A studies On Biology Of Some Nile Fish Species (Alestes baremose, Bagrus bayad and Mormyrus caschive) During 98 – 1999

By

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بسم الله الرحمن الرحيم
(وما أوتيتم من العلم إلا قليلاً)
(الجبر: 85)
صدق الله العظيم
To my parents, brothers and sisters whose encouragement was my primary motivation and for whom I am indebted with may love
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ABSTRACT

Some aspects of primary productivity and biology of *Alestes baremose*, *Bagrus bayad* and *Mormyrus caschive* in Jebel Aulia reservoir were studied.

The correlation between some environmental factors and plankton ranged from negative (water temperature and density of plankton, pH and dissolved oxygen) to positive (dissolved oxygen and nitrogen). The correlation between air temperature and water temperature was very highly significant (*p*< 0.001) and that between air temperature and dissolved oxygen is significant (*p*<0.05).

The food and feeding habits of *Alestes baremose*, *Bagrus bayad* and *Mormyrus caschive* collected from Jebel Aulia reservoir were studied. Whole guts and stomachs from 363 of *A. baremose*, 318 of *B. bayad* and 311 of *M. caschive* were investigated during June 1998 and May 1999. *Alestes baremose* is an omnivorous feeder, since it feeds mainly on planktons, insects, seeds, worms, higher vegetation, molluscs and fish remains. *Bagrus bayad* is a carnivorous feeder, as it feeds mainly on animal sources such as fish, molluscs, insects and shrimp. *M. caschive* may be considered a bottom feeder, because it feeds on worms, water insects (dragon fly larvae), terrestrial insects and higher vegetation. The relationship between the body weight from one side and the total food weight, stage of gonads maturity and standard length from the other side are very highly significant (*p*< 0.001) for each species.

Sex ratio is close to unity in *A. baremose* and *M. caschive* (0.96: 1 and 1.16: 1), but is 1.39: 1 for *B. bayad*. It is worth pointing out that in all three species males attain maturity stages at a relatively smaller sizes than females.

*Alestes baremose* has two breeding seasons, but *Bagrus bayad* and *Mormyrus caschive* have one breeding season.

In *Alestes baremose* the length of first maturity ranged between 50.7 to 14.1 cm in total length. *Bagrus bayad* 22.5 to 35.1cm. In *Mormyrus caschive* the first length of maturity is very difficult because their stage one is not found in all collected fishes.


**Alestes**

(Orchis caschive) 1:1.39 22.5 1:1.16 14.1 1.39 

(p<0.001) 1:0.96 13

(35.1-22.5) 1:1.16 14.1-5.7 1:1.16 14.1-5.7 1:1.16 14.1-5.7

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CHAPTER ONE: INTRODUCTION

Fish plays a major role in international food security programs and in developing countries as a cheap source of animal protein. It forms about 12% of the world’s animal protein, and supplies 50% of animal protein in the diet of 15 millions people in the Sudan (Medani, 1972). The inland waters in the Sudan cover more than 2,000,000 hectares. Scientific investigations on the White Nile indicate that one hectare of water yields 30 kg of fish annually (Hassaneian, 1975).

The Soviet Research Expedition to the Sudan (1964) reported that the part of Jebel Aulia reservoir extending from the dam up to Kosti was most suitable for commercial fishing operations. This area is about 120,000 hectares; hence the annual catch can be raised to 3,600 tons. In Sudan fisheries exploitation is increasing gradually and winning more attention at governmental and public levels. However, lack and / or scarcity of information on the different interrelated aspects of fish production handicap full exploitation of fish resources.

This study, which had continued for a whole year, describes some aspects of primary productivity of Jebel Aulia reservoir, food and reproduction of the three fish species: *Alestes baremose* (Plate 1), *Bagrus bayad* (Plate 2) and *Mormyrus caschive* (Plate 3). Commercially important species of the families Hydrocynus, Bargidae and Mormyridae are found in the Jebel Aulia reservoir (Boulenger, 1907; Pekkola, 1918; Sandon, 1950; Abu Gideiri, 1984 and Bailey, 1993).

