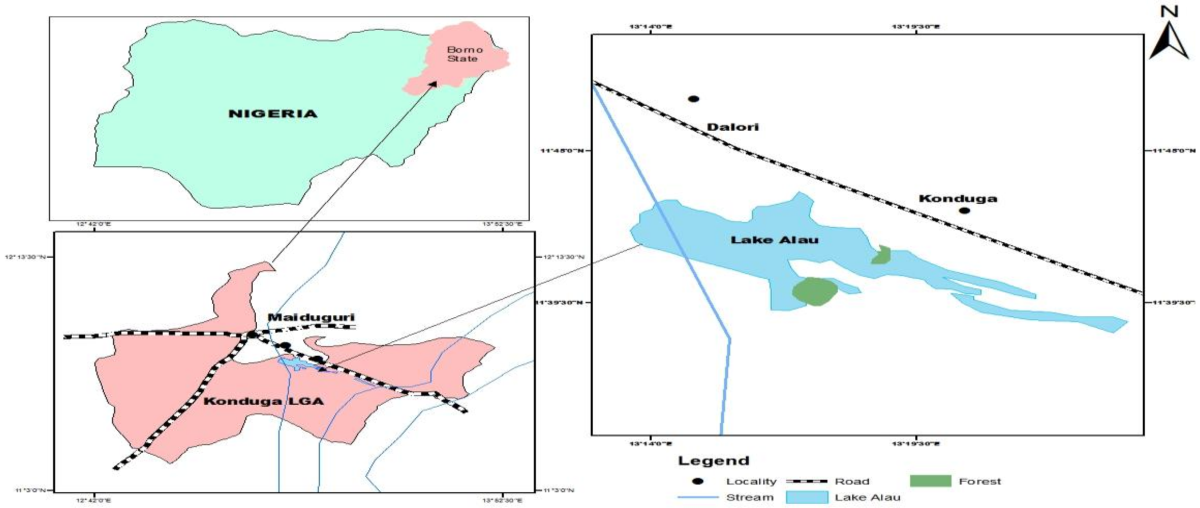

Fig. 1. Lake Alau, Borno State

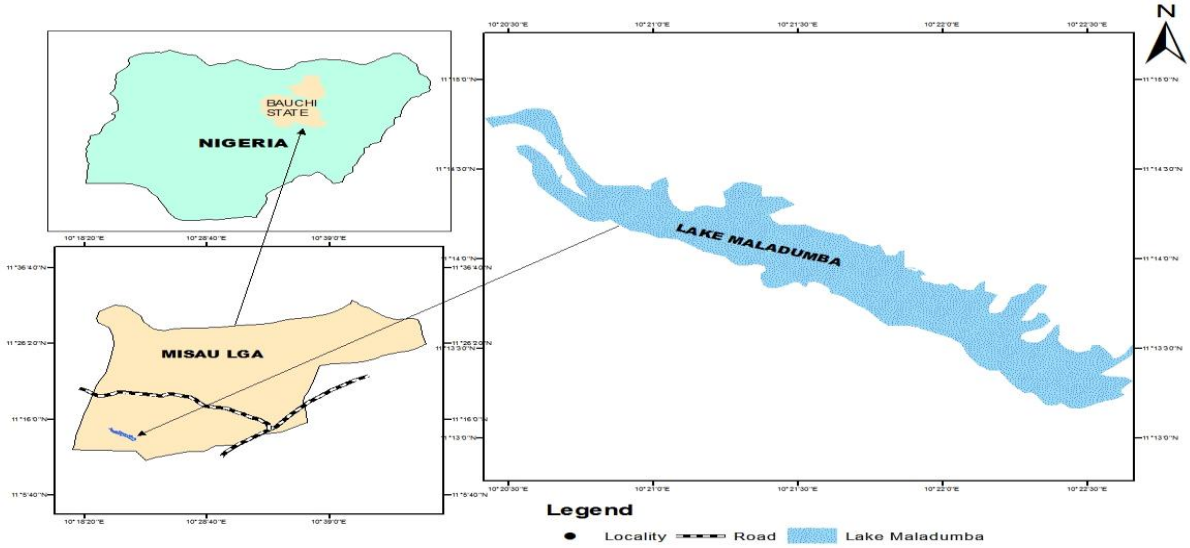

Fig. 2. Lake Maladumba, Bauchi State

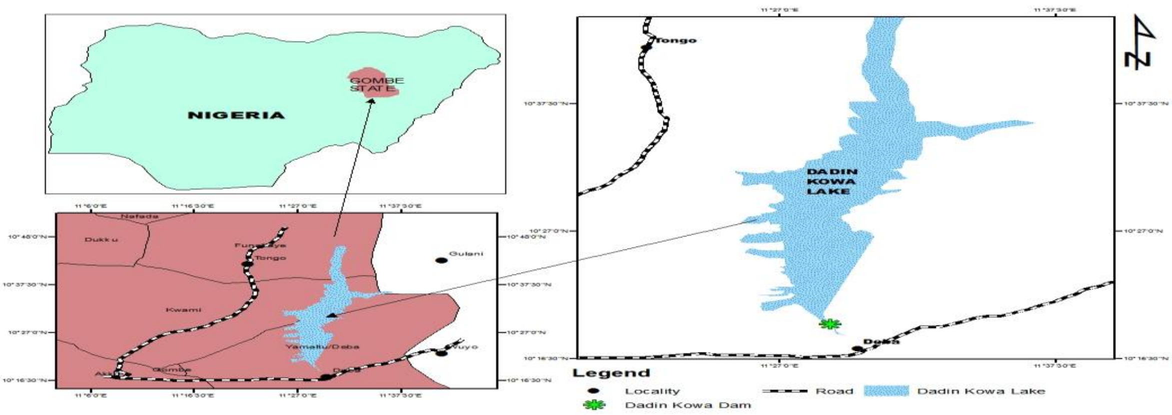

Fig. 3. Dadin Kowa Dam, Gombe State

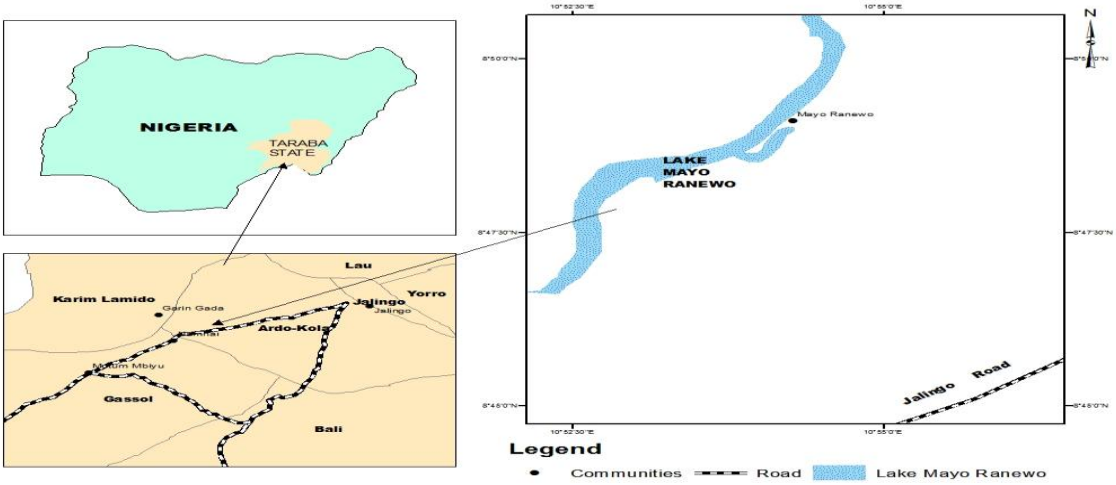

Fig. 4. Lake Mayo Ranewo, Taraba State

2.2 Collection, Identification and Transportation of *Clarias gariepinus* Broodstock

A total of 80 male *C. gariepinus* broodstocks were collected from the above four lakes (20 fish each) in North-East Nigeria from May to August from catches of local fishermen using traps, gill nets, and cast nets in the lakes. All fish specimens were still alive at the time of purchase. The fish were transported in containers containing water from the lakes to the research laboratory in the Department of Fisheries, University of Maiduguri, Nigeria which is situated between latitude 11°51^1 N and longitude 13°05^1 E. The area is characterized by a cool dry climate from January to March and on average, the warmest month of April. It has a mean annual rainfall of over 800mm. The rainy season usually begins in April and ends in August. The relative humidity of the study area is 5-54.5% and atmospheric temperature ranges from 38-40^{0}C during the day which drops to 29-31^{0}C during the night for further investigations. After transportation, the experimental fish were Identified using fish identification guides by [42]. The *Clarias gariepinus* were acclimated and conditioned in separate tanks for one week and were fed with 40% crude protein commercial pelleted feed at 3% body weight twice daily at 9.00 and 18.00 hours.

