International Journal of Advancing Research, Innovation and Entrepreneurship

Vol 1(1), DOI:10.82036/b9y5yx76, April 2025 *ISSN:2977-9332*

Assessment of Morphology and Gonadosomatic Index of *Gymnarchus niloticus* in the Niger River, Lokoja, Nigeria for Sustainable Fisheries

***[1]Hauwa Ohunene Sadiq, [2]Muyibah Olayinka Ajibade & [1]Aisha Opeyemi Afolabi**

[1]Department of Fisheries, Aquaculture and Wildlife, University of Abuja, Nigeria

[2]Department of Animal Science, University of Abuja, Nigeria

*Corresponding Author Email address: hauwa.sadiq@uniabuja.edu.ng

ABSTRACT

The morphology, gonadosomatic index (GSI) and length-weight relationship of *Gymnarchus niloticus* were evaluated from specimens collected in the Niger River at Lokoja, Kogi State, Nigeria. A total of 40 specimens, with total lengths from 80.00 to 107.66 cm and total weights from 620.17g to 1135.82g, were collected. Morphometric parameters, meristic characteristics, and gonadosomatic index (GSI) were analysed using ANOVA and Duncan's Multiple Range Test. In this study, significant differences were observed in body weight (620.17g – 1135.82g), standard length (69.00cm – 92.0cm), eye diameter (1.15cm – 1.93cm), and dorsal fin length (89.0cm – 144.0cm). The LWR results indicate that the study fish exhibits a negative allometric growth pattern. The GSI results revealed that *G. niloticus* exhibits significant seasonal variation in reproductive activity; the species has unpaired gonads and a gonochoristic reproductive pattern. Although the species has low fecundity, it has large ovaries, suggesting it can be a suitable candidate for aquaculture. This species of fish is a potential candidate for achieving sustainable development goals of zero hunger (SDG 2), clean water and sanitation (SDG 6), responsible consumption and production (SDG 12) and life below water (SDG 14) in Nigeria. To improve aquaculture production and ensure sustainable fisheries in Nigeria, there is a need for improved efforts in fisheries management, habitat restoration, sustainable fishing and harvesting practices in the Niger River.

Keywords: African Knifefish, Morphometric parameters, Reproductive biology, Sustainable Development Goals, Sustainable fisheries.

I INTRODUCTION

In many developing countries around both inland and coastal water bodies, fish is one of the easily available, accessible and cheap sources of animal protein (Sadiq *et al*., 2022). Fish like other aquatic organisms play a crucial role in food as well as nutritional security in many African countries where many people are poor and under- or malnourished (Chan *et al*., 2019). The exceptional blend of high-quality protein and other essential nutrients makes fish a uniquely valuable food. It is a good source of animal protein, it is estimated that about 140/150g of fish provides nearly 60% of the daily protein requirements of man, this is in addition to other essential nutrients that are non-existent or insufficient in other protein sources like cereals and meat (Sadiq *et al*., 2022). The popularity of aquaculture as a means of raising fish to meet the growing demand of this well-sought protein source is increasing especially with the declining output from capture fisheries due to overfishing and other factors (Sadiq *et al.*, 2024).

Reports have shown that over 80% of Nigerian fish farmers culture only catfish. For Nigeria to maintain a steady increase in aquaculture production, there is a need to explore other potential aquaculture species other than catfish (*Clarias gariepinus*) and tilapia (*Oreochromis niloticus*), the predominantly cultured species in Nigeria (Sadiq *et al.*, 2024). Some of the likely candidates for aquaculture include indigenous species like *Gymnarchus niloticus*, *Synodontis schall*, *Chryschthys nigrodigitatus* as well as exotic species such as, *Anabas testudineus*, *Labeo rohita*, *Abramis brama*, *Cyprinus carpio* and *Pangasius pangasius* (Ibidapo-Obe and Yusuff, 2024). These potential aquaculture species exhibit desirable traits for culture such as fast growth, tolerance of diverse environmental conditions, efficient feed conversion and command high nutritional values. Including these species in Nigeria aquaculture sector will not only significantly improve production and meet the fish protein demands of the growing population, it will also boost the nation's economy by providing foreign exchange. To recruit a new aquaculture species, the study of the biology of fish species enables the primary and relevant knowledge to be obtained for the survival, growth, continuity and sustainability of life (Agbugui, *et al.*, 2021a).

