SUDAN UNIVERSITY OF SCIENCE AND TECHNOLOGY

COLLEGE OF GRADUATE STUDIES

SOME BIOLOGICAL ASPECTS OF *LABEO NILOTICUS, SYNODONTIS SCHALL* AND *AUCHENOGLANIS OCCIDENTALIS,* IN UPPER ATBARA AND SETIT DAMS

تقييم بعض الجوانب البيولوجية للدبس، القرقور، وحمار الحوت، في سدي أعالي عطبرة وسيتيت

A Thesis Submitted in Fulfillment of the Requirements for the Award of the Degree of Master of Animal production (Fisheries Sciences)

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الآيـــــــــة

قــال تعــالي:-

بسم الله الرحمن الرحيم

﴿ قَالُواْ سُبْحَانَكَ لاَ عِلْمَ لَنَا إِلاَّ مَا عَلَّمْتَنَا إِنَّكَ أَنتَ الْعَلِيمُ الْحَكِيمُ ﴾

صدق الله العظيم

سورة البقرة الآية (٣٢)

DEDICATION

This research dedicated to my dearest

Parents

Wife and daughters

Brothers and sisters

Friends and Colleagues

ACKNOWLEDGEMENT

Firstly: Thanks and praise be to Allah Almighty, so all credit is attributed to him for completing this research, and perfection remains for Allah alone.

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Abstract

This study was undertaken to assess some biological aspects of *Labeo niloticus*; *Synodontis schall* and *Auchenoglanis occidentalis*, it was Length-weight relationship, condition factor, Gonadal maturation, Ganado-somatic index and sex ratio as well as to determine the main spawning season, in Upper Atbara and Setit Dams, from September 2019 to January 2020. Samples of fish were collected monthly for a 5 months period. A total of fourteen seventy five specimens of *L. niloticus* (500 samples), *S. schall* (five hundred samples) and *A. occidentalis* (475 samples). The fish specimens used for the study were obtained from fishers operating along Upper Atbara and Setit Dams. Length-weight relationship of studied fish species to the total, spinal, standard length and the value of the regression coefficient (b) for *L. niloticus, S. schall,* and *A. occidentalis* in the study area were found to be 2.848, 2.838, 2.832; and 2.619, 2.700, 2.651; and 2.823, 1.801, 2.854, respectively with highly significant correlation (r) vary between 0.974, 0.983; and 0.902, 0.907; and 0.724, 0.906 respectively. This indicates allometric growth pattern ($b \neq 3$). Very high condition factor values were recorded for *L. niloticus, S. schall,* and *A. occidentalis* during the study period; the condition factor's value fluctuated between 3.048, 3.241; and 2.543, 3.253; and 2.151, 2.484, respectively, with an average of 3.12, 2.902; and 2.366, respectively. All collected samples of *L. niloticus* during this study appear immature. While *S. schall* exhibited 8.3% maturing. For *A. occidentalis* spawning season maybe coincided with *S. schall* spawning season. Two peaks of Ganado-somatic index (GSI) of *L. niloticus* female were observed in the present study. Simultaneously, the decrease of GSI of *S. schall* female was observed. Fluctuated GSI value between increase and decrease for *A. occidentalis* female observed in this study resembles spawning pattern *S. schall* (stated

above). Sex ratio of males to females of *L. niloticus, S. schall,* and *A. occidentalis* in the study area was 1:1, 1:1, and 1:09, respectively.

المستخلص

أجريت هذه الدراسة لتقييم بعض الجوانب البيولوجية للدبس ، القرقور ، وحمار الحوت مثل: علاقة الطول بالوزن ، معامل الحالة ، نضوج الغدد التناسلية ، مؤشر وزن المناسل للجسم ، النسبة الجنسية وكذلك لتحديد موسم التفريخ الرئيسي في مجمع سدي أعالي عطبرة وسيتيت ، خلال الفترة من سبتمبر ٢٠١٩ إلي يناير ٢٠٢٠. تم جمع العينات شهريا لمدة خمسة أشهر بلغ مجملها ١٤٧٥ عينة لكل من الدبس (٥٠٠ عينة) ، القرقور (٥٠٠ عينة) ، وحمار الحوت (٤٧٥ عينة). تم الحصول علي عينات الأسماك المستخدمة في الدراسة من الصيادين العاملين علي طول مجمع سدي أعالي عطبرة وسيتيت. علاقة الوزن بالطول الكلي ، الطول الشوكي ، والطول القياسي لكل من الدبس ، القرقور، وحمار الحوت ، حيث كانت قيم معامل الانحدار (b) ٢,٨٤٨ ، ٢,٨٣٨، ٢,٨٣٢ و ٢,٦١٩ ، ٢,٧٠٠، ٢,٦٥١ و ٢,٨٢٣ ، ١,٨٠١ ، ٢,٨٥٤ علي التوالي مع ارتباط معنوي (r) تراوح بين ٠,٩٧٤، ٠,٩٨٣ و ٠,٩٠٢ ، ٠,٩٠٧ و ٠,٧٢٤ ، ٠,٩٠٦ علي التوالي. توصلت هذه الدراسة إلي أن علاقة الطول بالوزن لأنوع الأسماك تحت الدراسة يشير إلي نمط نمو غير متماثل allometric ($b \neq 3$). تم تسجيل قيم عالية جدا لمعامل الحالة لكل من الدبس ، القرقور ، وحمار الحوت خلال فترة الدراسة. تقلبت قيمة معامل الحالة بين ٣,٠٤٨ ، ٣,٢٤١ و ٢,٥٤٣ ، ٣,٢٥٣ و ٢,١٥١ ، ٢,٤٨٤ علي التوالي بمتوسط ٣,١٢ ، ٢,٩٠٢ و٢,٣٦٦ علي التوالي. خلال هذه الدراسة أظهرت إناث أسماك الدبس عدم نضج للمبايض ، بينما أظهرت إناث أسماك القرقور معدل نضج بنسبة ٨,٣% . أما بالنسبة لأسماك حمار الحوت فقد تزامن موسم تفريخها مع موسم تفريخ القرقور. لوحظت قمتان لمؤشر وزن المناسل إلي الجسم (GSI) لإناث أسماك الدبس ، كما لوحظ انخفاض في مؤشر GSI لإناث القرقور. أما إناث أسماك حمار الحوت فقد كانت قيمة GSI متذبذبة بين الزيادة والنقصان. كانت نسبة الذكور إلي الإناث للدبس ، القرقور ، وحمار الحوت في منطقة الدراسة ١:١ ، ١:١ ، و٠,٩:١ علي التوالي.

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CHAPTER I

1. INTRODUCTION

Fish play an important role in the development of a nation. Apart from being a cheap source of highly nutritive protein, it also contains other essential nutrients required by the body (Kumolu-Johnson and Ndimele, 2010). The fish supply 50% of the animal protein in the diet of over 15 million of people in Sudan. Furthermore, fishes are a rich source of easily digested, high quality proteins containing all essential amino acids, fats (e.g. long- chain three omega fatty acids), vitamins (D, A and B) and minerals (including calcium, iodine, zinc, iron and selenium), particularly if eaten whole, and even small quantities of fish can have a significant positive nutritional impact on human diets in many countries. In 2013, fish accounted for about 17 percent of the global population’s intake of animal protein and 6.7 percent of all protein consumed. World catches in inland waters were about 11.9 million tonnes, continuing a positive trend that has resulted in a 37 percent increase in the past decade. The annual per capita consumption of fish in Sudan is estimated at around 1.7 kg per year per person, compared to higher rates in some of the neighboring countries, like Yemen (25.1 kg per capita) and Saudi Arabia (twelve point nine kilograms per capita). Maintaining fish consumption rates for the Sudan’s population of 35 million people at this low level without resorting to imports poses a major challenge, (http//fao.org, 2014).

The state of Al Gadarif in Sudan is renowned for its natural production for commercial purposes. This is due to the availability of productive ingredients from vast and flat muddy plains and abundant groundwater, in addition to the ubiquity of ponds, natural pits and water harvesting pits. The state abounds with agricultural and residential areas and a substantial consumption of dried fish, which is estimated at more than 40 tons/year.

Furthermore, natural production is undertaken through the use of the resources primarily located in the lake of the Upper Atbara and Setit Dams complex (one thousand and seven hundred tone/year) and the Al-Rahad River, in addition to the canal of Al-Rahad Agricultural Project and the Mina Canal. The quantities of fish that are brought to the markets of Gadarif, the capital city of Al Gadarif, are estimated at about 800 – 1000 tons/year of fresh fish. The most popular fish are *Lates niloticus*, *Barbus bagrus*, *Oreochromis niloticus*, *Clarias garieginus*, *Synodonitis schall*, *Hydrocynus brevis*, *Mormyrus niloticus*, and *Labeo niloticus*. The state of Al Gadarif produces about 80% of its the fish supply and the remaining 20% is sourced from neighboring states, usually in the event of scarcity, for example 960 quintals/year of dried fish (Cajik) comes mostly from Ethiopia, (Fish Administration, 2018).

The Atbara River, a tributary of the Nile, forms one of the five sub-basins of the Nile system within Sudan. This River is characterized by strongest seasonality and extreme flow regime compared with the other rivers. Its origin and main portion is situated on the Ethiopian high plateau between 12°- 15° N and 36°- 40° E, at altitudes ranging from 2500 to 3500 m, from Ethiopia, the Atbara River flows north and crosses the border to the Sudanese territory some 100 Km upstream of Khashm Al-Girba Dam. Downstream, it joins the main Nile about 320 Km north of the confluence of the Blue and White Niles, (Abdalla, 2018).

Abdalla, (2018) explained that, *O. niloticus* was found dominant in Khashm El-Girba reservoir, and contributed to about 25.67% and 19.15% at El-Remila and El-Monaba, respectively; while, *L. niloticus* was found to be dominant in Atbara River, and constituted about 24.21%. Fish growth is influenced by a number of factors including food, space, temperature, salinity, season and physical activity. Since fish are poikilothermic and live permanently immersed in water, they are directly affected by changes in their ambient medium. The term growth will signify change in magnitude. The variable undergoing change may be the length or other physical dimensions, including volume, weight, or mass either of an organism's whole body. Growth may also relate to the change in the number of animals in population. The relationship between length and weight of a fish species in a given geographic region is useful for at least three reasons: (a) for the estimation of weight-at-age from total reported catch weight and length-frequency distributions; (b) the weight-length relationship is a practical index of the condition of fish; (c) for between-regions life-history comparisons. The relationship between the length (L) and weight (W) of a fish is usually expressed by the equation $W = al^b$. Values of the exponent 'b' provide information on fish growth. When b = three, increase in weight is isometric. When the value of b is other than three, weight increase is allometric (positive if $b > 3$, negative if $b < 3$), (Weatherly and Gill, 1987).

Many studies have been carried out on Length-Weight relationships and condition factors of fishes in different water bodies. Edward, (2018) in Upper River Benue, Yola- Adamawa State, Nigeria. Aldow, (2019) in Khashm El-Girba Reservoir, Sudan. Ahmed, *et. al.*, (2017) in Roseires Reservoir, Sudan. Abdalla, (2018) in Khashm El-Girba reservoir and Atbara River, Kassala State, Sudan. Getso, *et. al.*, (2017) in Wudil River, Kano, Nigeria. Shalloof, and El- Far, (2017) in the River Nile, Egypt. Elias, (2016) in Lake Chamo, Ethiopia. Bhatta and Goswami, (2014) in a riparian wetland of Dhemaji District, Assam, India. and Samat, *et. al.*, (2008) in Malaysia Peninsula. but no study has been done on the species in Upper Atbara and Setit Dams complex at Gadarif State.

It is important to note that, apart from the FAO reports, there is almost no scientific literature available on the ecological features and dynamics of fish populations in the inland waters of Sudan. This emphasizes the importance of organizing a research program on the fisheries in this area in order to fully understand the biology and dynamics of the fisheries of this important part of the Nile basin (Hamza, 2012).

Objectives

The main objective of the present investigation was to assess some biological aspects of three commercially important fishes in Upper Atbara and Setit Dams complex, in order to fill the gap of knowledge about the status of the fish and fisheries of this important fresh water resource, and utilize this information in the optimum exploitation and management of its fishery resources.

Specific objectives

i. To determining the Length-weight relationship and condition factor (K) for the studied species in Upper Atbara and Setit Dams complex.
ii. To assess some biological aspects for them (gonado-somatic index, gonadal maturation and sex ratio).
iii. To determine the main spawning season for these species in Upper Atbara and Setit Dams complex.

CHAPTER II

2. LITERATURE REVIEW

2.1. Background

The Sudan inland water bodies occupy about 114,000 km2 during periods of high water level. The main fresh water fisheries are located on the River Nile and its tributaries covering an estimated total area of about three point zero seven five km2, and contributing over 90% of the estimated fish production potential of the country. The major man- made lakes and reservoirs in Sudan include the Jebel Aulia Dam (White Nile), Roseires and Sennar Dams (Blue Nile), Khashm El-Girba Dam (Atbara River), and Lake Nubia and Merowe Dam on the main Nile. These lakes and reservoirs represent the main source for freshwater supply for agriculture irrigation, navigation, water for human use, hydroelectric power generation, and for exploitation of natural fish stocks and aquaculture projects (DeGraaf *et al*., 2006). It is estimated that the total natural renewable water resources amount to149 km3/year, of which eighty percent comes across the borders from upstream countries, and only twenty percent is produced internally from rainfall. Hence, the share of water generated from rainfall is both erratic and prone to drought spells (Roskar, 2000 and Hamza, 2006).

Fish are of great importance as a source of food, nutrients and income generation, livelihood security to a large proportion of inhabitants in various parts of the world, especially, in developing countries. Due to their several qualities, fishes are also used in a variety of applications, such as biopharmaceutical drugs, oil, rituals and leather industry, (Nelson, 2006).

FAO, (2020) reported that, since 1990's most growth in production from the fisheries sector (including marine and inland fisheries) came from aquaculture, while capture fisheries production has remained relatively stable, with some growth concerning inland capture fisheries. According to FAO, (2020) the volume of global fish production is 178 million metric tons in 2019, compared with 148.1 million metric tons in the third quarter of 2010, of this amount, one hundred fifty six million metric tons were used for human consumption, securing an annual/capita consumption of 20.5kg. In 2018, African countries contributed only 7% of the total world fish production, of which inland fisheries produced about 3.00 million metric tons, (FAO, 2020).