2.3 Gonadosomatic Index

Gonadosomatic Index (GSI) is the proportion of gonad weight to body weight. It is used to appraise regenerative conditions. The GSI is valuable in distinguishing days and seasons of spawning, amid which ovaries of gravid females increase in size before spawning; it is indicative of reproductive success [43].

The broodstocks after observing the latency period of 12 h were evacuated from the troughs; they were placed dorsally on a damped towel. The fish were sacrificed by spinal transaction and were held firmly down to ensure careful removal of the testis using a sharp sterile blade, the abdominal cavity of the fish was dissected ventro-posteriorly, and testes were carefully removed from where they were lying, at the ventral wall of the abdominal cavity [44]. The gonads were obtained, weighed, and recorded.

The Gonadosomatic Index (GSI) of each fish was determined as:

GSI = Gonad Weight (GW)/ Total Weight (TW) x 100

Where Gw = weight of Gonad and Tw = Total weight of fish [45].

2.4 Sperm Volume

After the male broodstocks were sacrificed and their testis was collected, cuts were made on testicular lobes using a sterile surgical blade [42] and fresh milt was squeezed into a petri dish and transferred into 2 mL calibrated glass tubes to obtain milt volume (mL) [46,47]. Thereafter, milt was sieved to remove dead tissues.

2.5 Statistical analysis

Regression and correlation analyses were used to analyze Gonadosomatic Index and milt volume using the PASW windows software program (version 19.0). Significant differences between the means of GSI in the population fish were carried out using SPSS version 15.0 for Windows.

3. RESULTS

The mean body weight (g) for the male population strains of *Clarias gariepinus* from four (4) lakes in North-East Nigeria is displayed in Table 1. The highest mean body weight 525±25.00 was recorded for Lake Alau, followed by 465±00.185.00 recorded for Lake Mayo Ranewo. Lake Maladumba and Lake Dadin Kowa both recorded mean body weights of 350±50.00 and 315.00±15.00 respectively. There was a significant difference (*P<0.05*) in the mean body weight of fish broodstocks among Lakes.

The mean gonad weight (g) for the male population strains of *Clarias gariepinus* from four (4) lakes in North-East Nigeria is displayed in Table 1. The most noteworthy cruel gonad weight 2.20±0.60 was recorded for Lake Alau, followed by 195±0.25 recorded for Lake Mayo Ranewo. Lake Dadin Kowa and Lake Maladumba both recorded a mean gonad weight of 1.35±0.15 and 1.00±0.20 respectively. There was a significant difference (*P<0.05*) in the mean gonad weight of fish broodstocks among Lakes.

The mean Gonadosomatic Index (GSI) for the male population strains of *Clarias gariepinus* from four (4) lakes in North-East Nigeria is displayed in Table 1. The highest mean GSI recorded for Lake Mayo Ranewo was 0.48±0.14 while Lake Alau and lake Dadin kowa had a mean GSI of 0.43±0.14 and 0.43±0.23 respectively, the least value of 0.28±0.01was obtained for Lake Maladumba. There was a significant difference (*P<0.05*) in the GSI of male fish broodstocks among Lakes.

The mean milt volume of the experiments presented in table 1, ranged from 2.32 ml in male broodstock from Lake Alau and Lake Dadin Kowa to 2.66ml in male broodstock from Lake Mayo Ranewo. The highest milt volume (2.66 ±0.16ml) was obtained from broodstock caught in Lake Mayo Ranewo and the least milt volume (2.32±0.14ml and 2.32±0.11 ml) from broodstocks caught from Lake Alau and Lake Dadin kowa respectively. There was no significant difference (P>0.05) in sperm volume among the Lakes.

The mean body weight (g) for the female population strains of *Clarias gariepinus* from four (4) lakes in North-East Nigeria is displayed in Table 2. The highest mean gonad weight 600±0.00 was recorded for Lake Mayo Ranewo, followed by 500±50.00 recorded for Lake Alau. Lake Dadin Kowa and Lake Maladumba both recorded mean body weights of 450.00±50.00 and 400.00±100.00 respectively. There was a significant difference (*P<0.05*) in the mean body weight of fish broodstocks among Lakes.