Gymnarchus niloticus, belonging to the family Gymnarchidae and commonly known as the African knife fish or Aba, is a freshwater species, prevalent in the inland waters of West Africa, spanning from Senegal, Gambia,

Vol 1(1), DOI:10.82036/b9y5yx76, April 2025 ISSN:2977-9332

Chad, the Nile, Niger and Lake Turkana (Lalèyè *et al.*, 2020 and Froese and Pauly, 2014). *Gymnarchus niloticus* is harvested from the wild for subsistence fisheries and has considerable economic and socio-cultural values in Nigeria; the flesh of the species commands a high price in local markets (Olopade and Taiwo, 2013, Agbugui *et al.*, 2021b). While *G. niloticus* is of least concern across the rest of Africa, it has been categorized as endangered in Nigeria and this is due to decline brought on by overfishing, habitat loss, irregular and uncontrolled fishing techniques, and human activities along the river (Agbugui and Umaru, 2020). Despite its importance, there is a paucity of detailed studies on the biological and ecological characteristics of *G. niloticus*, particularly its morphometric and reproductive traits especially in the Niger River at Lokoja, Kogi State. Important steps must be taken to improve the conservation of this species, safeguarding its habitat, breeding, production, culture, and commercial propagation in order to prevent the extinction of this highly prized and commercially valuable fish. *Gymnarchus niloticus* has an elongated body with a dorsal fin that runs through almost the entire length of the fish and has no pelvic, anal or caudal fins (Agbugui *et al.*, 2021b). It hunts and stuns its prey using weak electric currents from its body (Olopade and Taiwo, 2013).

Gonadosomatic index (GSI) is a useful tool in fish reproductive studies, providing insights into the breeding season, fecundity, and overall reproductive health of fish populations (Sadiq *et al.*, 2022). The length-weight relationship is a standard method that provides valuable biological information and is crucial for fish stock assessment. It aids in assessing weight variations for specific length groups. Additionally, it is vital for calculating the biomass of a fish sample based on the length frequency (Kuriakose, 2014). Study by Shola *et al.* (2017) on the GSI and feeding habits of *Late sniloticus*, *Oreochromis niloticus*, *Bagrus bayad*, *Mormyrus macrophthalmus*, *Synodotis nigrita*, *Heterotis niloticus*, *Malapterurus electricus* and *Clarias gariepinus* in Lake Kalgwaiin Jigawa State, Nigeria served as preliminary data on GSI of these species, however, *Gymnarchus niloticus* was not one of the species studied. Similarly, the morphometric and GSI of some selected species were studied in Lake Alau, Borno State Nigeria in 2024, where the authors concluded that the baseline data collected for these species including *G. niloticus* can assist in the prediction of these species growth and reproduction (Iliyasu *et al.*, 2024). The GSI and morphometry of several other fish species have been studied in many water bodies in Northern Nigeria that empties into the Chad River system (Shinkafi and Ipinjolu, 2012; Mikaheel *et al.*, 2019; Dambo and Solomon, 2021; Eze *et al.*, 2022).

There is a need to shift from catfish culture in Nigeria to meet fish demands of the nation's populations, hence, it is very imperative to search for suitable aquaculture candidates especially if Nigeria is to achieve her sustainable development goals of zero hunger and life below water. The knowledge of the breeding periods via the study of the gonadosomatic index of species that do not breed in captivity such as *Gymnarchus niloticus* holds the potential to promote the culture of these species (Sadiq *et al.*, 2022). This study therefore, was aimed at evaluating the morphology and some reproductive aspects of *Gymnarchus niloticus* in the Niger River, Lokoja, Nigeria.