Inland open water fishery resources play a significant role in the economy culture, tradition and food habits of the people of a nation, (Atama, *et. al.,* 2013). There is huge potential for fisheries and aquaculture in Sudan, however, the contribution of fisheries to the country's Gross Domestic Product (GDP) is marginal. Sudan is also dependent on imports of fish and fishery products to satisfy the limited per capita fish consumption. The country has great potential to drastically boost the overall national fish production already exists, (http//fao.org, 2014). The contribution of fisheries to the Gross Domestic Product (GDP) of Sudan is currently marginal. However, the country is endowed with water resources (by way of the Nile river system) and lands that can support vigorous capture fisheries and aquaculture. Sudan's capture fisheries production was almost 38400 tonnes in twenty seventeen, 35100 tonnes from inland water catches and 3300 from marine catches. In 2017, there were an estimated 2330 small boats and six hundred five powered boats. A total of 13686 people was reported as engaged in inland water fishing in 2017, with 11% women. Capture fisheries activities are centered around the River Nile and its tributaries, seasonal flood plains and four major reservoirs as well as the territorial waters of Sudan on the Red Sea. Freshwater fish culture is primarily based on the pond culture of the Nile tilapia *Oreochromis niloticus* and African catfish. The country is also dependent on imports of fish and fishery products estimated at about five point three million United States Dollar (USD) in 2017) to satisfy the limited per capita fish consumption (about 1.1 Kg in 2017). Exports are very small and were estimated at USD 1.5 million in 2017, (http//fao.org, 2014).

2.2. Fisheries in Al Gadarif State

The state of Al Gadarif in Sudan is renowned for its natural production for commercial purposes. This is due to the availability of productive ingredients from vast and flat muddy plains and abundant groundwater, in addition to the ubiquity of ponds, natural pits and water harvesting pits. The state abounds with agricultural and residential areas and a substantial consumption of dried fish, which is estimated at more than 40 tons/year. Furthermore, natural production is undertaken through the use of the resources primarily located in the lake of the Upper Atbara and Setit Dams complex (one thousand and seven hundred tone/year) and the Al-Rahad River, in addition to the canal of Al-Rahad Agricultural Project and the Mina Canal. The quantities of fish that are brought to the markets of Gadarif, the capital city of Al Gadarif, are estimated at about 800–1000 tons/year of fresh fish. The most popular fish are *Lates niloticus, Barbus bagrus, Oreochromis niloticus, Clarias garieginus, Synodonitis schall, Hydrocynus brevis, Mormyrus niloticus*, and *Labeo niloticus*. The state of Al Gadarif produces about 80% of its the fish supply and the remaining 20% is sourced from neighboring states, usually in the event of scarcity, for example 960 quintals/year of dried fish (Cajik) comes mostly from Ethiopia, (Fish Administration, 2018).

2.3. Cyprinidae

The family Cyprinidae is the most widespread and has the highest diversity (more than 2000 species) among all freshwater fish families and even among vertebrates, (Nelson, 1994). The Cyprinidae are the most species-rich family of vertebrates with an estimated 2420 species (Nelson 2006), distributed in freshwaters in North America, Africa and Eurasia, with major species diversity in eastern and south-eastern Asia. Traditionally, cyprinids have been diagnosed by the toothless jaw bones, presence of strong pharyngeal teeth organized in 1‑3 rows, upper jaw protrusible and bordered by premaxilla, barbels as well as spine-like fin rays present in some species (Nelson 2006). Cyprinids of freshwater fishes that comprise of the carp, the true minnows and their relatives commonly called the carp family or minnows, (Holden and Reed, 1972). Fishes with a moderately compressed body, relatively large cycloid scales, no adipose fin and protrusible toothless mouths. Eighteen species in six genera, (Bailey, 1994). It is highly important food fish and they make the largest part of biomass in most water bodies except for fast flowing rivers, (Turan, *et. al.*, 2013). The most characteristic feature of cyprinidae is that there are no teeth of any kind on the jaws, there are 1, 2, or 3 rows of highly specialized teeth in the floor of the pharynx between the bases of the gill bars. These teeth work against a horny pad in the roof of the pharynx. Unfortunately, nothing of these structures can be seen simply by looking into the open mouth as they are hidden behind another thick soft pad of tissue, resembling a tongue, growing from the roof of the mouth cavity. This dorsal tongue-like structure is also very characteristic of the family. Generally speaking, any fish with soft fin rays, abdominally situated pelvic fins, forked caudal fin, no adipose fin, body moderately compressed and covered with fairly large scales but with no scales on the head and with a more or less protractile mouth devoid of teeth will belong to this family. Some species of Barbus and all of *Labeo attain* a sufficient size to be economically useful, but others are small and feeble fish of little value as food and they all contain large numbers of small bones. Five genera occur in the Sudan, (Sandon, 1950). Morphological characters that support the monophyly of the Cyprinidae were reviewed by Conway et al. (2010). They concluded that only three characters, i.e. (1) anterior opening of the trigeminal-facial chamber positioned between the prootic and pterosphenoid, (2) loss of contact between infraorbital 5 and the supraorbital and (3) presence of an opercular canal, are autapomorphies of the Cyprinidae.

Cyprinids are stomachless fish with toothless jaws. Even so, food can be effectively chewed by the gill rakers of the specialized last gill bow. These pharyngeal teeth allow the fish to make chewing motions against a chewing plate formed by a bony process of the skull. The pharyngeal teeth are unique to each species and are used by scientists to identify species. Strong pharyngeal teeth allow fish such as the common carp and ide to eat hard baits such as snails and bivalves. Hearing is a well-developed sense in the cyprinids since they have the Weberian organ, three specialized vertebral processes that transfer motion of the gas bladder to the inner ear. The vertebral processes of the Weberian organ also permit a cyprinid to detect changes in motion of the gas bladder due to atmospheric conditions or depth changes. The cyprinids are considered physostomes because the pneumatic duct is retained in adult stages and the fish are able to gulp air to fill the gas bladder, or they can dispose of excess gas to the gut. Cyprinids are native to North America, Africa, and Eurasia. The largest known cyprinid is the giant barb (*Catlocarpio siamensis*), which may grow up to 3 m (9.8 ft) in length and 300 kg (660 lb) in weight. Other very large species that can surpass 2 m (6.6 ft) are the golden mahseer (*Tor putitora*) and mangar (*Luciobarbus esocinus*). The largest North American species is the Colorado pikeminnow (*Ptychocheilus lucius*), which can reach up to 1.8 m (5.9 ft) in length.[8] Conversely, many species are smaller than 5 cm (2 in). The smallest known fish is *Paedocypris progenetica*, reaching 10.3 mm (0.41 in) at the longest. All fish in this family are egg-layers and most do not guard their eggs; however, a few species build nests and/or guard the eggs. The bitterlings of subfamily Acheilognathinae are notable for depositing their eggs in bivalve molluscs, where the young develop until able to fend for themselves. Cyprinids contain the first and only known example of androgenesis in a vertebrate, in the Squalius alburnoides allopolyploid complex. Most cyprinids feed mainly on invertebrates and vegetation, probably due to the lack of teeth and stomach; however, some species, like the asp, are predators that specialize in fish. Many species, such as the ide and the common rudd, prey on small fish when individuals become large enough. Even small species, such as the moderlieschen, are opportunistic predators that will eat larvae of the common frog in artificial circumstances. Some cyprinids, such as the grass carp, are specialized herbivores; others, such as the common nase, eat algae and biofilms, while others, such as the black carp, specialize in snails, and some, such as the silver carp, are specialized filter feeders. For this reason, cyprinids are often introduced as a management tool to control various factors in the aquatic environment, such as aquatic vegetation and diseases transmitted by snails. Unlike most fish species, cyprinids generally increase in abundance in eutrophic lakes. Here, they contribute towards positive feedback as they are efficient at eating the zooplankton that would otherwise graze on the algae, reducing its abundance tiger barb (https://en.wikipedia.org, 2022).

2.3.1. Labeo

Labeo is a genus of carps in the family Cyprinidae. They are found in freshwater habitats in the tropics and subtropics of Africa and Asia (https://en.wikipedia.org, 2021). Fishes of the genus Labeo contribute significantly to subsistence fisheries in Africa. The species are characterized by a complex ventral mouth, homodont pharyngeal teeth which are close together to form a single grinding surface, and long coiled intestines, features all suited for specialized epibenthic. Labeo species conform to two general ecological groups: one favor large frequently turbid, open water bodies where the main food items are diatoms, filamentous algae and organic detritus; the second group favors flowing waters and tends to be more micro phytophagous than the first (El-Kasheif, *et. al.*, 2007). Labeo is found in the tropics. It is larger, and has more spindle shapes body, and their mouth look very different. It's one of the most common species that contributes by a considerable part to the catch of inland fisheries, ranging in length from 31 to 54 cm, (http://en.wikipedia.org, 2015).

Labeos have the two barbels on the rostrum which are common among the Cyprinidae, and also another pair of barbels at the rear edges of the lower maxilla, which has been lost in some of their relatives. They have a well-developed vomeropalatine organ. In the Weberian apparatus, the posterior supraneural bone is elongated and contacts the skull at the forward end (Stiassny, and Getahun., 2007).

Four species occur in the Sudan; *L. niloticus*, which is according to Boulenger, (1907), is by far the commonest fish between the mouth of the Nile and Halfa. *Labeo horie* and *Labeo coubie* (locally name in Sudan Tutkum) on the other hand are rare in the lower Nile and are found mainly in the Blue and White Niles. *Labeo forskalii* (locally name in Sudan Massas) is present in all three rivers and is said to occur mainly in rocky or stony places. The first three species are all fairly common at Khartoum, but the fourth is rare there, and all species are capable of growing to a considerable size, as they commonly reach about 500 mm, in length but are said to be capable of growing to nearly twice this. *L. coubie* which attains a length of 2 feet and a weight of about 10 lbs, and found in reedy waters, is full of bones and has little fat. However, in the rivers of the eastern Sudan, the usual weight of Labeo is only about 1/2 lb, (Sandon, 1950).

2.3.2. *Labeo niloticus*

The cyprinid fish *Labeo niloticus*, locally known as Lebeis, is one of the most common fish of family Cyprinidae in Egypt. In the past *Labeo niloticus* played an important role in the fishery of the River Nile (El-Kasheif, *et. al.*, 2007). The species of *labeo niloticus* is popular market fishes in rural and urban areas, and belong economically to the different traditional grades, according to consumer and fishermen preference in Sudan (Alawd and Mohammad, 2017). This species has a wide distribution, with no known major widespread threats. It is therefore listed as Least Concern. It has also been assessed regionally as Least Concern for northern and north eastern Africa. It is common along the River Nile in Egypt. In 1996 it contributed to about two percent (1441 tonnes) of the total Nile catch in Egypt. It was previously common in Lakes Manzala, Burullus and Idku (during flooding times before Aswan High Dam construction in 1970). Although the Aswan High Dam has impacted the species the species is still common over 25 years after the construction of the dam. This species is common along the Nile, from Egypt to Sudan. Northern Africa: It is known from the river Nile in Egypt. It is present in Lakes Manzala, Burullus and Idku during flooding time, also in Wadi El Rayan Lakes and Nozha Hydrodrome. Northeast Africa: It occurs in the Baro and Omo Rivers and Rift valley lakes, Ethiopia, and Sudan Nile (Azeroual, *e. al*., 2010). Clucas (1996) reported that the crude protein of fresh fish ranges between 14-20% and higher levels are obtained during winter season. Romijo (1992) reported that the moisture of fresh *Labeo spp* fish was (70.4-71.2%). Ali, *et. al.*, (1996) studied body characteristics yield and chemical composition of *Labeo spp.* They found that the results of the proximate chemical composition were 76.7%, 19.3%, 2.1 and 1.6% for moisture protein, fats and ash, respectively. Alawd, A. S, and Mohammad, S. A., (2017) studied Fillet Yield and Chemical Composition of *Labeo niloticus.* They found that the results of the proximate chemical composition were 71.2±0.2, 22.2±0.5, 4.5±0.6, and 2.1±0.6 for moisture, protein, fats and ash, respectively.

2.4. Catfish

Catfish are heavily exploited and widely cultivated. They are the fourth most widely cultivated freshwater fish after Carp, Salmon and Tilapia. There are about 13 genera and 86 known species of Claroteids in two subfamilies. The sub families are Claroteinae and Auchenoglanidinae. The subfamily Auchenoglanidinae is sometimes classified as a separate family Auchenoglanidinae. Distribution of Claroteidae includes the Nile River basin and most of west and central Africa south to the tropic of Capricorn, including the East African lakes. The most commonly known species are the (Giraffe catfish) *A. occidentalis*, (African big eye catfish) *C. longipinnus*, Leptoglanis, and Parauchenoglanis. *A. occidentalis* are of ecological and economical important in Akata Lake (Ikongbeh, *et. al.*, 2013). Catfishes support the thriving commercial fisheries in many West African countries (Lalèyè, *et. al.*, 2006).

2.5. Claroteidae

The Claroteidae are a family of catfish found in Africa, which *A. occidentalisis* a prominent member, (Nelson, 2006). Family Claroteidae was carved out of the traditional Bagridae to reflect a monophyletic group of African catfishes, (Berra, 2001). This group was also often formerly placed in Bagridae, (Nelson, 2006). The family of the Claroteidae, which has been separated from the Bagridae by Mo (1991), is endemic to Africa. It is defined by eight derived characters, including the presence of a prominent anterolateral laminar sheath of the palate. Other characteristics are a moderately elongate body, usually four pairs of barbells, an adipose fin, and strong pectoral and dorsal fin spines, (Mo, 1991). Divided the family in two subfamilies: the Claroteinae, with seven genera, diagnosed on seven derived characters, including the presence of an accessory toothplate on the palate; and the Auchenoglanidinae, with six genera, including *Parauchenoglanis Boulenger*, defined on the basis of 15 derived characters, including the location of the anterior nostrils on the anteroventral side of the upper lip, the rounded caudal fin and the location of the mandibular barbells at the outer margin of the lower jaw bones. The 12 genera contain 86 known species of claroteids in two subfamilies, Claroteinae and Auchenoglanidinae (Geerinckx, *et. al*., 2004). The subfamily Auchenoglanidinae is sometimes classified as a separate family Auchenoglanididae. This group was also often formerly placed in Bagridae (Nelson, 2006). The monophyly of Auchenoglanidinae is uncontested; it contains the three genera *Auchenoglanis*, *Parauchenoglanis* and *Notoglanidium* (Otero, *et. al*., 2007; and Geerinckx, *et. al*., 2013). Two commonly known species are the giraffe catfish, *Auchenoglanis occidentalis*, and the African big-eye catfish, *Chrysichthys longipinnis*. Claroteids have moderately elongated bodies, usually with four pairs of barbels, an adipose fin, and strong pectoral and dorsal fin spines (Geerinckx, *et. al*., 2004).

2.5.1. Auchenoglanis

The genus is diagnosed on the basis of a unique combination of characters: a deep and broad skull, narrow mouth, reduced pramaxillary tooth patches, anterior nostrils on the upper lip, and three large nuchal plates, the first which is in close proximity to the rear of the supraoccipital- a bone on the dorsal side of the great foramen(opening) of the skull. There are 9 Species:

Auchenoglanis acuticefs, *Auchenoglanis, biscutatus, Auchenoglanis* cf *occidental*, *Auchenoglanis occidental*, *Auchenoglanis sacchii*, *Auchenoglanis senegali*, *Auchenoglanis tanganicanus*, *Auchenoglanis tchadiensis* and *Auchenoglanis wittei*.