The mean ovary weight (g) for the female population strains of *Clarias gariepinus* from four (4) lakes in North-East Nigeria is displayed in Table 2. The highest mean ovary weight 54.35±1.15 was recorded for Lake Mayo Ranewo, followed by 45.10±25.10 was recorded for Lake Alau. Lake Maladumba and Lake Dadin Kowa both recorded mean body weights of 34.25±0.75 and 18.25±1.75 respectively. There was a significant difference (*P<0.05*) in the mean ovary weight of fish broodstocks among Lakes.

The mean GSI for the female population strains of *Clarias gariepinus* from four (4) lakes in North-East Nigeria is displayed in Table 2. The highest mean GSI recorded for Lake Maladumba was 9.18±2.48, while Lake Mayo Ranewo and Lake Alau had a mean GSI of 9.06±0.19 and 8.60±4.16 respectively, the least value of 4.06±0.65was obtained for Lake Dadin Kowa. There was a significant difference (*P<0.05*) in the mean GSI of fish broodstocks among Lakes.

Table 1. Overall mean of gonadosomatic index and sperm volume of male *Clarias gariepinus*

Lakes	Mean body weight (g)	Mean gonad weight (g)	Mean GSI (%)	Mean sperm volume (ml)
Lake Alau	525.00±25.00	2.20±0.60	0.43±0.14	2.32±0.14
Lake Dadin Kowa	315.00±15.00	1.35±0.15	0.43±0.23	2.32±0.11
Lake Maladumba	350.00±50.00	1.00±0.20	0.28±0.01	2.44±0.11
Lake Mayo Ranewo	465.00±185.00	1.95±0.25	0.48±0.14	2.66±0.16

Means with the same superscript column are not significant at (P>0.05)

Table 2. Overall mean of Gonadosomatic Index of female *Clarias gariepinus*

Lakes	Female body weight (g)	Ovary weight (g)	Female GSI (%)
Lake Alau	500.00±50.00	45.10±25.10	8.60±4.16
Lake Dadin Kowa	450.00±50.00	18.25±1.75	4.06±0.65
Lake Maladumba	400.00±100.00	34.25±0.75	9.18±2.48
Lake Mayo Ranewo	600.00±0.00	54.35±1.15	9.06±0.19

Means with the same superscript column are not significant at (P>0.05)

4. DISCUSSION

The mean of the GSI values obtained for females (9.18±2.48) was relatively higher than those obtained for males (0.48±0.14) in all four lakes. This could be as a result of heavier gonads with the presence of eggs, possessed by female fish. The higher and the lower values of GSI recorded for wild female and male *Clarias gariepinus* respectively showed that reproductive activities were from May to August which was when the fish samples were collected. In females, the reproductive activities were high as at when they were caught which is an indication that spawning is likely to be in the rainy season and the male might have released their milt during fertilization. The reproductive cycle is annual as reported by [48-50]. The result obtained is in agreement with the findings of [51,52]. It was reported that GSI is a reliable indicator of fish health condition [7]. Gonadosomatic index (GSI) as observed in this study agrees with the findings of [53] who reported GSI to be between 3.6-37.9% respectively (at the peak of the season). Because during rainy season, the IGS value is higher than in the dry season. The contributing factors include the amount of food available in the waters in the rainy season more than the dry season which results in the development of body weight Fish gonads are getting bigger and will directly affect the IGS value. The increase in IGS value at each level of gonad maturity of female fish is greater than male fish this is related to the process of vitellogenesis and egg cell growth, while in male is associated with spermatogenesis and an increase in the volume of tubuli seminiferi.

The GSI for both the male and the female broodstocks obtained in this study is lower than the GSI obtained by [54] in Oba reservoir in Oyo state, Nigeria, and [42] from Unical, Calabar state Nigeria. This may be because the males were caught during spawning season and might have fertilized eggs which caused the release of milt there reducing the weight of the gonad. The mean of all GSI values for female specimen harvested was calculated to range from 4.06±0.65 to 9.18±2.48 which means that the female fish species invested 4.06 to 9.18% of their body weight for egg production. This result was higher than the mean value of 4.6% reported [55]. However, the positive linear relationship was an indication that generally, the gonad weight increases with the body weight.

The mean body weight (g) for the female *C. gariepinus* is higher than that of the males. However, the mean body weight range (315±15.00 to 600.00±0.00) for both the wild female and male *C. gariepinus* reported in this study is higher than the mean body weight range of 84.30 to 181.00g reported by [55] and mean body weight range of 93.33 to 206.5g reported by [54].