2 METHODOLOGY

2.1 STUDY AREA

Fish samples were collected from fishermen at landing sites by the Niger River at Lokoja, Nigeria. Lokoja lies between 7° 48' 59.99" N latitude and 6° 44' 59.99" E longitude (figure 1) (Iyaji and Yaro, 2016). The fish samples were then transported in icebox to the Animal Science laboratory, University of Abuja.

2.2 SPECIMEN COLLECTION

Forty mixed species of *G. niloticus* were collected from fishermen at the landing sites by the water body between October 2023 and December 2023. The fish were washed under running water before they were weighed using a camry digital scale (0.5g – 5kg) and morphometric parameters measured using a transparent metric ruler (0 – 30cm). Morphological parameters measured and recorded were; total length (TL), standard length (SL), head depth (HD), head length (HL), body depth (BD), body width (BW), snout length, eye diameter (ED), width of caudal peduncle, and fin lengths (FL).

Sexing of the fish samples were done by physical examination of the cloacae on the ventral side of the fish and were confirmed after dissection. Following the procedures of Agbugui *et al.* (2021a) and Adebiyi *et al.* (2011), gonads were carefully detached, weighed, and maturity stages assigned to each sample on established criteria (Table I).

Vol 1(1), DOI:10.82036/b9y5yx76, April 2025 ISSN:2977-9332

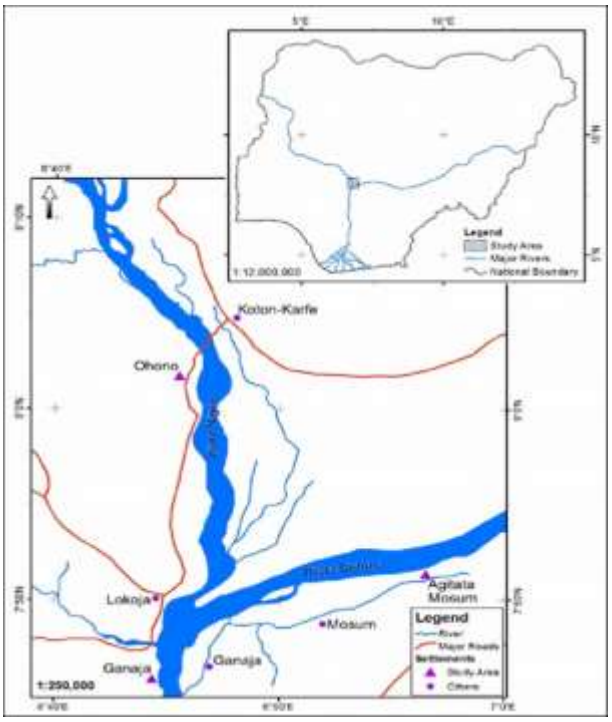


Figure 1: Map of the Study Area (Iyaji and Yaro, 2016) Mag: x0.4

TABLE I: GONADAL DEVELOPMENT STAGES OF FISH

Maturity stage	Gonadal development
Stage I	Immature
Stage II	Quiescent/Resting
Stage III	Maturing
Stage IV	Mature
Stage V	Running
Stage VI	Spent

Adapted from Agbugui *et al.* (2021a)

Gonadosomatic index was calculated to determine reproductive status. The GSI was determined using the following formula:

$$GSI = \frac{Weight\ of\ gonad\ (g)}{Weight\ of\ fish\ (g)}\ x\ 100 \quad (1)$$

The length-weight relationship was calculated using the formula:

$$W = a\ x\ TL^{b} \quad (2)$$

where; ***W*** is weight of fish, ***a*** is intercept, ***TL*** is the total length and ***b*** represent the slope.

2.3 STATISTICAL ANALYSIS

Recorded and collected data were subjected to analysis of variance (ANOVA) using SPSS Version 17.0. Significant differences were separated using Duncan's Multiple Range Test.

3 RESULTS AND DISCUSSION

Fish sampled in November were significantly larger than to those sampled in both October and December (Table II). This difference was also noticed in other morphological characteristics such as; total length, head length, and body depth across the sampling months except eye diameter. These variations are likely influenced by environmental factors such as water temperature, food availability, and breeding cycles within the Niger River at Lokoja. Other researchers have also suggested that, net mesh size and age of fish can also be responsible for the observed variations (Olopade and Taiwo, 2013; Mohammed *et al.*, 2019).