2.5.1.1. *Auchenoglanis occidentalis*

Auchenoglanis occidentalis inhabit lakes and large rivers, they occur in shallow water with muddy bottom, (Eccles, 1992). *A. occidentalisare* fairly common in October to December especially in swamps and rivers, (Nelson, 2006). The genus is diagnosed on the basis of a unique combination of characters: a deep and broad skull, narrow mouth, reduced pramaxillary tooth patches, anterior nostrils on the upper lip, and three large nuchal plates, the first which is in close proximity to the rear of the supraoccipital- a bone on the dorsal side of the great foramen (opening) of the skull. The adult body is uniformly dark brown on the sides of the body and dorsally and light brown ventrally. Juveniles are heavily spotted. The fins of adults are mostly dark but may have vague mottling. The maxillary barbels are very dark but the mandibular barbels are less dark but not white. The sides and top of the head are brown and without spots. The lower side of the head is white or light brown. the upper lip is dark but the lower lip is less pigmented. The anterior edge of the adipose fin rises gradually to its maximum height at the posterior end of the fin, well behind the mid-point of the fin. There is a good chance the size potential of the different species of Auchenoglanis may be much bigger than what is shown on the data pages. This species will grow very quickly on a diet of live or frozen foods, but prepared foods are equally popular and easier on the budget. In nature this fish is found living in both lakes and rivers, so the only real requirement is not too much bright light. Plants, although not eaten, will be uprooted in the search for food (https://www.planetcatfish.com, 2020).

2.5.2. Synodontis

The genus Synodontis is of great commercial importance, (Reed, *et. al*., 1967; and Olatunde, 1989). The genus Synodontis, commonly known as the up-side-down catfish belongs to the family Mochokidae (Akombo, *et. al.*, 2014). The Family comprises three genera-Mochochus, Synodontis and Chiloglanis, (Reed, *et. al*., 1967; Holden and Reed, 1972; and Araoye, 1999). Synodontis is the largest genus of the catfishes, Siluriformes and most widely distributed. The genus is commercially important in the inland waters of West Africa and in River Benue at Makurdi. *Synodontis schall* is one of the species that can be seen in the fish markets throughout the year, (Friel and Vigliotta, 2006). Synodontis accounts for important parts of the commercial catches in Northern Nigeria, and they are available throughout the year. Synodontis accounted for 18.00% by number and 18.68% by weight of the total fish caught, (Mortwani and Kanwai 1970). The genus Synodontis, commonly referred to as squeaker or upside-down catfish is widely distributed in African freshwaters ranging from the Nile basin, Chad, Niger and much of the West African region. The genus has over 112 species. And some of the species are commercially important comprising up to 40% of the total landings by weight in some regions of Africa, (Dadebo, 2016). Catfishes of the genus Synodontis, are small to medium-sized fish belonging to the family Mochokidae. These are a highly valued food-fish in Benin, (Baras and Laleye, 2003). And contribute an unquantified but significant proportion to the fishery of the rivers. The genus contains approximately 110 species. And hence, have more species than any teleost genus in Africa other than Barbus and Haplochromis. In Benin, about 11 species of Synodontis have been identified and 3 species, *S. schall, S.*

nigrita and *S. sorex,* are known from the Ouémé River, (Laleye, *et. al*., 2004). Laleye, *et. al*., (2006) described it as a highly valued food-fish in Benin contributing an unqualified but significant proportion to the fishery of the rivers. The genus consists of many species, some of which are commercially more important than others. Synodontis are very common throughout the year and probably more important in the commercial catches than any other genera. Very few species such as *Synodontis schall* occur universally. The genus Synodontis commonly known as the catfish is the most favoured edible fish in Northern Nigeria, (Akombo *et. al.,* 2011). Synodontis are highly relished in Ilorin, Kwara state, Nigeria and its environs because of its bony head and fleshly body which usually attracts lovers of common pepper soup, (Araoye, 1997; 2004). According to Ofori-Danson (1992), Five species were encounted, namely *Synodontis schall, Synodontis gambiensis*, *Synodontis ocellifer*, *Synodontis velifer* and *Synodontis eupterus,* in the Kpong Headpond in Ghana.

2.5.2.1. *Synodontis schall*

Synodontis schall is the most tolerant species of the genus to adverse environmental conditions and it has the widest distribution in Africa, (Lowe-McConnell, 1987). In Ethiopia, it is found in Lakes Abaya, Chamo, Turkana and Omo River in the south, Baro River and its tributaries in the west and in Wabe Shebele River in the southeast, (Shibru Tedla, 1973; Paugy and Roberts, 1992; Golubtsov, *et. al*., 1995; and Mulugeta 2016).

All species in the genus *Synodontis* have a hardened head cap that has attached a process (humeral process) which is situated behind the gill opening and pointed towards the posterior. The dorsal fin and pectoral fins have a hardened first ray which is serrated. Caudal fin is always forked. There is one pair of maxillary barbels, sometimes having membranes and occasionally branched. The two pairs of mandibular barbels are often branched and can have nodes attached. The cone-shaped teeth in the upper jaw are short. S-shaped and movable in the lower jaw. These fish produce audible sounds when disturbed rubbing the base of the pectoral spine against the pectoral girdle. A robust and large fish. In juveniles the spots are smaller on the head and more faded on the fins the body having fairly evenly spaced small round dark spots on a whitish and brown mottled body. Sub-Adult coloration is solid shade of very dark gray or brown with small dark spots which are even smaller on the head and usually denser higher on the body. The fins can still retain faded spotting. As the fish gains adult size the spots will fade leaving a solid brown. Some specimens have reddish tails, as in *Synodontis clarias,* with which *S. schall* has often been confused. The "schall complex" includes several closely related fishes including *S. macrops* and *S. budgetti*. The long triangular humeral process comes to a point and has a thick lower margin. The Maxillary barbels have a narrow membrane. The genital pore is in a small furrow of tissue (in healthy fish) and will be obstructed by the pelvic fins. The male has a somewhat ridged genital papillae on which the spermatoduct is on the back side, facing the tail fin. A gravid female will also show an extended papillae but the oviduct is on the ventral side of the papillae (And may also show a little redness if really gravid). A thin or emaciated female will have just two pink pores, the oviduct and the anus. Omnivore with a voracious appetite. Will eat small tank mates! On the subject of food, this fish is an important food fish and has been from the time of the ancient Egyptians. Has not been bred in aquaria. Is bred in irrigation canals and large ponds. In nature, breeding occurs during the flood season (https://www.planetcatfish.com, 2020).

Synodontis schall does not have any direct commercial importance to the traditional fishery of Lake Chamo, Ethiopia apart from being used as bait to capture other piscivorous fish species. However, it is ecologically important because it serves as the main prey of the commercially valuable catfish, (Hailu and Seyoum, 2001). It is also among the prey fishes of the most valued piscivore, the Nile perch (*Lates niloticus*) in this lake, (Elias, 2012). *Synodontis schall* is a fecund fish with variations in time and localities. Also, variability of reproductive parameters with age, size, weight and gonad weight are evident, (Mekkawy, and Hassan, 2011). *Synodontis schall* is one of the most abundant fish in both littoral and pelagic regions of the lake. According to Elias, *et. al,*. (2012) the fish picks scales from the bodies of other fish using comb-like bony structures found on the marginal part of its mouth. The local fishermen consider the species as a nuisance since it entangles to their gill nets by its long and serrated spiny fin rays making it very difficult to remove from the gillnets. Akombo, *et, al*., (2014) they recorded that mean condition factor of *S. schall* in river Benue, (Nigeria) fluctuated between 2.838 to 2.874 for female, male and combined sex. While Laleye, *et, al*., (2006) they reported that mean condition factor of *S. schall* in Oueme river (Benin) 1.513. [Ahmed, *et. al,*. (2017) reported that, negative allometric growth pattern with regression coefficients of 2.569 for *S. schall* in Roseires Reservoir] Sudan. Alawd, A. S, and Mohammad, S. A., (2017) studied Fillet Yield and Chemical Composition of *Synodontis schall*. They found that the results of the proximate chemical composition were 73.5±0.6, 22.2±0.8, 2.0±0.3, and 2.3±0.5 for moisture, protein, fats and ash, respectively.

2.6. Length-Weight relationship

Fisheries management and research often require the use of biometric relationships in order to transform data collected in the field into appropriate indices, (Ecoutin, *et. a.,* 2005). Studies about fish biology and ecology are important in order to improve fishery management and conservation. In this

sense, studies about length-weight relationship (LWR) are of great importance in fishery assessments and management, (Atama, *et. al.*, 2013).
Study of morphometric and meristic characteristics applicable for evaluating the population structure, identifying stocks, studying short-term, environmentally induced disparities and the findings can be effectively used for improved fisheries management (Singh, *et. al*. 2012).

Length-weight relationship (LWR) of fishes are important in fisheries and fish biology because they allow estimation of the average weight of the fish of a given length group by establishing a mathematical relation between them, (Sarkar, *et. al.,* 2008; and Mir, *et. al.,* 2012). Moussa, (2003) Stated that the relation between body weight and length is a simple but essential in a fishery management. This relation represents one of the most studied biological characters of fish biology. It is known that weight of a fish increases as a function of its length. Length-weight relationship is an essential biological parameter needed to appreciate the suitability of the environment for any fish. Data on the length and weight of fish have commonly been analysed to yield biological information. The length. Length-weight relationship is very important for proper exploitation and management of the population of fish species, (Anene, 2005). The growth performance and well-being of any fish species in relation to habitat diversity are determined through the measure of its length-weight relationship and condition factor. Such a knowledge on length and weight is useful in the assessment of fish stock and population to predict the potential yield of the species. The size variation in relation to growth in biomass of fish is expressed in length-weight statistics. In the natural population the growth dynamics of any fish species is dependent on its habitat variability. The growth pattern in fishes follow the cube law. As the fish grows isometrically exhibiting the exponential value exactly at three point zero, such relationship is considered valid. However, in reality, it may deviate from this ideal value due to environmental condition or condition of the fish, (Bhatta and Goswami, 2014).

Several indices are used in assessing the condition of a fish with regard to factors that affect their distribution and abundance, alteration in food, spawning and breeding grounds. Some common indices used to assess fish status is the length-weight, length-length relationship, growth factor and condition factor, (King, 2007; and Mahmood, *et. al*., 2012). These indices require biometrics relationship to show the status of the fish life in a given ecosystem. In length-weigh relationship, fisheries can attain either isometric or allometric, which can either be positive or negative Isometric growth is associated with no change of body shape as an organism, (Nehemia, *et. al*., 2012). length-weigh relationship of fishes is most frequently used in the calculation of fish's average weight for a certain length-class and the conversion of an equation of growth in length into an equation of growth in weight, besides morphological comparisons between population of some species or between species by pauly, (Shinkafi and Ipinjolu, 2010). Length-weight relationship has a number of important applications in fish stock assessment, (Morey, *et. al*., 2003). The relationship between total length and other body weight are also very much essential for stabilizing the taxonomic characters of the species, (Ahmed, et. al., 2011). The length-weight relationship is very important for proper exploitation and management of the population of fish species, (Edward, 2018). To obtain the relationship between total length and other body weight, it is very much essential for stabilizing the taxonomic characters of the species, (Pervin and Mortuza, 2008). The Length-weight relationship can give information on the repeated, growth rate, life ex-pectancy, mortality and production of fish species and it is an important tool in fish biology, repeated, physiology, ecology and fisheries assessment, (Atama, *et. al.*, 2013; Oscoz, *et. al.*, 2005; Samat, *et. al.*, 2008, and Pawar, and Supugade, 2017). Moreover, it is useful in determining weight and biomass when only length measurements are available, as indicator of condition, to assess the relative well-being of a fish population and to allow for statistical comparisons of species growth between different populations, (King, 1996; Shenouda, *et. al.*,1994; and Soyinka, and Ebigbo, 2012). Abdalla (2018) concluded that Length-weight relationship which species indicates allometric growth pattern ($b \neq 3$). According to Ahmed, *et. al*., (2011) The growth coefficient (b) values obtained for the six fish species ranged between two point two seven eight for *Clarias lazera* and 3.680 for *Bagrus bayad* and differed significantly ($p<0.005$) from 3, which indicates that most of the fish species (61.1%) have negative allometric growth. According to Ahmed, *et. al.*, (2017) The slope (b) values obtained for the five fish species ranged between two point zero two nine for *Alestes baremose* and 2.973 for *Eutropius niloticus* and differed significantly ($p<0.005$) from 3, which indicates that all of the fish species have negative allometric growth. Edward, (2018) concluded that “b” values obtained during the period of the study showed that increase in length is not in equal proportion with the weight under constant specific gravity. There was a significant correlation ($P<0.05$) between length and weight of *A. occidentalis* exhibiting linear relationship in all the Sites. *C. gariepinus* and *O. niloticus* did not correlate significantly ($p>0.05$) between length and weight exhibiting linear relationship. Hamid, (2018) explained that value of the regression coefficient (b) of the length and weight relationship of *Labeo niloticus, O. niloticus, S. schall* and *A. dentex* in Awal-Bab site, exhibited negative allometric growth of the four studied species. Values of one point four seven seven, 2.154, 2.507, and 2.649 were recorded *A. dentex, O.*

niloticus, *Labeo niloticus* and *S. schall* respectively in Awal-Bab site. The correlation coefficient (r) was highly significant and varied between 0.442 and zero point seven nine eight for the four studied species. While the values of the exponent (b) varied from 2.285, 1.528, 2.007, and 1.196 for *O. niloticus*, *L. niloticus*, *A. dentex* and *S. schall* respectively in El-Regaiba fishing site, indicating negative allometric growth of the four fish species. The correlation coefficient (r) was highly significant and ranged between 0.404 and 0.848 for the four studied species. As for Kirma fishing site, the values of the exponent (b) ranged between 2.796, 2.393, 2.156, and 2.648 for *L. niloticus, A. dentex*, *S. schall* and *O. niloticus* respectively, indicating negative allometric growth of the four fish species. The correlation coefficient (r) was highly significant and ranged between 0.539 and .0931 for the four studied species. In Wad El Mahi fishing Site the values of the exponent (b) were found to vary between three point one eight for *Labeo niloticus*, 2.656 for *A. dentex*, 2.426 for *S. schall* and 2.445 for *O. niloticus*. Hence, while *Labeo niloticus* exhibited isometric growth, *A. dentex*, *S. schall* and *O. niloticus* showed negative allometric growth during the period of investigation. The correlation coefficient (r) was highly significant and varied from 0.626 - 0.998 for the four studied species. According to Samat, *et. al.*, (2008) It was revealed that *P. pardalis* has the allometric growth with b = 2.538 ± 0.039 and a = 0.040 ± 0.006 (n = 928). According to Bhatta and Goswami, (2014) The relative growth coefficient (b) values for male was found to be 4.18 and for female was 2.65. According to Abd-Elhalim, (1983). Values of regression coefficient (b) for *S. schall* 1.3671 for female and 1.2617 for male.