The genus *Alestes* in the Nile in Sudan is represented by *Alestes baremose* (Joannis, 1835); *A. dentex* (L.1757); *A. nurse* and *A. macrolepidotus* (Cuv. And Val. 1849). These species are abundant in
the White Nile. The genus *Bagrus* is represented by *Bagrus bayad* (Forskal, 1775) and *B. docmac* (Forskal, 1775). The genus *Mormyrus* is represented by *Mormyrus caschive* (L, 1762); *M. kannume* (Forskal, 1775); *M. hasselquisti* (Cuv. And Val., 1846) and *M. niloticus* (Forskal, 1775).

Objective of the study:

The objectives of this research are to study:

Some aspects of the primary productivity of Jebel Aulia reservoir.

Morphometric of the three selected reservoir species (*Alestes baremose, Bagrus bayad* and *Mormyrus caschive*).

Food and feeding habits of three species.

Some aspects of their reproduction.

These aspects have not been, so far, studied specifically for Jebel Aulia Reservoir for the three specie
Annex 5: Maps of Jebel Aulia Reservoir's 1997 Frame Survey

Figure 1: Map of Jebel Aulia Reservoir's fishing sites

Northern Kordofan State

Jebel Aulia Reservoir

Khartoum State

White Nile State

El Seikh

El Bashir

Jebel Aulia

Elbiga

Abdelhadi

El Mansoorab

Sheikh El Imam

Telain El Hamdab

Abu Dareesh

Wad Ballal

El Giteina

Wad El Gamal

Um Arda

Hireldana

El Daradir

El Gammalab
Plate 1: *Alestes baremose*
Plate 2: *Bagrus bayad*
Plate 3: *Mormyrus caschive*
CHAPTER TWO: LITREATURE REVIEW

2.1 Jebel Aulia Dam:

The construction of dams along the Nile has changed its hydrological and biological conditions (Brook and Rzoska 1954; Talling, 1957 and Prowse and Talling 1958). Jebel Aulia dam, which is built 45 km south of Khartoum, converted the northern part of the White Nile into a shallow slow-flowing lake where the water is stored in July-August until February after which it is released progressively. The damming effect on the biology of the stored water was found to extend till 350 km south the dam with a maximum effect in the last 50 km above the dam (Rzoska, et al, 1955). According to Henderson (1975) the resulting impoundment is a long thin lake stretching for 629 km, from the town of Renk to the barrage. The lake is shallow with a range of depth of 2.3 to 6 m and a surface area of 600 to 1500 km$^2$. The reservoir holds the second largest potential after the Sudd Swamps and the main sources for providing Khartoum and nearby areas with fresh fish throughout the year. The potential is estimated at about 15000 tons/year (Henderson, 1975).
In common with many tropical waters, the Nile basin is not only rich in species, but also extremely productive of fish. In particular, valuable fisheries exist in the delta lakes, and in the White Nile at Jebel Aulia dam basin (Hickling, 1961). The relative high productivity is attributable to the characteristics of the White Nile. The current is relatively slow resulting in considerable primary production (Ahmed, 1985). The swampy upstream reaches of the reservoir are excellent natural breeding grounds that supply the fishery with good level of recruitment. Furthermore, the macrophytes that infest the area, such as *Vosia cuspidata* and *Echinochloa sp.*, create favourable conditions for breeding and later production of juveniles. It is thought that some fish stocks in the reservoir are over exploited particularly in areas adjacent to the dam (Ahmed, 1985).

### 2.2 Physical and chemical characteristics:

Although the White Nile is quite well known hydrobiologically, little is definitely understood of its physical history (Ball, 1939; Worthington, 1947; Andrews, 1948). Considerable climatic fluctuations have taken place in the valley of the White Nile river (Flint, 1959). Many of the factors influencing the flow of the White Nile changed or fluctuated during the latter part of the Pleistocene period. The drainage area of the Nile as a whole has changed a number of times (Berry, 1961).

In both the White and Blue Niles near Khartoum photosynthetic activity of the algal population resulted in marked seasonal changes in the pH and dissolved oxygen content. These features also showed a marked daily variation (Sinada and A/El karim, 1984 a, b and c). Dense populations dominated by blue-green algae in water at relatively high temperatures provided very favourable conditions thus imposing stratification on the distribution of oxygen and pH. The resultant increase in both factors induced
by photosynthetic activity, is largely restricted to the upper most strata (Talling, 1954).

The main modifications in the White Nile waters are attributed to the influence of the Sobat, which not only contributes 61% of the total discharge, but also affect its characteristics. The latter show its effects in the main river below by an increase in pH, nitrate and ammonia nitrogen, silicones, phosphates and chloride and a decrease in conductivity, oxygen…etc (Bishai, 1962).