TABLE II: MORPHOLOGICAL CHARACTERISTICS OF *GYMNARCHUS NILOTICUS* FROM NIGER RIVER, LOKOJA

Parameters	October	November	December	SEM
BWG (g)	795.14^{ab}	1135.82^{a}	620.17^{b}	10.42
TL (cm)	91.00	107.66	80.00	10.32
SL (cm)	83.33^{ab}	92.00^{a}	69.00^{b}	4.01
HL (cm)	12.66	17.53	10.00	1.79
HW (cm)	9.50	11.15	7.50	1.34
HD (cm)	7.60	8.52	6.00	1.07
ED (cm)	1.67^{b}	1.93^{a}	1.15^{a}	0.13
SNL (cm)	7.60	10.85	6.00	1.13
BD (cm)	9.50	13.15	7.50	1.34
BW (cm)	12.66	17.53	10.00	1.79
CPD (cm)	0.97	28.88	0.83	9.34
CPL (cm)	14.10	14.90	8.50	2.15
DBL (cm)	15.83	21.91	12.50	2.24
DFL(cm)	100.00^{b}	144.00^{a}	89.00^{c}	11.28

Means in the same row with different superscripts differ significantly ($P<0.05$).

Key:

SEM = standard error of mean, BWG = body weight, TL = total length, SL = standard length, HL = head length, HW = head width, HD = Head depth, ED = eyes diameter, SNL = snout length, BD = Body depth, BW = body width, CDP = width of caudal peduncle, CPL = length of the caudal peduncle, DBL = dorsal base length and DFL = dorsal fin length.

The results of the meristic characteristics of *Gymnarchus niloticus* in Niger River, Lokoja are presented in Table III. The pectoral fin rays (PFR), dorsal fin rays (DFR), Dorsal fin rays (DFR), caudal peduncle scale (CPS), transverse scale (TS), predorsal scale (PS) values. All the parameters evaluated did not vary statistically ($P>0.05$) across the months except caudal peduncle scale.

Vol 1(1), DOI:10.82036/b9y5yx76, April 2025 ISSN:2977-9332

TABLE III: MERISTIC CHARACTERISTICS OF *GYMNARCHUS NILOTICUS* FROM NIGER RIVER, LOKOJA

Parameters	October	November	December	SEM
DFR	46.66	62.66	72.00	8.58
CPS	75.00[b]	76.66[b]	103.33[a]	5.37
TS	33.00	31.00	34.00	0.64
PDS	8.66	8.66	9.00	0.27

Means in the same row with different superscripts differ significantly (P<0.05)

Key:

SEM = standard error of mean, DFR = dorsal fin rays, CPS = caudal peduncle scale, TS = transverse scale, PS = predorsal scale.

The length weight relationship of Gymnarchus niloticus obtained from across the study period is presented in the Table IV. Earlier researches have reported that, the value of B indicates growth pattern and is said to be an isometric growth when B equals 3 and an allometric growth when it differs from 3 significantly (Alam et al., 2014; Fafioye and Ayodele, 2018). The B value seen in this study (Table IV) is less than 3 which indicates that G. niloticus exhibits negative allometric growth, a condition reflecting that, they become more elongated rather than robust as they grow and increase in weight. This result aligns with that of Agbugui et al. (2021a) discovering the allometric growth of G. niloticus in lower Niger River in Agenebode. Subsequently, R^2 is 0.906 indicating a strong correlation between the length and weight.

TABLE IV: LENGTH-WEIGHT RELATIONSHIP OF OF G. NILOTICUS FROM NIGER RIVER, LOKOJA

Parameter	Value
a	1.9596
B	0.908
R^2	0.906
Growth Type	Negative Allometric

The stages of gonadal development in G. *niloticus* are presented in Table V. No records were documented for the immature and the spent stages. *Gymnarchus niloticus* possesses a single ovary in the female and single testis in the male which is often referred to as unpaired gonad. Unpaired gonads are also reported in *Notopterus notopterus* and *G. niloticus* and (Opadokun and Ajani 2015; Agbugui *et al.*, 2021b) unlike most species with paired gonad structure. In this study, immature and spent gonads were not encountered during the sampling period. The numbers of gravid females (10) and mature males (4) encountered of the total number of fish caught during the sampling period suggests that the breeding period of the fish is from November to sometime after December. This fish has also been reported to be nest breeders which explains the number of gravid and matured fish sampled (Agbugui *et al.*, 2021b).