The mean gonad weight value reported in this study showed a significantly different (P<0.05) and the lower value obtained for wild *Clarias gariepinus* reported by [56]. This could be attributed to sperm and eggs allocation tactics which can vary according to the size and status of a male and female or the amount of available sperm or eggs in gonads [57]. These differences may likely be due to feeding conditions, water quality, and different environmental conditions and spawning seasons [56].

Viable sperm is an essential component of any successful animal production operation and the success of the reproduction process is dependent on a supply of high quality and quantity gametes [58]. Poole and Dillane [59] opined that qualitative evaluation of gametes should consider not only motility and fertility rates but also sperm volume. The ability of the fish to produce a high volume of milt and fertilize the eggs is an essential quality of successful artificial spawning [21,60] because the higher the sperm volume the higher the sperm motility and the strong relationship between milt volume and percentage egg fertilization and hatching in *C. gariepinus* [61]. Sperm volume is one of the parameters that are essential in determining the capacity of spermatozoa to fertilize [20,62,63]. The mean sperm volume obtained in this study is higher than that obtained in a study reported by Oguntuase and Adebayo [64]. In this study, the mean sperm volumes for all the lakes are not significantly different (P>0.05). : Fertility of fertilized fish sperm takes place externally on generally only lasts on time short one. This is caused by short period of sperm motility in waters. Decreased motility and sperm progression in general lead to a decrease in fertility sperm. To prolong sperm viability Then the preservation method was developed sperm at low temperature with addition of a cryoprotectant. Although This method is quite effective but in implementation requires equipment specifics such as storage packaging (straw), liquid nitrogen cylinders as well as use of cryoprotectants so that This method is not practical for applied by farmers or in emergency state.

This means that male *Clarias gariepinus* broodstocks can be caught from any of the four lakes for artificial breeding because the cultured male broodstocks are constantly decreasing because they are mostly sacrificed during artificial breeding and have the same milt volume as the wild as reported by Odo et al. [65]. This is at variance with [66], which reported a significantly different (p<0.05) in the mean semen volume of both fish cultured and wild samples of *C. gariepinus*; attributed to feeding and environmental conditions.

The ability of fish to produce high-quality gametes is critical for successful and optimal reproductive outcomes and this is largely dependent on the quality of the rearing environment. As such high-quality gametes may reflect the state of health or fitness of the fish population in aquatic ecosystems [11]. Other reports have also indicated that the quality of fish sperm may be as important as the quality of fish eggs to achieve viable progenies and subsequent larval survival [64,67].

It is also known, as opined by Mylonas et al. [68] and Zohar and Mylonas [69] that, the treatment of fish with hormones by injection typically results in a short-term increase in milt volume and changes in plasma steroids. It is possible that, in smelting, the increase in milt volume was partially caused by milt hydration, indicating that seminal plasma volume was being increased at a faster rate than spermatozoa production.

The quality of fish sperm is as important as the quality of female eggs for viable off-springs, various studies have been carried out on induced spawning in female fish with lesser attention on the male counterpart. Sperm morphology, density, volume, motility, and fertilizing capacity, as well as composition and osmolality of the seminal plasma, are parameters commonly measured to assess sperm quality in fish [67].

5. CONCLUSION

The baseline information obtained from this experiment on Gonadosomatic Index (GSI) and Milt volume show that the wild *Clarias gariepinus* broodstocks were physiologically healthy. The consideration of GSI and good sperm volume based on the parameters assessed is of paramount importance in fisheries management and aquaculture production. The parameters are important for understanding the reproductive biology of the wild *Clarias gariepinus* broodstocks. When all these factors are considered, monitored, and properly managed, there will be improvement and sustainability in the aquaculture system in Nigeria.

Therefore, future research should focus on the fecundity, fertilization, and hatching rate of the wild *Clarias gariepinus* from North-East Nigeria.

ACKNOWLEDGEMENTS

The authors wish to thank the Department of Fisheries, University of Maiduguri, Borno State for the use of their Teaching and Research Farm and Laboratory and the Department of Fisheries and Aquaculture, Nigeria Maritime University for analyzing the collated data. We are indebted to the fisherfolks assistance and for sparing their catch and time without which it would not have been possible to accomplish this research.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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