2.2.1 Water temperature:

Water temperature is an important factor, which influence growth, reproduction and maturity of fish. In addition, it affects the development of aquatic micro and macro-organisms, which are the principle components of the fish food chain. For every fish species there is an optimum temperature at which the individual shows the best physiological performance. Furthermore, the temperature influences the amount of dissolved oxygen and consequently the rate of respiration of fish (Bishai, 1962).

Mean annual water temperature at Jebel Aulia was about 26 °C at 8.0 a.m. The maximum being 31 °C and the minimum is 16 °C. Two maxima and two minima characterized the annual range of water temperature. The first maxima were during the end of the dry season in June. The second maxima were in the beginning of the dry season in late September and October. The first minimum was towards the middle of the dry season in January. The second minimum was towards the beginning of the second half of the rainy season during July (Ahmed, 1978). At Jebel Aulia reservoir the temperature range was from 16 to 31 °C. Two maxima were observed, one before the flood season  (May 28.5 °C) and the other after the flood season. The lowest temperature was observed during winter where
the temperature dropped to 16 °C in January. Temperature stratification was observed in the first 1.5 m depth (Ahmed, 1985).

2.2.2 Turbidity:

The turbidity increases towards the dam, contrary to what is expected in lake-like conditions near the dam. This was explained by the distribution of other suspended material such as the vast number of plankton and abundant detritus (Brook and Rzoska, 1954; Prowse and Talling, 1958).

Turbidity is known as the ability of water to scatter light caused by small particles in water. Thus it is a measure of the suspended particles in water or wastewater, like silt, clay, organic and inorganic matter. Plankton and microscopic organisms in water are usually held in suspension by turbulent flow and brownian movement (Tebutt, 1983 and WHO, 1984).

Many freshwater fish species occur in very turbid water, but some are affected by the turbidity, which harms their environment and effects the development of the fish eggs, food organisms and so the fish dies when turbidity reaches 50,000 ppm (Abu Gideiri, 1985).

The transparency ranging between 12.5 - 25 cm. High values were recorded at December and January and least value at the flood season, in June and July. Transparency was studied because of the relationship between light penetration and the productivity of the primary producers, phytoplankton. Another important factor is the role of high siltation in initiating spawning of fish specially the Cyprinid (Ahmed, 1985).

2.2.3 pH:

The pH showed a gradual increase with a maximum rise in the neighborhood of the dam. This increase in the pH is due to the uptake of free CO₂ from carbonate – bicarbonate buffer system of the natural waters (Rabinowitch, 1951, 1956 and Ruttner, 1953).
The maximum pH recorded – in all cases- above the dam was attributed to the maximum increase of the plankton in this region. Also the high pH or associated deficiency of CO₂ or bicarbonate never seriously limits the photosynthesis of the algal population (Brook and Rzoska, 1954; Talling, 1956 and Prowse and Talling, 1958).

The pH is a measure of hydrogen ion concentration in solution and it indicates the acid - base balance in water. Carbon dioxide, bicarbonate, carbonate equilibria usually govern the pH of natural freshwater and it ranges between 4.5 - 8.5. Generally speaking the surface water is alkaline and the ground water is more acidic (FAO, 1975).

**Freshwater fishes can live in water with pH between 5.0 and 9.0. Most resistant fish species, can tolerate a pH below 4.0 and above 10.0, but the sensitive fish (young) can tolerate it for short periods (FAO, 1975). Acidic and alkaline waters have various effects on fish. Young fish are more sensitive to pH fluctuations than adults ones (Doudorff, 1957 and FAO, 1975). In Jebel Aulia reservoir the range of pH was 7.4 - 8.6. High value was recorded after the flood season in November and December and the least value was recorded during the flood season. The importance of the pH is its role in ionizing chemical compounds to produce free ions for the readily use of phytoplankton (Ahmed, 1985).**

**2.2.4 Dissolved oxygen:**

The amount of dissolved oxygen increases in the region of the dam and reaches saturation in its neighbourhood due to the maximum development of phytoplankton in this region (Brook and Rzoska, 1954; Talling, 1957; Prowse and Talling, 1958 and Bishai, 1962).