2.7. Condition Factor (Fulton's factor) (K)

In fisheries science, the condition factor is used in order to compare the "condition", "fatness" or wellbeing of fish. It is based on the hypothesis that heavier fish of a particular length are in a better physiological condition, (Ahmed, *et. al*., 2011). Condition factor is also a useful index for monitoring of feeding intensity, age, and growth rates in fish, (Ndimele, *et. al*,. 2010). The condition factor (K) is a parameter of the state of well-being of the fish based on the hypothesis that heavier fish of a particular length are in a better physiological condition, (Atama, *et. al.,* 2013). The condition of a fish reflects recent physical and biological circumstances, as it is strongly influenced by both biotic and abiotic environmental variables, and fluctuates by interaction among feeding habits, parasitic burden and fish physiological conditions, (Seiyaboh, *et. al.,* 2016; Ikongbeh, *et. al.,* 2013, and Imam, *et. al.,* 2010) Condition factor is essential in understanding the life cycle of fish species and it also contribute to adequate management of the species, (Iyabo, 2015). Also condition factor reflect the interactions between biotic and abiotic factors in the physiological condition of the fishes, (Lalrinsanga, *et. al*., 2012). It can be used to compare the inter- and intra- specific "condition", "fatness" or wellbeing of fish from the same or contrasting habitats, it is a useful index for the monitoring of feeding intensity, age and growth rates in fish, (Oni, *et. al.,*1983). And it can be used as an index to assess the status of the aquatic ecosystem in which fish live, (King, 1996; Bakare, 1970; and Ezenwaji, 2004). Abdalla (2018) concluded that mean condition factor of *O. niloticus* ranged between 2.547 to 3.560 and between 1.671 to 2 - 548 for *L. niloticus.* According to Ahmed, *et. al.,* (2011) the condition factors (K) of the fish species ranged from (0.506 ± 0.416) in *Clarias lazera* to (3.415 ± 0.707) in *Oreochromis niloticus.* According to Ahmed, *et. al.,* (2017) the condition factors (K) of the fish species ranged from (0.7018 ± 0.1912) in *Hydrocynus froskalii* to (1.9505 ± 0.2293) in *Eutropius niloticus.* Hamid, (2018) explained that seasonal variation of condition factor (K) of *Labeo niloticus* relatively high values of (K) were observed for *L, niloticus* in Awal-Bab and Kirma fishing sites, and relatively low values of (K) were recorded for El-Regaiba and Wad El-Mahi fishing sites. A minimum value of (K) in Awal-Bab site (two point one nine four) was recorded (July), while a maximum value of (K) (three point nine six two) was recorded in August, with an average value of three point seven five one. In El-Regaiba site, the condition factor varied between 2.307 - 3.106, with an average value of 2.713. The minimum value of (K) was obtained in December, and the maximum value in July. In Kirma fishing site, the condition factor of *L. niloticus* ranged from 2.501-3.633 and an average value 3.297. The minimum value of (K) was recorded in March, and maximum value in February. However, the minimum value of (K) in Wad-El-Mahi site was recorded in November (1.552), while the maximum value 2.486 was obtained in June, with an average value of 1.963. While high values of (K) were observed for *S. schall* in Awal-Bab fishing site, while relatively low values of (K) were recorded in El-Regaiba, Kirma and Wad El-Mahi fishing sites. The minimum value of (K) recorded for this species in Awal-Bab site was 3.002 (August), and the maximum value of 3.957 in October, with an average value of 3.856. In El Regaiba site, the condition factor of *S. schall* varied between1.535 - 2.700, with an average value of two point four two eight. The minimum and maximum values were recorded in December and June respectively. In Kirma site, the minimum recorded value of (K) was 1.619 (October), and the maximum value of 3.127 was recorded in May, with an average value of 1.982. However, the condition factor of *S. schall* varied between 1.733 (September) and 3.082 (January), and an average value of 1.966 in Wad El-Mahi site. According to Samat, *et. al.,* (2008) the condition factor (K) for *P. pardalis* ranged between 1.125 and eight point eight zero two. According to Bhatta and Goswami, (2014) the condition factor

(K) value was 1.29 ± 0.27 for male and 1.66 ± 0.28 for female. According to Abd-Elhalim, (1983). The mean value of (K) ranged between 2.279±0.189 and 3.269 ± 0.346 for male and female.

2.8. Gonadal maturation

Shankafi and Ipinjolu, (2012) recorded sex maturation stages of gonad of *Auchenoglanis occidentalis* in River Rima (Nigeria). Babiker and Ibrahim, (1979) noticed seven stages of *O. niloticus* gonad maturation. Babiker, (1984) recorded sex stages of gonad maturation of *T. nilotica*. According to Roy and Mandal, (2015) seven maturity stage of *Labeo bata* were differentiated in India. According to Macki, *et. al.,* (2005) in Western Australia; ten stages of *Scomberomorus commerson* ovary maturation form juvenile to spent fish and five stages of testes form immature to spawning. Montchowui, *et. al*., (2012) recorded five stages of gonad maturation of *Labeo parvus*. Ganie, *et. al*., (2013) in Yamuna River (India), recorded sex maturity stages of *Oreochromis mossambicus*. Adebiyi, *et. al.,* (2013) noted sex maturity stages of *Pomadasys jubelini* in Lagos coast (Nigeria). Seasonal variations in the incidence of different stages of gonad maturity of *O. niloticus* were also discussed by Shalloof and Salama, (2008) they reported five stages for gonad maturity, with two peaks of breeding time. Murua and Saborido, (2003) reported sex maturity stages of marine fish.

2.9. Gonado-somatic index (GSI)

The gonado-somatic index is use to follow the seasonal development of the gonads. The GSI increase with development of gonads in both male and female fish; however, the indices decreased in running and spent fish, (Abdalla, 2018).

Estimation of fecundity and GSI of a fish is essential for evaluating the commercial potentialities of its stock, life history, practical culture and actual management of the fishery (Gupta and Shrivastava 2001, Rahimibashar *et al*. 2012). Fecundity of fish stock is one of the important components of fishery biology as it has direct bearing on fish production, stock recruitment and stock management. Estimation of fecundity is not only important for these parameters but it is equally important for acquiring knowledge about different races, as different races have characteristic fecundities and egg diameter, which inturn is helpful in recognizing the population wither it is a homogenous population (with a single species) or a heterogeneous type of population (including different stocks), (Shafi, 2012). According to Bagenal and Braum, (1978) Fecundity may be defined as the number of mature eggs in the ovary of female fish before spawning. Identifying the spawning chronologies of riverine fishes is an important component in determining basic life-history information, for assessing the impacts of environmental variability on the dynamics of fish populations to relate environmental parameters to successful spawning, and for relating habitat selection to an associated fitness consequence (Rosenfeld, 2003). Knowledge of spawning activity is gaining more importance as restoration efforts on large rivers to benefit endangered species and fish diversity requires specific knowledge of when fishes reproduce and the coincidence of environmental conditions. GSI, a ratio of gonad weight to body weight, is a commonly used indicator of reproductive periods. The reliability of GSI in determining reproductive status has varied among species with different reproductive strategies. Found GSI to be reliable in determining the reproductive status of fish species that spawn once annually but is of limited value when fish are protracted spawners. Alternatively, histology is an effective technique used to identify reproductive timing of fishes even when species spawn multiple times or have low reproductive investment. Whereas histology is a more reliable technique than GSI, the amount of time required and cost associated with histology diminish the practical advantage of the technique. Therefore, because of ease of calculation and minimal cost, GSI may be the preferred method once validated (Brewer, *et. al*., 2008). The proportion of mature individuals at age or length, usually called the maturity ogive, is an important population attribute because it directly relates to the reproductive potential of the population. Knowledge of the maturity ogive is especially important in exploited fish populations because it determines the spawning biomass upon which conservation measurements are usually based. The estimation of the maturity ogive commonly consists of three steps. First, the spawning season must be identified. Second, representative samples of individuals collected during the spawning season are assessed to establish their maturity stage. Finally, observed proportions of maturity at length or age are computed which are then conventionally modelled using a logistic function. The maturity staging process is the most crucial step in estimating the maturity ogive because small errors in stage assignment can lead to profound variations in estimated parameters for the fitted model (Vitale, *et al*., 2006).

GSI is a metric that represents the relative weight of the gonad to the fish weight. GSI has been widely used to evaluate reproduction timing because it is inexpensive and easy to compute. Changes in GSI are mostly determined by variations in yolk concentration during different oocyte stages and thus it provides information about maturation and seasonal patterns in gonad development (Lowerre-Barbieri, *et al*., 2011).

Abdalla, (2018) concluded that gonado-somatic index of *O. niloticus* females ranged between 1.965 - 2.620 and 0.434 - 0.439 for males, with two periods of increase, and this verify two breeding seasons of this species. The gonado-somatic index of *L. niloticus* showed one period of increase, and ranged between 1.281 - 1.795 and 0.499 - 1.701 for females and males respectively. According to Abd-Elhalim, (1983) GSI varied from about 0.5 to ten point eight (August), suggesting a combination of spent and ripe female, however, the mean index being 1.13 suggested that the influence was greater from the spent females. Highest indices were calculated from August just that onset of spawning, and apart from April and October. According to Ghanbahadur, *et. al* (2013) the peak value of GSI was observed only once in the month of May (47.29%) indicating only one spawning period in *C. gachua* i.e. from June to August. According to Mekkawy, and Hassan, (2011) gonado-somatic index recorded the higher value during the period from January to July for the females of *S. schall*. The highest value was recorded in March for the males of *S. schall*.

2.10. Sex ratio

The biology of reproduction accounts for the interaction of the individuals and their surroundings, the identification of the breeding season, the onset of the maturity and spawning times and frequency, the behavior attached to breeding, the fecundity, the parental care recruitment and replacement. Sex ratio is very important in fishery application, and determination of the spawning season by examination of the gonad, (Abdalla, 2018). Sex ratio variation is a longstanding theme in evolutionary biology. Fisher, (1930) famously theorized that natural selection should maintain 1:1 sex ratios by continuously favouring the rare sex, thereby always returning skewed sex ratios to equality. In nature, skewed sex ratios are a common observation across the tree of life, and explanations include differential mortality rates for males and females, inbreeding and local competition for mates, endocrine- disrupting environmental pollutants, and adaptive maternal effects that allow differential investment in male or female offspring. Despite the attention paid to the causes of sex ratio variation in nature, and in some cases its consequences for population growth, theory and tests of its effects on communities and ecosystems are lacking. This lack of attention may be in part due to a presumption that the sexes of most species are ecologically equivalent in their effects on communities and ecosystems. (Fryxell, 2015). According to Abdalla (2018), the sex ratio of *L. niloticus* was approximately 1:1. According to Komolafe and Arawomo (2007), the sex ratio of *O. niloticus* was approximately 1:1. According to Hamid (2018) Sex ratio of males to females of *L. niloticus* varied from 1:1.5 to 1:2 to 1:1.4 to in Awal-Bab site, El-Regaiba site and Kirma site respectively, revealing that the two sexes were equally represented in the catch in the three fishing sites. However, only three specimens of *L. niloticus* were caught in Wad El-Mahi sampling site. Sex ratio of males to females of *S. schall* showed values of (1:2.4) in Awal-Bab and El-Regaiba fishing sites, revealing that the females have considerably outnumbered the males in the two fishing sites. In Kirma and Wad El-Mahi fishing sites, sex ratio of *S. schall* showed that both sexes were present in nearly equal numbers in the catch, with a value of 1:1.4 for males to females. According to Abobi, *et. al.*, (2015), in White Volta,(Ghana), sex ratio of *Labeo senegalensis*, belonging Cyprinidae family was 1: 1.5. According to Araoye, (2001) the sex ratio of *Synodontis schall* was 54.6% for females, and forty five point four percent for males.

CHAPTER III

3. MATERIALS AND METHODS

3. 1. Study Area

The Upper Atbara and Setit Dams complex is a twin dam complex comprising Rumela Dam on the Upper Atbarah River and Burdana Dam on the Setit (Tekezé) River in eastern Sudan. It is located on latitude 14º16′36″N and longitude 35º53′49″E (Plate 3.1). The site of the twin dam is located about twenty kilometres upstream from the junction of the Atbarah and Setit rivers and about 80 kilometres south of the Khashm el-Girba Dam. Rumela Dam on the Atbarah is 55 metres in height and Burdana Dam on the Setit is 50 metres in height. The two dams are connected and have a total length of thirteen kilometres. The twin dam complex has a joined reservoir with a storage capacity of about 2.7 billion cubic metres of water. The maximum filling level is 517.5 metres above sea level (http://en.wikipedia.org, 2015).

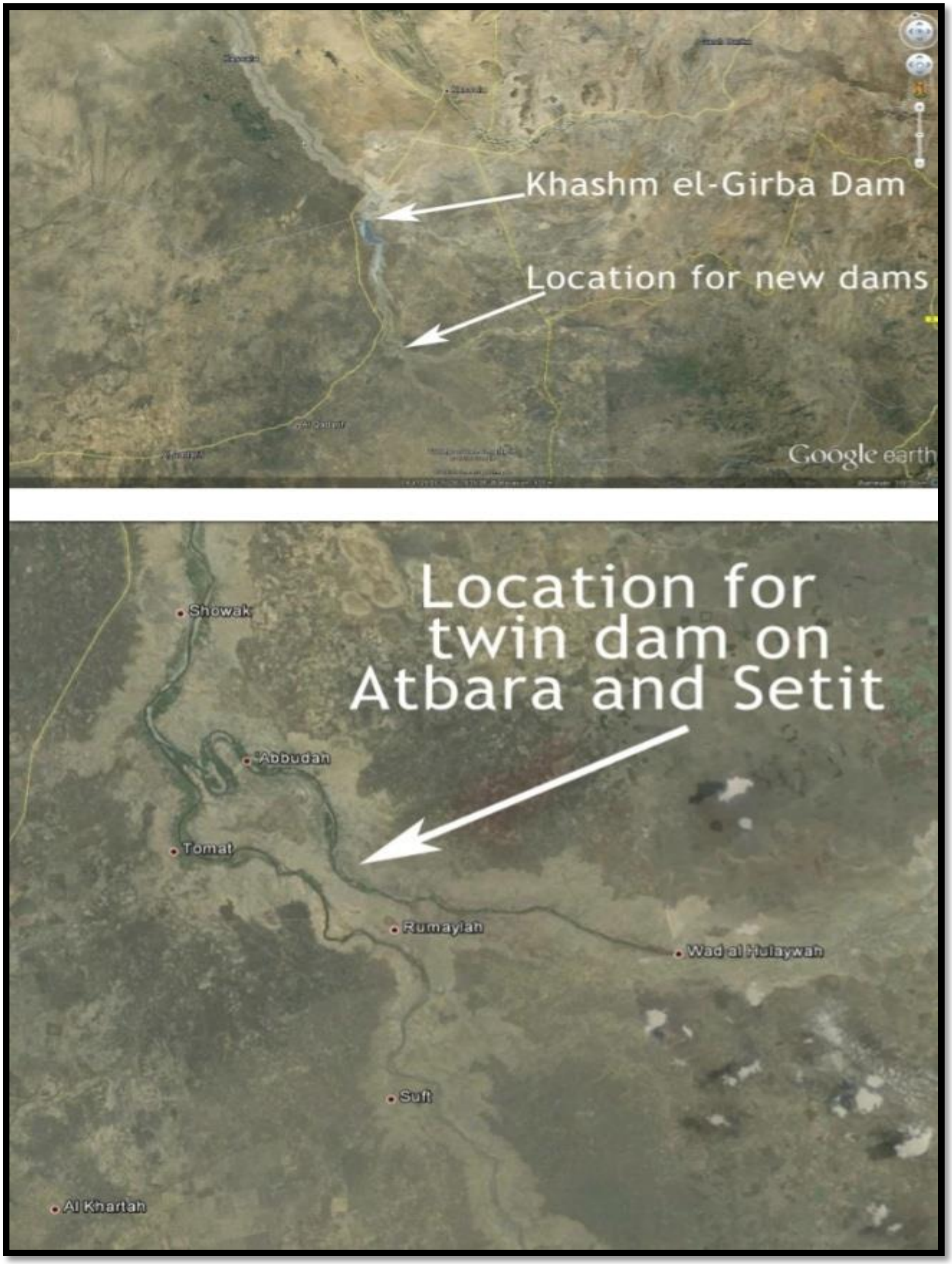

Plate 3.1: A map of location for twin dam on Atbara and Setit, and the sampling site (source http://preservethemiddlenile.wordpress.com, 2012).