The variations in the gonadosomatic index of *G. niloticus* from River Niger at Lokoja, Nigeria is shown in Table VI. The GSI of *G. niloticus* varied significantly across the months, with the highest values recorded in November. Females exhibited higher GSI values compared to males, indicating a synchronous breeding strategy and is in tandem with reports of Flores *et al.* (2015). The gonadal development of many bony fishes are cyclical and season (Araújo *et al.*, 2019), the significant variations in GSI across months suggest seasonal reproductive cycles, with peak breeding activity occurring in November. The GSI values of *G. niloticus* varied significantly across the months, with the highest values recorded in December. This suggests a peak in reproductive activity during this period, particularly among females. The observed morphological variations and high GSI values in December align with known breeding patterns, suggesting that *G. niloticus* has a distinct reproductive season in the Niger River. The knowledge and understanding of these patterns are crucial for developing effective aquaculture practices and ensuring sustainable utilization of this species

TABLE V: STAGES OF GONADAL DEVELOPMENTS OBSERVED IN G. *NILOTICUS* IN NIGER RIVER, LOKOJA

Maturity stage	Gonadal development	Microscopic character	
		Testis	Ovaries
Stage I	Immature	Not encountered	Not encountered
Stage II	Quiescent/Resting	Testis were small and creamy in colour	The quiescent stage had ovaries that were translucent and creamy in colour, oocytes were not visible to the naked eye, blood vessels were seen on the surface of ovaries.
Stage III	Maturing	The males had small milt that was milky in colour.	The maturing stage had ovaries that were amber in colour with reddish patches indicating the presence of blood vessels. Oocytes were translucent and were not visible to the naked eye, blood vessels were seen on the surface of ovaries
Stage IV	Mature	The mature stage had larger milt that could be released with some pressure while the	Oocytes were amber and sometimes reddish in colour. Oocytes could be seen with naked eye and counted easily.
Stage V	Running	Milt could be released with little pressure	Eggs could be released with little pressure
Stage VI	Spent	Not encountered	Not encountered

Vol 1(1), DOI:10.82036/b9y5yx76, April 2025 *ISSN:2977-9332*

TABLE VI: VARIATIONS IN GONADOSOMATIC INDEX OF G. *NILOTICUS* FROM RIVER NIGER, LOKOJA

Parameters	October	November	December	Males	Females
N	15	12	13	18	22
GSI	0.8 – 5.4	4.7 – 13.90	6.00 – 12.78	0.50 – 4.18	4.10 – 14.75
Mean±SD	3.5±0.33	9.78±0.41	7.68±2.15	3.0±1.20	7.62±2.08

N = number; GSI = gonadosomatic index; SD = standard deviation.

4 CONCLUSION

The results of the current study suggest that, *Gymnarchus niloticus* is one of the promising fish species from Nigerian waters for aquaculture. *Gymnarchus niloticus* possesses desirable morphological and reproductive traits that support its potential for aquaculture. These results have shown that November is the peak breeding period for *G. niloticus* and the best period to collect young from the Niger River for culturing. *Gymnarchus niloticus* is a candidate for achieving sustainable fisheries and sustainable development goals of zero hunger (SDG 2), clean water and sanitation (SDG 6), responsible consumption and production (SDG 12) and life below water (SDG 14) in Nigeria. Further, the findings from the current study can be used as baseline information for management strategies of preventing overfishing and ensuring gear size restrictions during this period. Before *Gymnarchus niloticus* can contribute the the diversification of Nigerian aquaculture species, additional researches on gut contents and feeding habits, growth patterns and diseases and parasites of *Gymnarchus niloticus* are recommended to ensure an extensive sustainable culture procedures for this fish species in Nigeria.