The depletion of dissolved oxygen in water is due to decay of organic matter and respiration of various aquatic organisms, which usually cause sudden fish mortality. Generally high temperature, extremes of pH, high concentrations of carbon dioxide and other toxic substances increase the susceptibility of fish to dissolved oxygen deficiency (Brown, 1957 and FAO, 1975).

The dissolved oxygen for freshwater fish must be above 3 ppm, and it is quite fatal at fairly high temperatures. For the best biological performance its level has to be 7 ppm, at any time (WHO, 1984 and Abu Gideiri, 1985).

Oxygen concentration at Jebel Aulia Reservoir was above saturation all the year around. High oxygen concentration was recorded at December and
lowest at August. The mean oxygen concentration was 6.6 ±1 ppm. It is clear that oxygen concentration is beyond the demand of fish and other aquatic organisms (Ahmed, 1985).

2.2.5 Free CO₂:

The significant increase in the CO₂ content leads to decrease in the pH from 8.4 to 7. Dissolved carbon dioxide when present in high concentrations can be decidedly injurious to fish because of its toxicity or interference with respiration. Furthermore, high concentration of free CO₂ markedly increases the susceptibility of a fish to deficiency of dissolved oxygen (Douoroff, 1957 and Bishai, 1961).

2.2.8 Nitrate-nitrogen:

Nitrate-nitrogen is considered as the most important source for inorganic nitrogen used by phytoplankton. A concentration of about 0.02 mg/l may be a critical value for uptake by cells, although it is possible that this level may depend up on population density (Prowse and Talling, 1958).

The concentration of nitrate-nitrogen showed a sharp and considerable decrease 275 km south of the dam. This is partly attributed to the depletion of nitrates by algal populations particularly Melosira (Bishai, 1962).

In the absence of microbiological reduction, nitrate ion tends to accumulate in natural water. Unpolluted natural water contains minute amounts of nitrate and the excessive concentration of it is harmful to drinking water. In infant nitrates changes to nitrites in their intestinal tracts and enters the blood system (Ciaccio, 1972).

2.3 Plankton:
The plankton is the basic pillar in any aquatic food chain. It is composed of phytoplankton (of plant origin) and zooplankton (of animal origin).

2.3.1 Phytoplankton:
An increase of more than 100 times was noticed in the quantity of phytoplankton in the longitudinal section of the stored up basin as a result of the construction of Jebel Aulia dam (Brook, 1954).

At the Blue and White Niles shortly before their junction, the most abundant algae in both rivers is the blue-green *Anabaena flos aqua* var *intermedia f. spiroides*, but *Lyngbya limnetica* also plays an important part in the White Nile (Brook, 1954).

The dominant diatoms are *Melosira granulata* and *Melosira granulata var angustissina*. In all the years of observation the maximum density of phytoplankton occurred in late November in the White Nile (Brook, 1954).

There is a build-up of plankton in the Jebel Aulia basin due to the modification of Jebel Aulia dam. A higher density of *Melosira* develops in the lower layers during the afternoon, possibly due to a high sinking rate in conjunction with the existing density stratification (Prowse, 1955).

Studies on the Nile near the Jebel Aulia dam indicated the strong correlation between phytoplankton growth and current velocity (Prowse and Talling, 1958). The dam slows the Nile current and produces a rapid increase in planktonic concentration to a point where nutrient depletion, particularly of nitrates limits further increase. When the dam is open, the through flow is faster and plankton concentration drops (Prowse and Talling, 1958).

Although the relative abundance of organisms in terms per unit volume is lower during the floods, the absolute abundance may well remain the same owing to the dilution of the number of organisms by the enormously increased volume of water in the system. One of the major factors limiting phytoplankton abundance and distribution is the transparency of the water (Holden and Green, 1960).

Phytoplankton densities become less during the floods, with dense blooms occurring both in Kafue river at Nampongwe and in Namatengo.
lagoon between August and November when the floods had occurred (Currey, 1971).

(Rzoska, 1974) quoted values of between 40 and 140 cells ml\(^{-1}\) for the river where as densities in lagoons ranged from 1720 to 2880 cells ml\(^{-1}\), as in a lagoon at river post 12.

Differences in the specific composition of the phytoplankton were also common. Blue-green algae such as *Anabaena* and *Lyngbya* dominated in the standing waters, where as in the river the sparse flora was made up mainly of diatoms, especially *Melosira* (Rzoska, 1974).