Figure 3.1: The Upper Atbara and Setit Dams complex (source http://en.imsilkroad.com, 2019).

3.2. Sample collection

The samples for this study were collected from Upper Atbara and Setit Dams complex during September 2019 to January 2020. A total of fourteen seventy five individuals of *L. niloticus* (500 samples), *S. schall* (500 samples) and *A. occidentalis* (475 samples) were randomly sampled monthly for five months, four time a month, 25 samples for each species per week, usually in the morning between 8:00 – 10:00 am and in the evenings between 3:30 – 6:30 pm.

The fish specimens used for the study were purchased from fishermen operating along Upper Atbara and Setit Dams complex. These fishermen use various fishing gears including hooks, traps and a set of multifilament gill nets.

3.3. Materials and methods

3.3.1. Morphometric measurements

The collected fish were identified down to the species level using identification keys published by Sandon (1950), Abu Gideiri (1984) and Bailey (1994).

Total length (TL) from the tip of snout to the tip of caudal fins.

Spinal length (SP) from the tip of snout to the end of middle caudal fin rays.

Standard length (SL) from the tip of snout to the flexure between caudal peduncle caudal fin were recorded to the nearest (0.1 cm) Were measured using a measuring board. Body weight (W) gonad weight were taken and recorded to the nearest (0.1g) using a digital balance (SF-400A); After dissection, gonad maturity of each fish was identified according to Babiker and Ibrahim (1979).

3.3.2. Biological studies

3.3.2.1. Length-weight relationship

The relationship between length and weight of the *Labeo niloticus, Synodontis schall* and *Auchenoglanis occidentalis* were calculated according to the equation

$$W = al^b$$ (Bagenal and Tesch, 1978)

Where:

W= total weight.

L= standard length.

a and b are constants, were estimated by converting the logarithmic linear function, (Sparre and Venema, 1992).

$$\text{Log}(W) = \log(a) + b \log(L)$$

(a) and (b) were obtained using least square regression according to Sparre and Venema (1992), where (b) is the regression coefficient.

Excel package was used to plot the curve of the relationship between length and weight, and the values of the constants (a) and (b) for each species were estimated.

3.3.2.2. Condition Factor (Fulton's factor) (FCF)

The well-being of each *Labeo niloticus, Synodontis schall,* and *Auchenoglanis occidentalis* was calculated according to Bagenal and Tesch (1978), using the following formula:

$$FCF = \frac{w}{L^3} \times 100$$

Where

W= weight

L= standard length

This formula use according to length-weight relationship constant (b =3), if (b≠3) use this formula:

$$FCF = \frac{w}{L^b} \times 100$$

3.3.2.3. Gonad maturation

Fish were differentiated to sex and the stages of maturation for gonads were noted following Babiker and Ibrahim (1979), as in Table (3.1) and (3.2).

Table 3.1: - Distinctive feature of the ovaries at different stages of gonadal maturation (Babiker and Ibrahim, 1979).

Maturity stage	**Colour and shape**
Immature I a	Flesh coloured, thin and short
maturing I b	Cream coloured, translucent and elongate, no visible oocytes
Mature II	Light yellow with a red hue, numerous small visible oocytes
Ripening III	Bright yellow, distinct visible oocytes
Ripe IV	Dull yellow, with distinct large oval or pear-shaped oocytes. About one third of the visceral cavity in length
Spawning V	Dull yellow, flaccid, with numerous large yellow oocytes
Spent VI	Flesh coloured, flaccid and shrunken

Table 3.2: Distinctive feature of the testes at different stages of gonadal maturation (Babiker and Ibrahim, 1979).

Maturity stage	**Colour and shape**
Immature I a	Flesh coloured, thread-like and transparent
maturing I b	Flesh coloured, about half length of visceral cavity
Mature II	Dull white, thickened and enlarged. About ⅔ length of visceral cavity
Ripening III	Cream coloured, thicker and larger than stage II about 3/4 length of visceral cavity
Ripe IV	Cream coloured, thickened, enlarged and distended. Extended full length of visceral cavity
Spawning V	Cream coloured, extended full length of visceral cavity
Spent VI	Flesh coloured, tubular and shrunken

3.3.2.4. Gonado-somatic Index (GSI)

Was determined according to (Bagenal, 1978), using the following formula:

$$\text{GSI}(\%) = \frac{Gonadweight(g)}{Bodyweight(g)} \times 100$$

3.3.2.5. Sex ratio

The male and female was identify by genital papilla and confirmed by dissection, sex ratio was determined by the following formula

$$\text{sex ratio} = \frac{\text{number of females}}{\text{number of males}}$$

3.4. Data analysis

Data was analysed using statistical package: Past statistical package version 3.14 and Microsoft office Excel 2007, significant difference ($p \geq 0.5$).

CHAPTER IV

4. RESULTS

4.1. Morphometric measurements

The morphometrics measurements for all species in the study were presented in Tables (4.1, 4.2, and 4.3). The sample size, the minimum, maximum and mean length (± SD), also the minimum and maximum weights were measured for all species in the study and presented in table (4.4).

For the total length table (4.1) shows the sample size, the minimum, maximum and mean length (± SD), (all species in the study). The minimum value of total length for *Labeo niloticus* was 21.2 cm, and the maximum value was 47.5 cm, with an average value of 30.369 ± 4.996 cm. On the other hand, the minimum values of (TL) for *S. schall* was16.2 cm, and the maximum value was 39 cm, with an average value of 26.117 ± 3.330 cm. While it was the minimum value of total length for *A. occidentalis* 20.1 cm and the maximum value was 47 cm, with an average value of 36.175 ± 4.315 cm. with highly significant of correlation (*r*) vary between 0.964 and 0.882.

Table 4.1: shows data observation, minimum, maximum and average of total, length (TL) for (all species in the study).

species	No.	Min.(TL) in cm	Max.(TL) in cm	(mean(TL) ± sd) in cm	*r*
L. niloticus	500	21.2	47.5	30.369 ± 4.996	0.964
S. schall	500	16.2	39	26.117 ± 3.330	0.882
A. occidentalis	475	20.1	47	36.175 ± 4.315	0.888

Table (4.2) shows the sample size, minimum, maximum and average of spinal length (± SD), (SP) for (all species in the study). The minimum value of (SP) for *Labeo niloticus* was 18.4 cm, and the maximum value was 41.3 cm, with an average value of 25.894 ± 4.307 cm. The minimum values of (SP) for

S. schall were 13 cm, and the maximum value was 33.2 cm, with an average value of 20.790 ± 2.603 cm. While the minimum value of (SP) for *A. occidentalis was* 14.5 cm and the maximum value was 46 cm, with an average value of 35.103 ± 4.519 cm. with mid to high correlation significant (*r*) ranged between 0.969 and 0.547.

Table 4.2: shows data observation, minimum, maximum and average of spinal length (SP) for (all species in the study).

species	No.	Min(SP) in cm	Max.(SP) in cm	(mean(SP) ± sd) in cm	*r*
L. niloticus	500	18.4	41.3	25.894 ± 4.307	0.969
S. schall	500	13	33.2	20.790 ± 2.603	0.897
A. occidentalis	475	14.5	46	35.103 ± 4.519	0.547

For the standard length table (4.3) shows the sample size, minimum, maximum and average (± SD), for three species was studied, the minimum value of (SL) for *Labeo niloticus* was 17cm, while a maximum value was thirty seven centimeters. with an average value of 23.557 ± 3.903 cm. As for *S. schall*, it was the minimum value 11.6 cm, and the maximum value was thirty point five centimeters, with an average value of 18.511 ± 2.377 cm. While it was the minimum value of (SL) for *A. occidentalis* 16.7 cm, and the maximum value was 38.8 cm, with an average value of 29.367 ± 3.680 cm. with strong correlation coefficient (*r*) (highly significant) fluctuated between 0.962 and 0.867.

Table 4.3: shows data observation, minimum, maximum and average of standard length (SL) for (all species in the study).

species	No.	Min.(SL) in cm	Max.(SL) in cm	(mean(SL) ± sd) in cm	*r*
L. niloticus	500	17	37	23.557 ± 3.903	0.962
S. schall	500	11.6	30.5	18.511 ± 2.377	0.902
A. occidentalis	475	16.7	38.8	29.367 ± 3.680	0.867

For the total weight (W) table (4.4) shows data observation, minimum, maximum and average for (all species in the study). A minimum value of (W) for *Labeo niloticus* was 88 gm, while a maximum value was 927 gm, with an average value of 258.472 ± 139.411 gm. While the minimum value of (W) for *S. schall* was 49 gm, and the maximum value was 682 gm, with an average value of 189.978 ± 73.362 gm. As for *A. occidentalis* it was the minimum value 94 gm, and the maximum value was 1334 gm, with an average value of 632.417 ± 203. 714 gm. with mid correlation significant (*r*) ranged between 0.743 and 0.565.

Table 4.4: shows data observation, minimum, maximum and average of total weight (W) for (all species in the study).

species	No.	Min.(W) in gm	Max.(W) in gm	(mean(W) ± sd) in gm	*r*
L. niloticus	500	88	927	258.472 ± 139.411	0.565
S. schall	500	49	682	189.978 ± 73.362	0.743
A. occidentalis	475	94	1334	632.417 ± 203. 714	0.572

4.1.1. Length-weight relationship

4.1.2. Length-weight relationship of *Labeo niloticus*

The total, spinal and standard length of *L. niloticus* in Upper Atbara and Setit Dams complex were plotted against the corresponding weights yielded logistic curves that were straightened by logarithmic transformation of data, as shown in Table 4.5 and Figure (4.1), (4.2) and (4.3); Values of the regression coefficient (b) its 2.848, 2.838, and 2.832 respectively, with highly significant of correlation (*r*) vary between 0.974 and 0.983, this indicate negative allometric growth pattern of *L. niloticus*.

Table 4.5: Linear fit of length-weight relationship for species of *L. niloticus, S. schall* and *Auchenoglanis occidentalis* in Upper Atbara and Setit Dams complex during the study period (2019/2020).

Species	L-W Relationship	Equation	No.	Value		*r*
				(a)	(b)	
L. niloticus	TL – W	Log W= -1.842 + 2.848 Log TL	500	-1.842	2.848	0.974
	SP - W	Log W= -1.631 + 2.838 Log SP	500	-16.31	2.838	0.983
	SL - W	Log W= -1.507 + 2.832 Log SL	500	-1.507	2.832	0.975
S. schall	TL – W	Log W= -1.453 + 2.619 Log TL	500	-1.453	2.619	0.902
	SP - W	Log W=-1.300 + 2.700 Log SP	500	-1.300	2.700	0.904
	SL - W	Log W=-1.102 + 2.651 Log SL	500	-1.102	2.651	0.907
A. occidentalis	TL – W	Log W= -1.618 + 2.823 Log TL	475	-1.618	2.823	0.906
	SP - W	Log W= -0.003 + 1.801 Log SP	475	-0.003	1.801	0.724
	SL - W	Log W= -1.012 + 2.854 Log SL	475	-1.012	2.854	0.871

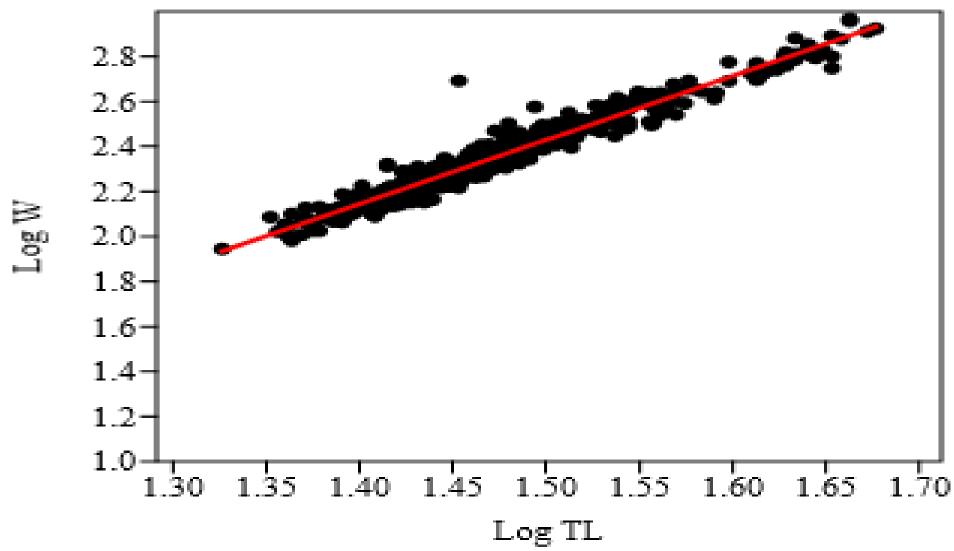

Figure (4.1): linear fit of total length-weight of *L. niloticus* in Upper Atbara and Setit Dams complex during the study period (2019/2020).