REFERENCES

Adebiyi, F. A., Siraj, S. S., Harmin, S. A., & Christianus, A. (2011). Ovarian development of a river catfish Hemibagrus nemurus (Valenciennes, 1840) in captivity. *Journal of Experimental Zoology, Part A: Ecological Genetics, Physiology, and Evolution* 315(1): 1-8.

Agbugui M. O. and Umaru J., (2020). *Gymnarchus niloticus* (Cuvier, 1830), a threatened fish species in the lower river Niger at Agenebode, Nigeria; the need for its conservation, *International Journal of Fisheries and Aquatic Research* **6 (**1): 54 – 65.

Agbugui, M. O., Abhulimen, F. E., & Adeniyi, A. O. (2021a). Abundance, distribution, morphometric, feeding evaluation and the reproductive strategies of *Gymnarchus niloticus* in the Lower River Niger at Agenebode, Edo State Nigeria. *Journal of Applied Science & Environmental Management* 25(3): 801-810.

Agbugui, M. O., Abhulimen, F. E., & Egbo H. O. (2021b). Gross Anatomy and Histological Features of *Gymnarchus niloticus* (Cuvier, 1829) from the River Niger at Agenebode in Edo State, Nigeria. *International Journal of Zoology*. 3151609: 7pp https://doi.org/10.1155/2021/3151609

Alam, M.M., Rahman, M.T. & Parween, S. (2014). Morphometric characters and condition factors of five freshwater fishes from Pagla River of Bangladesh. *International Journal of Aquatic Biology* 2(1): 14 – 19.

Araújo, F.G., Nascimento, A.A., Gomes, I.D., Sales, A., & de Oliveira, B.A.C. (2019). Gonadal development and reproductive period of the characin *Astyanax* aff. *bimaculatus* (Characiformes: Characidae) in a tropical reservoir in Southeastern Brazil. *Zoologia* 36: 1 – 14.

Chan, C. Y., Tran, N., Pethiyagoda, S., Crissman, C. C., Sulser, T. B. & Phillips, M. J. (2019). Prospects and challenges of fish for food security in Africa. *Global Food Security* 20: 17 – 25.

Dambo, A., and Solomon, S. G. (2021). Study on Length-Weight Relationships and Reproductive Biology of *Synodontis nigrita* (Valencienes, 1840) in Kangimi Reservoir, Kaduna State, Nigeria. *Fudma Journal of Sciences*, *5*(3): 367 - 374. https://doi.org/10.33003/fjs-2021-0503-763

Eze, F., Haruna, M. Y., and Victory, A. O. (2022). A Comparative Study on the Gonadosomatic Index and Milt Volume of Four Populations of Clarias gariepinus (Burchell, 1822) Broodstock Strains from North-East Nigeria. *Asian Journal of Fisheries and Aquatic Research*, *17*(5), 8–19. https://doi.org/10.9734/ajfar/2022/v17i530415

FAO. (2020). The State of World Fisheries and Aquaculture. Food and Agriculture Organization of the United Nations.

Fafioye, O.O. & Ayodele, O.P. (2018). Length-Weight Relationship and Condition Factor of Four Commercial Fish Species of Oyan Lake, Nigeria. *Examines in Marine Biology & Oceanography* 2(2): 227 – 230.

Flores, A., Wiff, R., & Díaz, E. (2015). Using the gonadosomatic index to estimate the maturity ogive: application to Chilean hake (*Merluccius gayi gayi*). *ICES Journal of Marine Science* 72(2): 508-514.

Froese, R. and Pauly, D. (2014). *Gymnarchus niloticus* in FishBase. April 2014 version.

Ibidapo-Obe, E., and Yusuff, K. (2024). Species Diversification, a Positive Trend toward Nigeria's Aquaculture Sustainability: A Review. *Federal*

Vol 1(1), DOI:10.82036/b9y5yx76, April 2025 *ISSN:2977-9332*

Polytechnic Ilaro Journal of Pure and Applied Sciences, *6*(1). Retrieved from https://fepi-jopas.federalpolyilaro.edu.ng/index.php/journal/article/view/132 on 13/03/2025.