Studies on the dynamics of phytoplankton in Khor Eljasir close channel in the White Nile indicated that the phytoplankton was more abundant in winter (January-March) and least during the flood period (Belly, 1995). A clear link between phytoplankton biomass and the level of eutrophication from Asalia sugar factory influence reaching Khor Eljasir was demonstrated. Khor Eljasir was found to have low nutrient concentration as compared with areas outside the Khor (Belly, 1995).

**3.3.2 Zooplankton:**

The two Niles at Khartoum carry periodically a true and pure zooplankton formation, with the following crustaceans as main representatives: *Diaphanosoma exeicum* sars, *Ceriodaphnia rigaudi* of the water - hyacinth where their massy root hairs slow down the current and house these organisms. Insects found were mostly those which pass their larval and pupae stages in the water such as chironomids. They were found all the year round (Brook, 1954).

Taxonomic studies on the species composing planktonic crustacean of the Nile system have been successfully concluded only in the case of *Ceriodaphnia cornuta* and *C. rigaudi*. Zooplankton at Jebel Aulia dam show marked vertical stratification, which do not necessarily follow the daily
rhythm of light intensity in the way usually found in standing waters. Thus maximum count of an organism may occur on the surface both in daylight as well as during the night (Rzoska, et al. 1955).

Sudden seasonal pulses in total zooplankton numbers seem to arise mainly by increases in rotifers, although the other major components of the zooplankton, the copepods and cladocera, also have characteristic peaks. Nauplii are common and are often washed out of the standing waters into the main channel during rising floods. Rhizopods have also been noted as an important element of the plankton at this time (Holden and Green, 1960). Counts of zooplankton at down stream of the Sudd in the Jebel Aulia dam reached 75000 / m³ (Talling and Rzoska, 1967).

Abu Gideirri (1969) studied the influence of mixing of the water of the two rivers at the junction on the composition of the plankton. In the Sudd zooplankton densities were higher in the dry season.

Zooplankton is much more common in the flood plain pools and backwaters where its abundance per unit volume is usually inversely correlated with the amount of water in the system. During periods of low or nil flow, greatly increased zooplankton biomasses were present, especially in the isolated side arms where values 30 times higher than those of the main river were recorded (Wellcome, 1979). In the standing waters of tropical flood plains there is a wide spread tendency for greater concentration of organisms to be present in the dry season, as is the case with phytoplankton. Like phytoplankton, however, the decrease in relative density of zooplankton may only be a dilution effect and the number of organisms over the flood plain as a whole may in fact be higher during the wet season than during the dry (Wellcome, 1979).

2.4 Feeding importance and habitat:
For fish, as for any kind of animal, food is a basic determining factor. It governs distribution, abundance, rate of growth, condition, movements and fertility. Knowledge about food is therefore essential for the academic understanding of the life of the fish and for providing answers to the practical problems, which are sure to arise as human exploitation of the resources of the rivers become intensified (Sandon and El Tayeb, 1953).

Knowledge of feeding habitat can be observed in several ways, namely (a) by direct observation of living fish in their natural conditions, (b) by observation of fish in captivity (in ponds or tanks) and (c) by examination of the contents of their stomachs and intestines, which is the most useful as it enables us to see directly what the fish had been eating before they were caught. The feeding habits of any species of fish are by no means invariable. They vary very obviously with age; the young in most cases cannot possibly eat the same kinds of food as the adults (Sandon and El Tayeb, 1953).

In the aquatic medium various types of food items are found. Their availability is affected by physical, chemical and biotic factors. The main food items recorded were phytoplankton mostly diatoms and some filamentous algae. These show great fluctuations, reaching its peak in March - May and drop in July - September (Yousif, 1972). Reasons may be attributed to factors as swift current during flood time, extensive use by the fry of fish, accumulation of waterweeds for along period and the change in water characteristics, which occurs in the White Nile waters (Yousif, 1972).

The water-hyacinth (part of waterweeds) especially the root hairs, were found in the gut of all fishes dissected even in strictly carnivorous ones such as *Hydrocyonus* (Yousif, 1972).

The major source of food are classified into autochthonous and allachthonous. Autochthonous included plankton community (phytoplankton and zooplankton); benthic community (mud and associated microorganisms, insect, worms, small crustacean, molluscs and large
decapods crustacean); plants, including filamentous algae and submersed, floating or emergent higher vegetation; aufwuchs community, epiphytic or epithic algae, associated organisms (including the root fauna and flora of floating vegetation); Neuston including surface living insects and larvae at the air / water surface; fish including eggs and larvae forms (Welcome, 1979). Allachthonous included vegetation matter (leaves, roots, flowers, fruits and seeds of plants growing near water; animal matter insects including ants, termites, beetles, flies together with arachnids, worms, etc. falling into the water (Welcome, 1979).