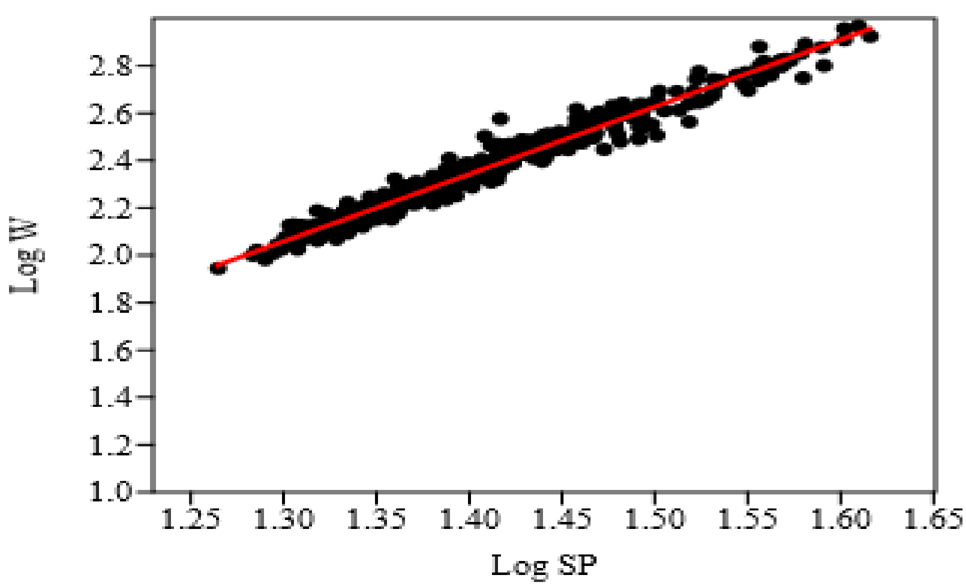

Figure (4.2): linear fit of spinal length-weight of *L. niloticus* in Upper Atbara and Setit Dams complex during the study period (2019/2020).

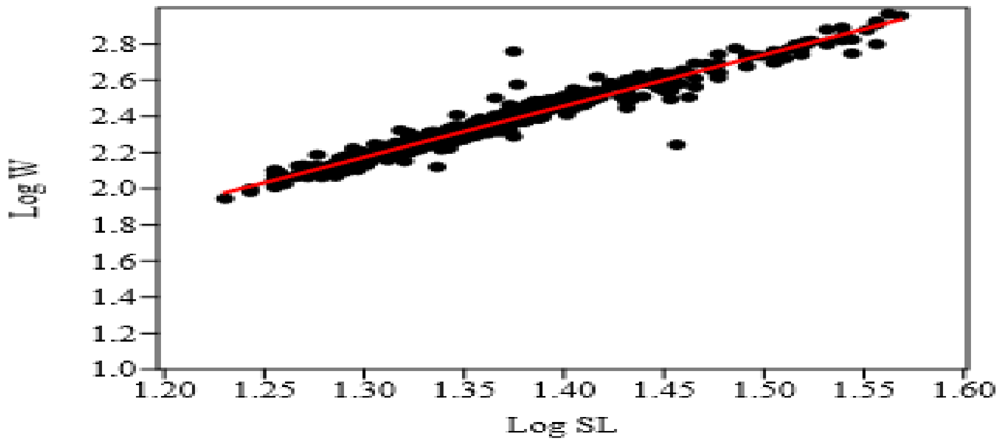

Figure (4.3): linear fit of standard length-weight of *L. niloticus* in Upper Atbara and Setit Dams complex during the study period (2019/2020).

4.1.3. Length-weight relationship of *Synodontis schall*

Regression coefficient (b) of the total, spinal and standard length against weight relationship of *S. schall*, exhibited negative allometric growth of this species; Values of this relation was 2.619, 2.700, and 2.651 respectively, with strong correlation coefficient (*r*) (highly significant) fluctuated between zero point nine zero two and 0.907; as showed in Table 4.5 Fig. (4.4), (4.5) and (4.6).

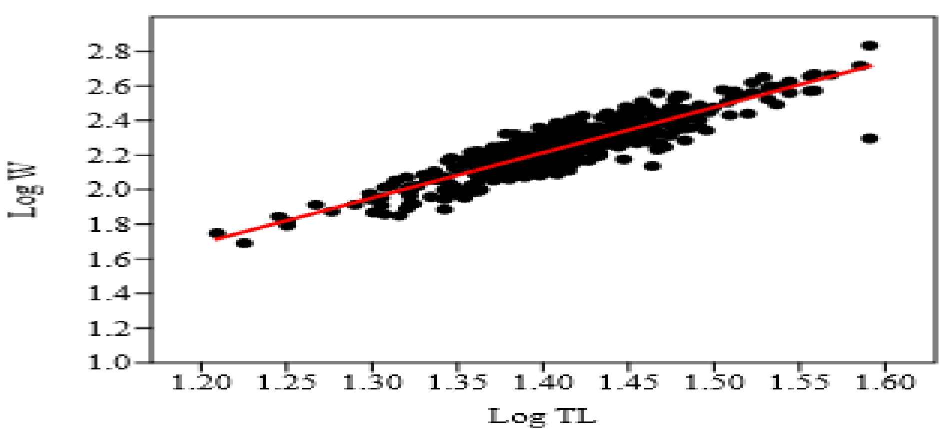

Figure (4.4): linear fit of total length-weight of *S. schall* in Upper Atbara and Setit Dams complex during the study period (2019/2020).

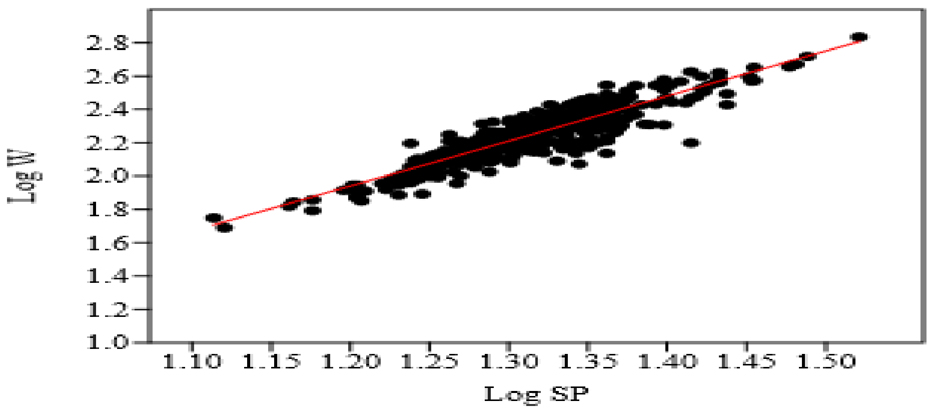

Figure (4.5): linear fit of spinal length-weight of *S. schall* in Upper Atbara and Setit Dams complex during the study period (2019/2020).

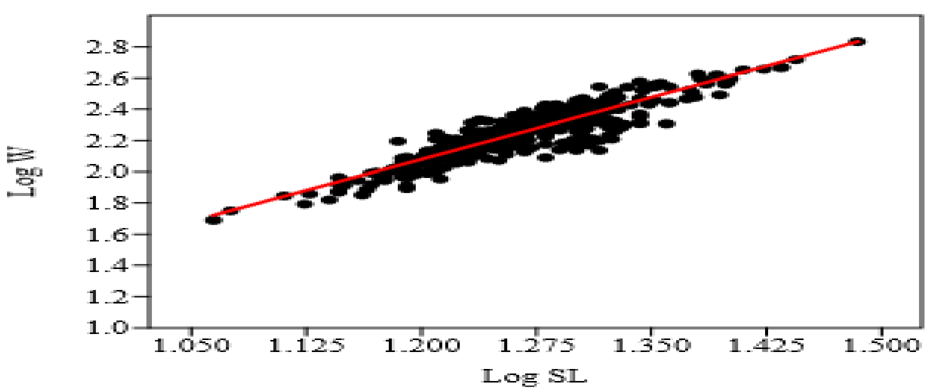

Figure (4.6): linear fit of standard length-weight of *S. schall* in Upper Atbara and Setit Dams complex during the study period (2019/2020).

4.1.4. Length-weight relationship of *Auchenoglanis occidentalis*

Relationship of total, spinal and standard length to weight of *A. occidentalis*; showed negative allometric growth include values of regression coefficient (b) 2.823, 1.801, and 2.854 respectively, with mid to high correlation significant (*r*) ranged between 0.724 and 0.906; as shown in Table 4.5 Fig. (4.7), (4.8) and (4.9).

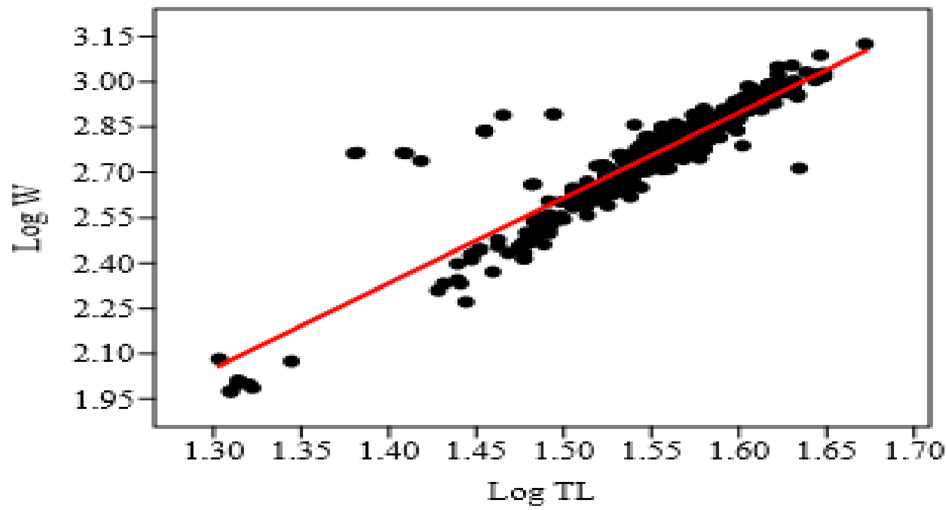

Figure (4.7): linear fit of total length-weight of *A. occidentalis* in Upper Atbara and Setit Dams complex during the study period (2019/2020).

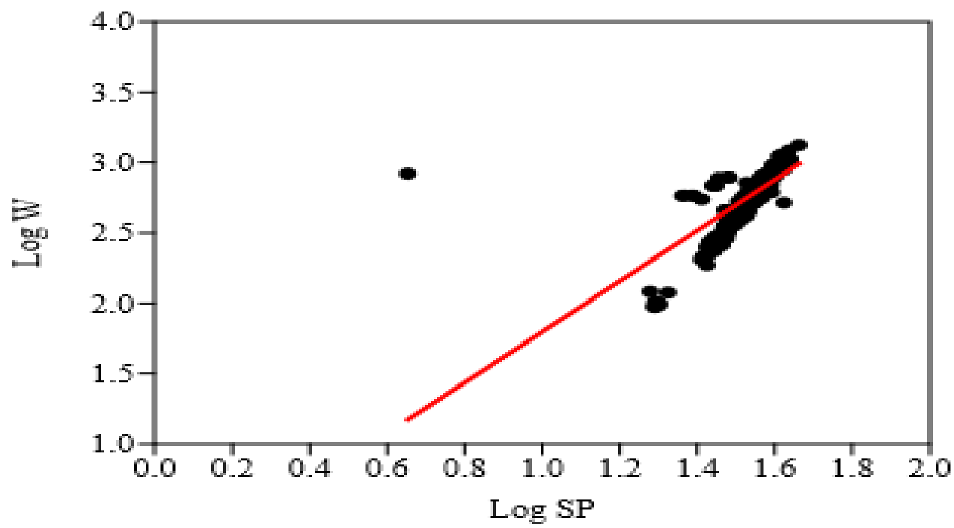

Figure (4.8): linear fit of spinal length-weight of *A. occidentalis* in Upper Atbara and Setit Dams complex during the study period (2019/2020).

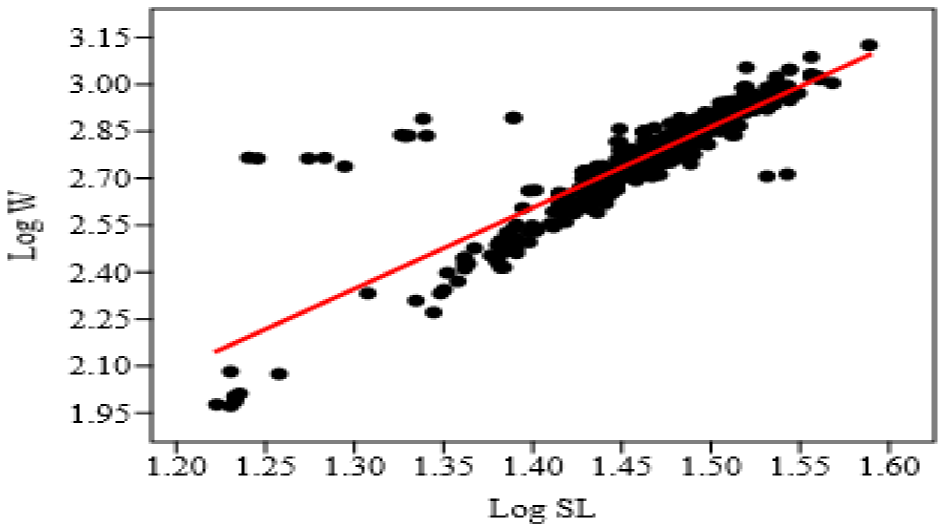

Figure (4.9): linear fit of standard length-weight of *A. occidentalis* in Upper Atbara and Setit Dams complex during the study period (2019/2020).

4.2. Condition factor of studied fish species

Table 4.6: Average condition factor for species of *L. niloticus*, *S. schall* and *A. occidentalis* in Upper Atbara and Setit Dams complex during the study period (2019/2020).

Month	*L. niloticus*	*S. schall*	*A. occidentalis*
Sep - 2019	3.096 ± 0.331	2.781 ± 0.347	2.484 ± 0.456
Oct - 2019	3.095 ± 0.281	2.543 ± 0.499	2.337 ± 0.231
Nov - 2019	3.123 ± 0.281	3.098 ± 0.313	2.433 ± 0.150
Dec - 2019	3.241 ± 0.235	3.253 ± 0.293	2.444 ± 0.190
Jan - 2020	3.048 ± 0.181	2.837 ± 0.303	2.151 ± 0.162
Mean	3.121 ± 0.262	2.902 ± 0.435	2.366 ± 0.292

4.2.1. Condition factor of *Labeo niloticus*

Very high values of condition factor were recorded for *L. niloticus* during study period; value of condition factor fluctuated between 3.048 and three point two four one, with an average 3.121, as shown in Table 4.6. These indicate to suitable environment condition for this species.

4.2.2. Condition factor of *Synodontis schall*

Values of condition factor recorded for *S. schall* in Upper Atbara and Setit Dams complex ranged between 2.543 and 3.253; while mean value of (K) calculated are 2.902, as shown in Table 4.6. This results showed better growth for this species, maybe due abundance of nutriment and environment condition beside low fishing effort.

4.2.3. Condition factor of *Auchenoglanis occidentalis*

Minimum value of (K) recorded for *A. occidentalis* in fishing sites were 2.151, and the maximum value is 2.484; with average 2.366.

Generally, very high values of condition factor ($p > 1.0$) were recorded for *Synodontis schall* in all three sampled fishing sites in Upper Atbara and Setit Dams complex, as shown in Table 4.6.