Iliyasu, D., Mustapha, A.R., Lawan, F. A., Ibrahim, M. A., Sambo, M. I. Abdullahi, A. M., Mustapha, M. and Timta, M. H. (2024). Morphometric and Gonadosomatic Index Studies of Some Fish species Collected from Lake Alau Maiduguri Borno state Nigeria. *Arid Zone Journal of Basic and Applied Research* 3(3): 101 – 109.

Iyaji, F. O. and Yaro, C. A. (2016). Monthly occurrence of nematode parasites of Synodontis species from rivers Niger-Benue confluence at Lokoja, Nigeria. *International Journal of Fisheries and Aquatic Studies* 4(5): 36 – 40.

Kuriakose, S. (2014). Estimation of length weight relationship in fishes. *CMFRI, FRAD Training Manual on Fish Stock Assessment and Management* (pp. 150–220). ICAR-Central Marine Fisheries Research Institute.

Lalèyè, P., Azeroual, A., Entsua-Mensah, M., Getahun, A., Moelants, T. and Vreven, E. (2020). "*Gymnarchus niloticus*". IUCN Red List of Threatened Species. 2020: e.T181688A134949091. doi:10.2305/IUCN.UK.2020-2.RLTS.T181688A134949091.en.

Mikaheel, U.A., Ipinjolu, J.K., Argungu, L.A. and Hassan, W.A. (2019). Evaluation of Growth and Gonadosomatic Index of Wild and Cultured African Mud Catfish (*Clarias gariepinus* Burchell, 1822), from Water Bodies around Sokoto Metropolis. *Journal of Agriculture and Environment* 15(2): 133 – 140.

Mohammed, Z. B., Diyaware, M. Y., Umar, H. M., Agaji, M. I., & Aliyu, M. (2019). Sex identification in *Heterotis niloticus* (Cuvier, 1829) using morphometric and meristic characters from Alau Lake, Borno State Nigeria. *FUDMA Journal of Sciences*, 3(3): 12-17.

Olopade, O. A., & Taiwo, I. O. (2013). Morphometric and meristic analysis of *Gymnarchus niloticus* (Teleostei: Gymnarchidae) from Oyan Dam and Epe Creek in South West, Nigeria. *African Journal of Tropical Hydrobiology and Fisheries* 14(2): 119-124.

Opadokun, I. O., & Ajani, E. K. (2015). Some aspects of the reproductive biology of *Gymnarchus niloticus* Cuvier, 1829 (Knife fish) in Lekki Lagoon, Nigeria. *International Journal of Fisheries and Aquatic Studies* 2(3): 166-170.

Sadiq, H. O., Igbani, F., & Akpan, M. A. (2022). Sex Ratio, Gonadosomatic Index and Fecundity of *Malapterurus electricus* in Upper Benue River in Ibi, Taraba State. *Nigerian Journal of Tropical Agriculture* 27(2): 377-384.

Sadiq, H. O., Tatah, G. W., Ganiyu, A. O., Oshioke, J. O and Ismaila, S. A. (2024). Effect of *Saccharomyces cerevisiae* on the Survival Rate and Growth Performance of *Clarias gariepinus* (Burchell, 1822). *Production Agricultural Technology* 20 (1): 19 – 25.

Shinkafi, B. A. and Ipinjolu, J. K. (2012).Gonadosomatic Index, Fecundity and Egg Size of *Auchenoglanis occidentalis* (Cuvier and Valenciennes) in River Rima, NorthWestern Nigeria. *Nigerian Journal of Basic and Applied Science* 20(3): 217 – 224.

Shola G. S., Victoria O. A., Musa A. T. and Victor T. O. (2017). Gonad Somatic Index and Feeding Habit of Selected Fish Species of Lake Kalgwaiin Jigawa State, Nigeria. *Fisheries and Oceanography Open Access Journal* 4(2): 555631. DOI: 10.19080/OFOAJ.2017.04.555631.