2.5 Reproduction:

Pekkola (1919) recorded that M. caschive and M. kannume breeds during May while B. bayad spawn in May. Nawar (1957) reported on the breeding habits and seasons of some Nile fishes from various localities along the White Nile. He suggested the occurrence of two main seasons, one during February to April and a second during May to August. Some of the summer breeders spawn before the rise of the river in Jebel Aulia e.g. Mormyrus hasselquisti and Barbus bynni. Some spawn during the river rise such as Labeo niloticus and Hydrocyon forskalii. One species, Eutropus niloticus, was observed to carry eggs at the beginning of the fall of the river level in the first week of September. But the majority of the species have their breeding season in the months of July and August (Nawar, 1957).

Nawar (1957) recorded that environmental factors, especially temperature govern the onset of oogenesis in the ovaries.

Banbireri (1989) established five stages of gonadal maturation in fishes (immature, maturing, mature, partially spent and spent). He stated that fractional and prolonged spawning periods are characteristic of tropical and sub-tropical fishes.

According to (Burns and Flores, 1981; Rajasilta et al., 1988) the external cues such as temperature, photoperiod, salinity and topography results in significant differences in brood size, determines the selection of the spawning site and regulates the start and duration of spawning. Some fish
species spawn once a year, other twice or thrice and some spawn at almost any
time of the year (Bardach and Passino, 1967). Fecundity in fishes is survival
value. Fishes, which protect their eggs, have a low fecundity in contrast to
fishes that don’t protect their eggs or youngs. These fishes produce a huge
number of eggs in open water. The higher investment of energy in
reproduction is aimed to increase the number and survival of the offspring.
Fecundity is affected by food quantity (Scott, 1962) and its survival value is
made at the cost of growth rates (Rincon and London, 1988).

2. 6 Fish community:

Although the Sudanian region has far fewer fish species than the Zaire region, it still has a very diverse fauna made up
primarily of Ostariophysi (39 Silurid species, 24 Characids and 23 Cyprinids) in the middle Niger (Daget, 1954).

Close investigation of fish species and feeding behavior has drawn the
attention of researchers to various behavioural adaptations to the specific habit

Throughout the tropics seasonal variations appear to be greatest at the end of the rains and in the dry season. The high water is the main feeding and
growing time for most fish species, except for some zooplankton feeders, and
predators, which may be able to catch prey more easily when they are less,
dispersed. As the water level falls, food supplies for most non-piscivorous
fishes become restricted in a rapidly contracting environment. Most of these
fish spawn early in the rains and the young grow fast and the ichthyomass is at
its greatest at the end of the rains before the enormous losses resulting from
predation and drop in water level (Lowe-McConnel, 1975).

As the dry season advances fish numbers are reduced and many species
cease to feed, where fishes do not cease to feed in the dry season, this may be
an other time of intense competition for food in confined pools (Lowe-
McConnel, 1975).
2.6.1 *Alestes baremose* (Joannis, 1835):

Characidae family comprises small fish excellent for food. Two genera *Hydrocynus* and *Alestes* are common at any period of the year but especially so during August, September and October (Pekkola, 1918).

Of *Alestes* there are four representatives *A. dentex*, *A. baremose*, *A. nurse* and *A. machrolepidotus*. The two former are called by the native’s kauwara baladi and the two later kauwara safsaf. All these fish have a delicate flesh. The Greeks salt these fish and though their method is very primitive, the taste is rather nice if salted in a proper manner (Pekkola, 1918). The family Characidae includes fish of high economic value (Ahmed, 1985).

All the members of *Alestes* are carnivorous. Their food generally consists of crustaceans, chironomids larvae and coleoptera. All the species of *Alestes* are abundant in the White Nile. The beautifully coloured *Ichthyoborus bess* (Joannis, 1853) is very common in Khor Barboi, near Tonga. It lives among the grass and its movements are very pike-like. It feeds chiefly on small fish and crustaceans (Pekkola, 1919).