4.3. Maturity status of studied fish species

All collected samples of *L. niloticus* during this study appear as immature, this indicate almost of this samples not reach maturity stage. While *S. schall* exhibited 8.3% maturing and 8.3% ripening of collected specimens during September 2019, this period situated between Autumn and Winter season; Maybe maturing and ripening sample catch by end of spawning season; for *A. occidentalis* spawning season maybe coincided with *S. schall* spawning season, the evidence here, during September 2019 8.3% of samples was spent and 16.6% of specimens are maturing this period also coincided with end of Autumn season, as shown in Fig. (4.10), (4.11) and (4.12).

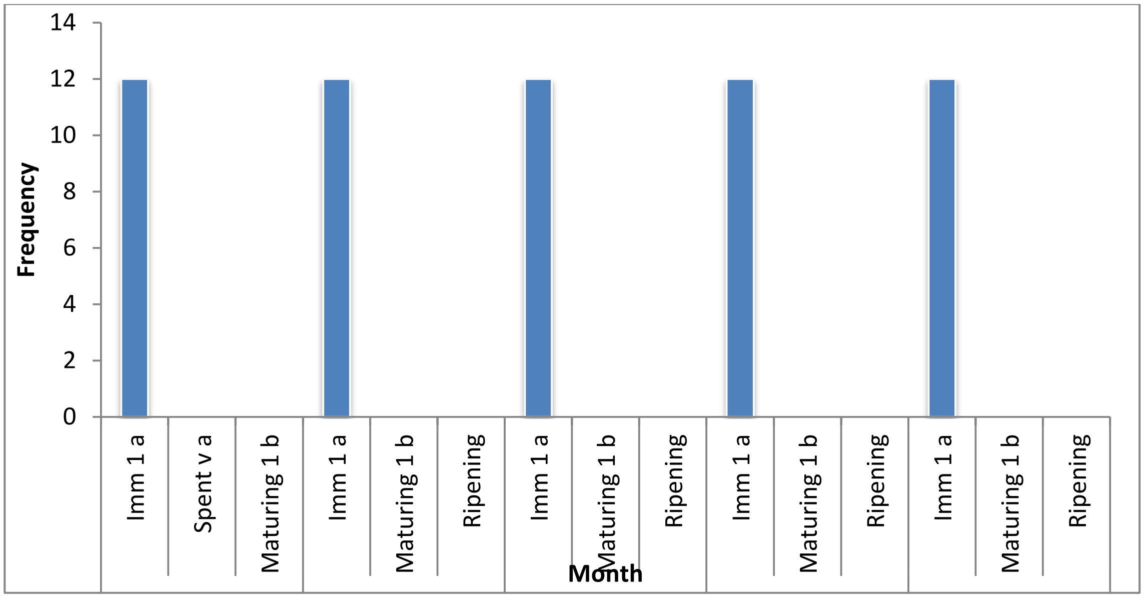

Figure (4.10): Maturity status of *L. niloticus* female per month in Upper Atbara and Setit Dams complex during the study period (2019/2020).

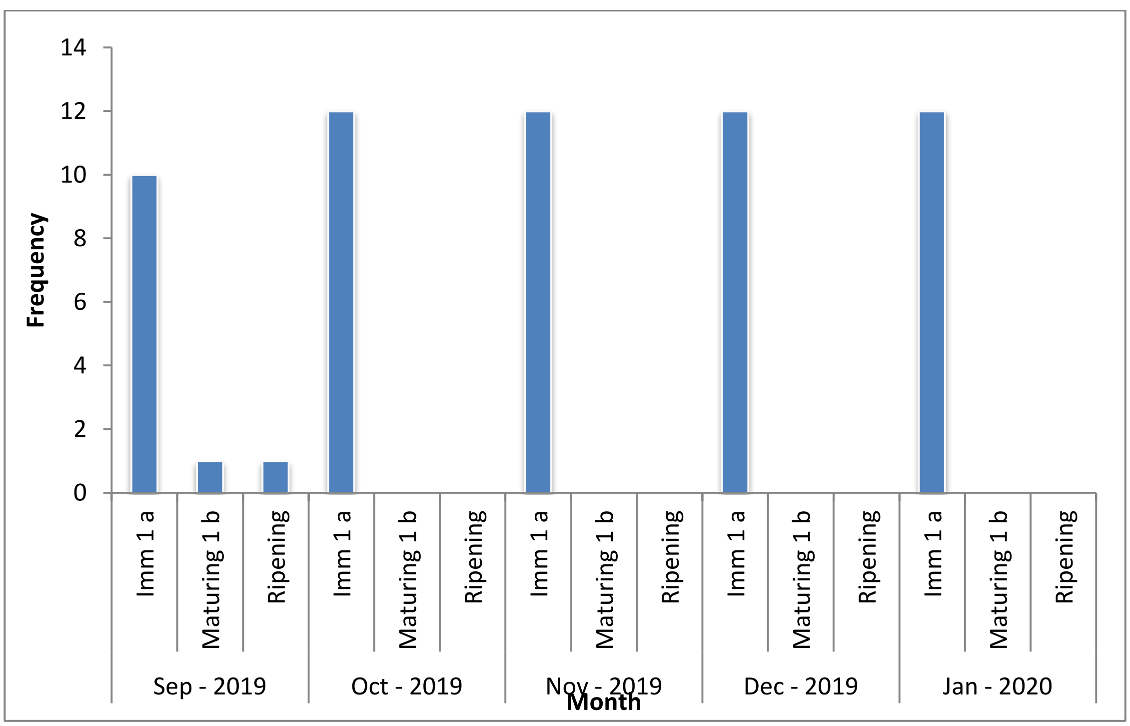

Figure (4.11): Maturity status of *S. schall* female per month in Upper Atbara and Setit Dams complex during the study period (2019/2020).

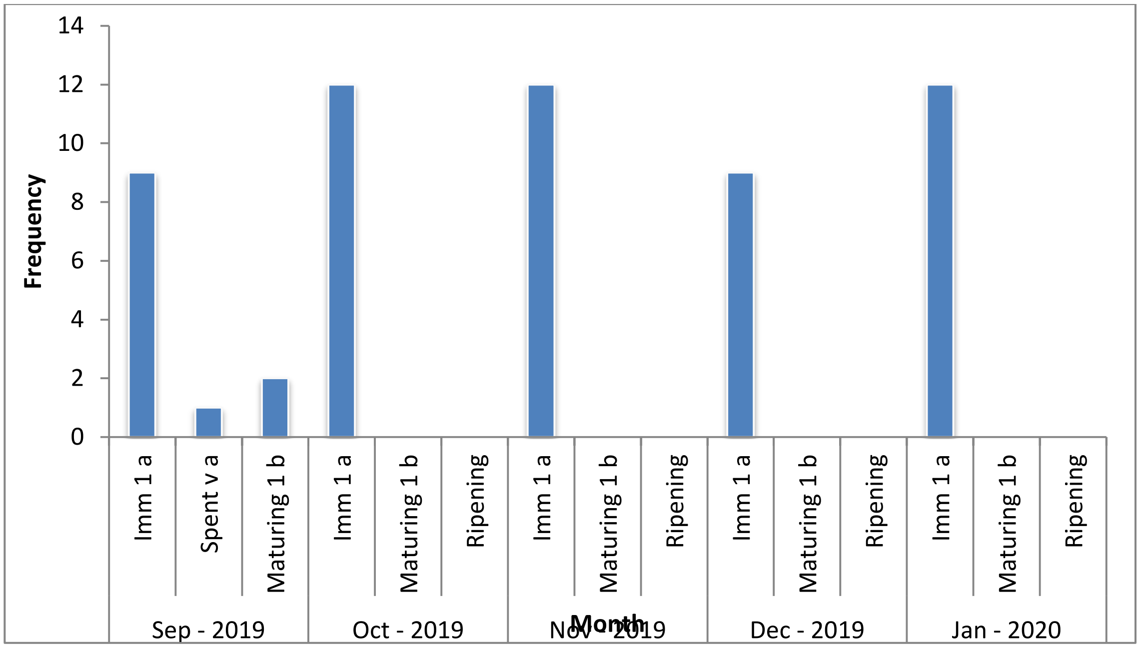

Figure (4.12): Maturity status of *A. occidentalis* female per month in Upper Atbara and Setit Dams complex during the study period (2019/2020).

4.4. Gonado-somatic index

4.4.1. Gonado-somatic index of *Labeo niloticus*

The development of the gonads is closely associated with the general growth of the body. Two peaks GSI of *L. niloticus* female were observed in present study, GSI start increase during September/October to reach first peak during November and decrease during November/December and start increase during December to reach highest level during January, as shown in Fig. (4.13).

4.4.2. Gonado-somatic index of *Synodontis schall*

Decrease of GSI of *S. schall* female were observed in present study, GSI start decrease during September/October, this decrease maybe refluxed to: some samples in spent stage and disappear of stages of gonad filled by ova; also, almost of specimens are immature. GSI, start increase during November to January, this maybe recurs to physiological change in gonad, as shown in Fig. (4.14).

4.4.3. Gonado-somatic index of *Auchenoglanis occidentalis*

Fluctuated GSI value between increase and decrease for *A. occidentalis* female observed in this study resembles spawning pattern *S. schall* (stated above), as shown in Fig. (4.15).

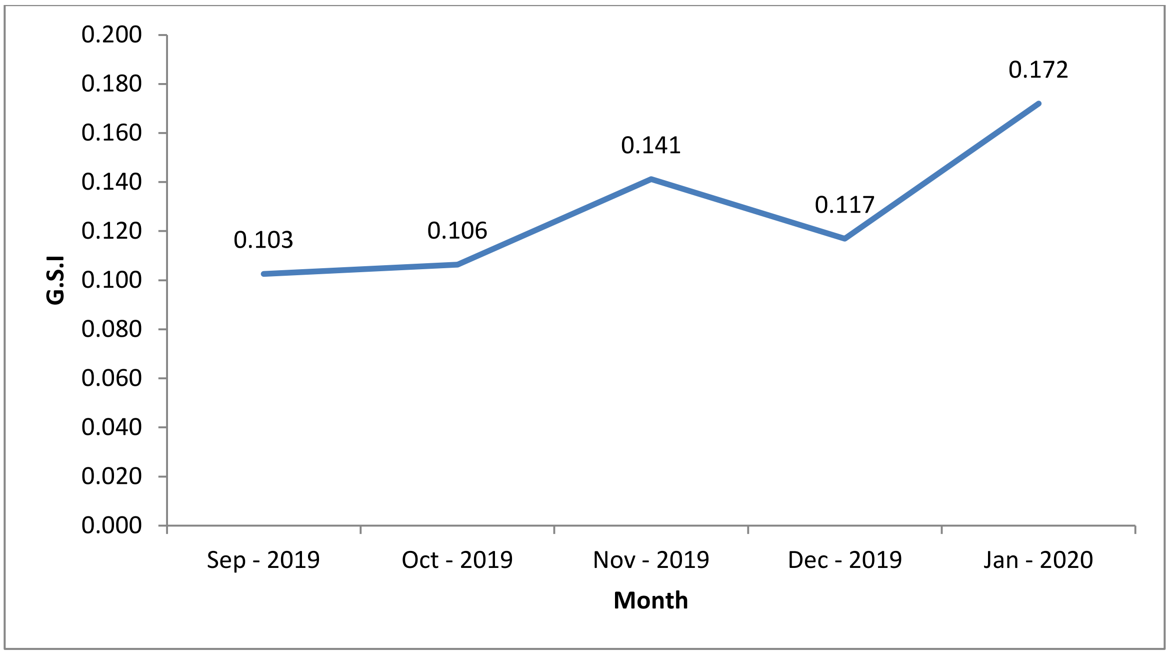

Figure (4.13): Average of GSI for *L. niloticus* female per month during the study period (2019/2020).

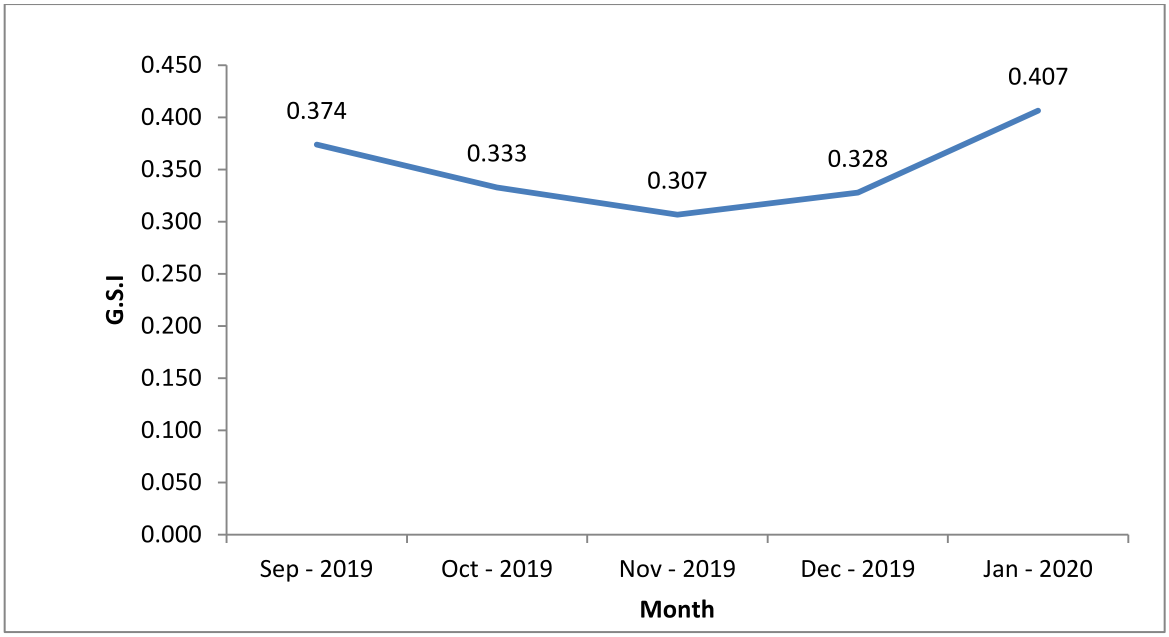

Figure (4.14): Average of GSI for *S. schall* female per month during the study period (2019/2020).

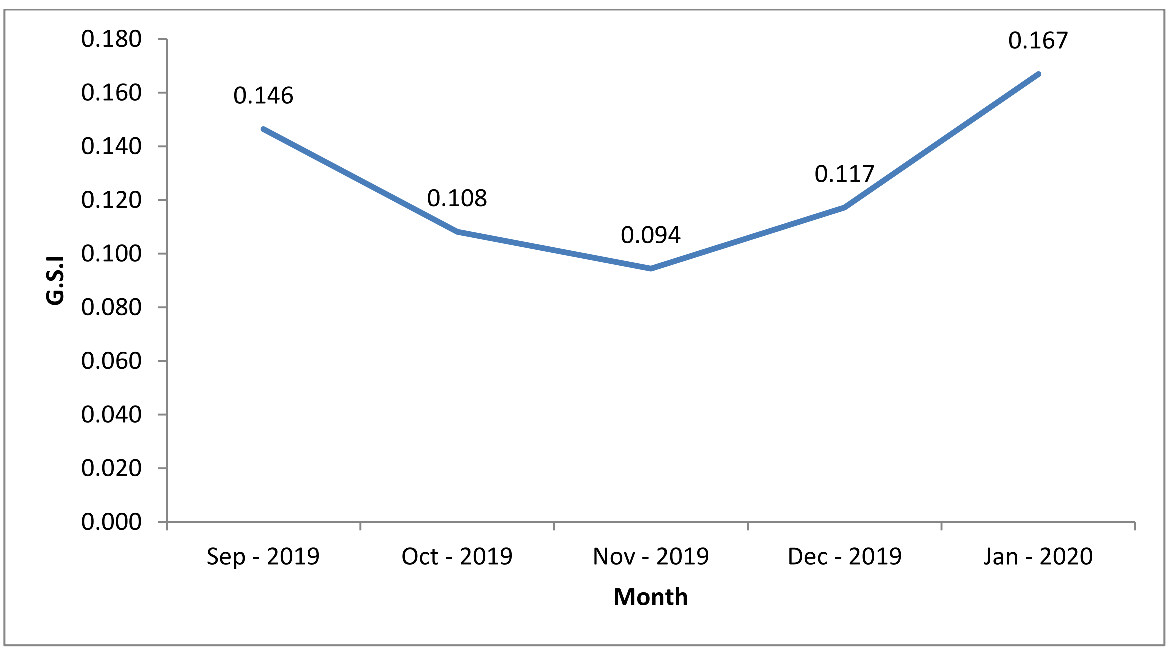

Figure (4.15): Average of GSI for *A. occidentalis* female per month during the study period (2019/2020).

4.4.4. Sex ratio of the studied fish species

Sex ratio of males to females of *L. niloticus*, *S. schall*, and *A. occidentalis* in the study area was 1: 1, 1:1, and 1:09, respectively, as shown in table (4.7), (4.8) and (4.9).

Table 4.7: Sex ratio of males to females of *L. niloticus* in Upper Atbara and Setit Dams complex during the study period (2019/2020).

Months	**Male**	**Female**	**Sex ratio**
Sep - 19	51	49	1.0:1.0
Oct - 19	53	47	1.0:0.9
Nov - 19	47	53	1.0:1.1
Dec - 10	49	50	1.0:1.0
Jan - 2020	48	52	1.0:1.1
Average	248	251	1.0:1.0

Table 4.8: Sex ratio of males to females of *S. schall* in Upper Atbara and Setit Dams complex during the study period (2019/2020).

Months	**Male**	**Female**	**Sex ratio**
Sep - 19	48	52	1.0:1.1
Oct - 19	58	42	1.0:0.7
Nov - 19	52	48	1.0:0.9
Dec - 10	49	50	1.0:1.0
Jan - 2020	48	52	1.0:1.1
Average	255	244	1.0:1.0

Table 4.9: Sex ratio of males to females of *A. occidentalis* in Upper Atbara and Setit Dams complex during the study period (2019/2020).

Months	Male	Female	Sex ratio
Sep - 19	55	45	1.0:0.8
Oct - 19	49	51	1.0:1.0
Nov - 19	47	28	1.0:0.7
Dec - 10	47	53	1.0:1.1
Jan - 2020	49	51	1.0:1.0
Average	247	228	1.0:0.9

CHAPTER V

5. DISCUSSION

The morphometric measurements taken for each fish were total length (TL), spinal length (SP) and standard length (SL). This study showed that, minimum total length 21.2; 16.2 and 20.1cm while the maximum length 47.5; 39 and 47 cm; with an average value (± SD) of 30.369 ± 4.996; 26.117 ± 3.330 and 36.175 ± 4.315 cm for *L. niloticus*, *S. schall* and *A. occidentalis* respectively, as shown in table (4.1).

Ikongbeh, *et. al*., (2013) reported the mean weight and standard lengths of *A. occidentalis,* were 284.6 ± 6.9 g and 25.34 ± 0.36 cm. The relationship between length and weight differs among species of fish according to their inherited body shape, and within a species according to the condition (robustness) of individual fish, (Schneider, *et. al*., 2000).

The relation between body weight and length is a simple but essential in a fishery management. This relation represents one of the most studied biological characters of fish biology. It is known that weight of a fish increases as a function of its length. Length-weight relationship is an essential biological parameter needed to appreciate the suitability of the environment for any fish, (Moussa, 2003).

In the present study the total, spinal and standard length of *L. niloticus* in Upper Atbara and Setit Dams complex were plotted against the corresponding weights yielded logistic curves that were straightened by logarithmic transformation of data, as shown in Table 4.5 and Figures (4.1), (4.2) and (4.3); Values of the regression coefficient (b) its 2.848, 2.838, and two point eight three two respectively, with highly significant of correlation (*r*) vary between 0.974 and 0.983, this indicate negative allometric growth pattern of *L. niloticus*. This similar pattern of growth was reported by many authors for the species under investigation (Ahmed, *et. al*., 2011; Abdalla, 2018 and Hamid, 2018) from the Khashm El-Girba reservoir, Atbara River. Roseirs Reservoir after heightening of the Dam. Pawar and Supugade, (2017) recorded that, length-weight relationship of *Labeo rohita* exhibited allometric growth in Borgaon reservoir (India).

Regression coefficient (b) of the total, spinal and standard length against weight relationship of *S. schall*, exhibited negative allometric growth of this species; Values of this relation was 2.619, 2.700, and 2.651 respectively, with strong correlation coefficient (*r*) (highly significant) fluctuated between 0.902 and 0.907; as showed in Table 4.5, Fig (4.4), (4.5) and (4.6). The above results agree with Hamid, (2018) from the Roseirs Reservoir after heightening of the Dam. Present result agrees with (Laleye, *et. al*., 2006; Akombo, *et. al*., 2014 and Ahmed, *et. al*,. 2017) with slight difference of b value of *S. schall* in Nigeria, Benin, and Roseires reservoir - Sudan. Ahmed, *et. al*., (2011) they recorded negative allometric growth pattern of *S. schall* in Khashm El-Girba reservoir and Atbara river in (El-Remila and Um Aswad) and positive allometric in Bawadra site. This result disagrees with Elias, (2016), he reported that, positive allometric growth pattern with regression coefficients of 3.248 for *S. schall* in Lake Chamo, Ethiopia. And El-Kasheif , *et. al*., (2007) he reported that, b value of relationship between length and weight of *L. niloticus* was three point one eight three.

Relationship of total, spinal and standard length to weight of *A. occidentalis*; showed negative allometric growth include values of regression coefficient (b) 2.823; 1.801, and 2.854 respectively, withmid to high correlation significant (*r*) ranged between 0.724 and 0.906; as shown in Table 4.5, Fig (4.7); (4.8) and (4.9). This result agree with Edward, (2018) he concluded that, “b” values obtained during the period of the study showed that increase in length is not in equal proportion with the weight under constant specific gravity. There was a significant correlation (P<0.05) between length and weight of *A. occidentalis* exhibiting linear relationship in all the Sites. Ikongbeh, *et. al*., (2013). Reportedthe growth pattern of both male and female *A. occidentalis*in Lake Akata exhibited negative allometric growth pattern; and Edward, (2018) he record *A. occidentalis* showed negative allometric growth pattern in Upper River Benue (Nigeria). This result disagree with Shinkafi and Ipinjolu, (2010) they reported that, *A. occidentalis* showed isometric growth in Rima River (Nigeria). The negative allometric growth in the length-weight relationship of fish in Upper Atbara and Setit Dams complex was an indication that the population of the species in these zones had heterogeneous groups with body weights varying differently with the cube of total length.

In fisheries science, the condition factor is used in order to compare the “condition”, “fatness” or wellbeing of fish. It is based on the hypothesis that heavier fish of a particular length are in a better physiological condition, (Bagenal, and Tesch, 1978). The condition factor of a fish reflects recent physical and biological circumstances, as it is strongly influenced by both biotic and abiotic environmental variables, and fluctuates by interaction among feeding habits, parasitic burden and fish physiological conditions, (Le-Cren, 1951). In the present study, very high values of condition factor were recorded for *L. niloticus* during study period; value of condition factor fluctuated between 3.048 and 3.241, with an average 3.121, as shown in Table 4.6. These indicate to suitable environment condition for this species. Values of condition factor recorded for *S. schall* in Upper Atbara and Setit Dams complex ranged between 2.543 and 3.253; while mean value of (K) calculated are 2.902, as shown in Table 4.6. This results showed better growth for this species, maybe due abundance of nutriment and environment condition beside low fishing effort.

Minimum value of (K) recorded for *A. occidentalis* in fishing Sites were 2.151, and the maximum value is 2.484; with average 2.366. Generally, very high values of condition factor (P> 1.0) were recorded for *Synodontis schall* in all sampled fishing sites in Upper Atbara and Setit Dams complex, as shown in Table 4.6. Similar studies were carried out on condition factor of *L. niloticus*, *S. schall* and *Auchenoglanis occidentalis*in different inland waters in Sudan and some African rivers. Abdalla, (2018) concluded that mean condition factor of *L. niloticus* ranged between 1.671 to 2.548. Hamid, (2018) explained that seasonal variation of condition factor (K) of *Labeo niloticus* relatively high values of (K) were observed for *L, niloticus* in Awal-Bab and Kirma fishing sites, and relatively low values of (K) were recorded for El-Regaiba and Wad El-Mahi fishing sites; Ahmed, *et. al*., (2011) they recorded variation of condition factor for *L. niloticus* in three location in Khashm El-Girba reservoir and Atbara Riverits ranged between 1.595 to 2.536. While high values of (K) were observed for *S. schall* in Awal-Bab fishing site, while relatively low values of (K) were recorded in El-Regaiba, Kirma and Wad El-Mahi fishing sites. This result was obtained via this study disagree with Ahmed, *et. al*., (2017) they reported that, condition factor of *S. schall* in Roseires reservoir 0.7018, the difference occurred here maybe due to the difference of techniques used and location.

The obtained results of condition factor of *S. schall* in this study disagree with that result recorded in Khashm El-Girba and Atbara River by Ahmed, *et. al*., (2011). Ikongbeh, *et. al*., (2013), reported that the mean condition factor of *A. occidentalis* in Lake Akata, Benue (Nigeria) varied between1.53 ± 0.02; While Edward, (2018) reported average value of condition factor of *A. occidentalis*is 1.21in Upper River Benue Nigeria. When comparing this result with the current study for *A. occidentalis,* we find that there is a difference can be attributed to contrast in weather conditions between Sudan and Nigeria.

The obtained result of condition factor of *S. schall* agrees with Akombo, *et, al*., (2014) they recorded that mean condition factor of *S. schall* in river Benue, (Nigeria) fluctuated between 2.838 to 2.874 for female, male and combined sex. While Laleye, *et, al*., (2006) they reported that mean condition factor of *S. schall* in Oueme river (Benin) 1.513. The result was occurring during this study agree with Shinkafi and Ipinjolu, (2010) they stated that, in river Rima (Nigeria) male and female of *A. occidentalis* exhibited allometric growth pattern.

The maturity stages for the species in the study were examined during the study period. For *L. niloticus* the stages were found to be not mature. While *S. schall* exhibited 8.3% maturing and 8.3% ripening of collected specimens during September 2019, this period situated between Autumn and Winter season; maybe maturing and ripening sample catch by end of spawning season; for *A. occidentalis* spawning season maybe coincided with *S. schall* spawning season, the evidence here, during September 2019 8.3% of samples was spent and 16.6% of specimens are maturing this period also coincided with end of Autumn season, as shown in Fig (4.10), (4.11) and (4.12). Elias, (2016) reported in Lake Chamo, *S. schall* exhibited extended breeding season with intensive breeding activity occurring during the months of May to September.

Two peaks GSI of *L. niloticus* female were observed in present study, GSI start increase during September/October to reach first peak during

November and decrease during November/December and start increase during December to reach highest level during January. This result differs with Abdalla, (2018), who showed a single peak during July/September. This may be due to the difference in location of the collection sites, where environmental conditions are different in the Khashm El-Girba reservoir and Upper Atbara and Setit Dams complex.While Roy and Mandal, (2015) recorded that, GSI of *Labeo bata* increase from April to August and reach peak during June in India. Decrease of GSI of *S. schall* female were observed in present study, GSI start decrease during September/October, this decrease maybe refluxed to: some samples in spent stage and disappear of stages of gonad filled by ova; also, almost of specimens are immature. GSI, start increase during November to January, this maybe recurs to physiological change in gonad. This results was obtained in present study disagree with Laleye, *et, al*., (2006) they recorded that, peak GSI of *S. schall* in Ouemeriver, (Benin) recorded in mid to late July. This may be due to differential location, environment and techniques. Fluctuated GSI value between increase and decrease for *A. occidentalis* female observed in this study resembles spawning pattern *S. schall* (stated above).

Sex ratio is an important factor in fishery application, as it represents an indicator for the spawning season. In the present study sex ratio of *Labeo niloticus, Synodontis schall* and *Auchenoglanis occidentalis* fluctuated monthly, and is generally similar at all collection sites (Table 4.7, 4.8 and 4.9). This is more or less agrees with the results obtained by Abdalla (2018) for *Labeo niloticus*.

Conclusions

The result obtained in this study showed general negative allometric growth among the fish species under study (*Labeo niloticus, Synodontis schall* and *Auchenoglanis occidentalis*). Very high values of condition factor ($P > 1.0$) were recorded for *Synodontis schall* in all three sampled fishing sites in Upper Atbara and Setit Dams complex. All collected samples of *L. niloticus* during this study appear as immature, this indicate almost of this samples not reach maturity stage.

Recommendation

i. More biological studies especially on reproduction biology for fish in Upper Atbara and Setit Dams complex are needed as these may provide better understanding for proper management and for better economic planning.

ii. Collection of statistical data and other relevant information on species composition, seasonal changes in fish stocks should be done as a rotine work.

iii. Carry out biological investigations to determinate the appropriate characteristics of fishes, including age and growth, maturation, reproduction and fecundity etc., of the most important commercial fish species.

iv. Fishermen should be educated on alternate method of fish farming like using fish pond etc. this will curtail from pressure on natural traps.

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Appendixes

Appendix 1: Take measurements of the lengths of *Labeo niloticus***.**

Appendix 2: Take measurements of the lengths of *Auchenoglanis occidentalis*.

Appendix 3: Take measurements of the lengths of *Synodontis schall*.

Appendix 4: Take the total weight of *Synodontis schall*.

Appendix 5: Dissection of *Synodontis schall* to find out the maturity stage of the gonads.

Appendix 6: Gonads in *Synodontis schall*.

Appendix 7: Gonads in *Synodontis schall*.

Appendix 8: The process of weighing gonads for *Synodontis schall*.