*Alestes* are very similar to *Hydrocynous* in general form and appearance but are smaller and less fierce. Although carnivorous, they feed on insects, etc. rather than on fish. Correlated with this is the structure and arrangement of the teeth, which are much smaller than in Hydrocynus and less, pointed, mostly having more than one cusp, and set in two rows along each jaw. All species of *Alestes* are common at Khartoum and in the White Nile. The maximal length given by Boulenger (1907) for *Alestes baremose* is 31 cm.

Many species select a succession of food types as the flood cycle progresses. Typical of these are the *Alestes* species, which changes from a diet of insects and seeds or even higher vegetation during rising water, to feeding
on phytoplankton as the waters being to recede. There is a tendency for food preferences to change as individuals grow older and the diet of juvenile fish often differs widely from that of the adults of the same species. Most extreme in this respect are the juveniles of the major piscivorous predators, such as *Lates niloticus* or *Hydrocynous* species, which eat small crustaceans or even phytoplankton. It may be concluded from this that the majority of flood plain species are very flexible in their feeding habits (Daget, 1952).

*Alestes baremose* are generally regarded as entirely carnivorous but with food consisting of crustacea, chironomid larvae, coleoptera, etc rather than of fish. All the four Nile species, however, some times eat vegetable matter. This habit seems to be more frequent in scaled species. Some feed on aquatic insects probably (hemiptera) while others feed on coarse vegetable matter only. Planktonic crustacea (*Moina* and *Ceriodyaphnia*) are abundant with fewer chironomid larvae in some *A. baremose* (Sandon and El Tayeb, 1953).

*Alestes dentex* (Linn) is an omnivore in Sudd but was identified as zooplantivore in Lake Chad (Lauzanne, 1972). Non-piscivorous Characids large enough to support important fisheries include various *Alestes*, such as *A. baremose* and *A. dentex*. Both are widely distributed omnivorous. In *A. dentex* from the Sudd, no single dietary item predominated overall in guts examined, although individuals were frequently selective with stomachs filled entirely with seeds, zooplankton, insects or fish fry (Bishai, 1977). There is considerable flexibility in the diet of *A. baremose*, which shifted from zooplankton to zoobenthos, detritus and macrophytes, as plankton densities declined (Hanna and Schiemer, 1993).

**2.6.2 Bagrus bayad (Forskal, 1775):**

Siluridae is so abundantly represented in the rivers near Khartoum. These are generally called catfishes, of which 15 genera occur in the Nile system.
Almost common genus is *Bagrus*, which includes two species *Bagrus bayad* (Forskal, 1775) and *Bagrus docmac* (Forskal, 1775); both are of great value as food. The former is known by the native bayad is common at any period of the year except during November and December. They reach a length of about a meter and their flesh is very good (Pekkola, 1918).

*Bagrus bayad* and *B. docmac* eat almost exclusively fish. Four specimens (150-300 mm) taken between June and August contained fish (*Alestes* and small *Chrysichthyus*) and in one case a prawn (caridina) as shown by Sandon and El Tayeb (1953). *Bagrus bayad* is one of macropredators consuming large invertebrates, notably decapods crustaceans, insects and other fishes (Holden, 1970).

*Bagrus spp* are the main predators in rivers over a wide area and in some of the Great Lakes (Lowe-McConnel, 1975).

Most Silurids have a considerable resistance to deoxygenated conditions. Those are termed ‘black fish’ in South East Asia. Their movements are therefore more limited than those of the ‘white fish’. They frequently remain in the standing water of the flood plain during the dry period (Welcombe, 1979).

Both *B. bayad* and *B. docmac* are widely distributed in rivers and lakes in the Bahr El Ghazal and Bahr El Jebel systems; White and Blue Niles, Nile, Lake Nubia. They are predacious-feeders on insects, crustaceans, molluscs and fish. Some debris and vegetable matter may also be ingested (Bailey, 1993).
2.6.3 *Mormyrus caschive* (Linn. 1762):

All members of Mormyridae family are African fish, of which 7 genera occur in the Nile system while species of each appear in the rivers near Khartoum (Pekkola, 1918).

Many of the large Mormyrids are bottom-fishes and their snout is especially developed to enable them to procure food such as worms and insects larvae from the mud, but some with a larger mouth, feed principally on fish. The smallest species live on vegetable matter, worms and larvae of insects. *Mormyrus* species are not rare in the White Nile. They appear on the Khartoum market every year and their food consists of chironomids larvae, Oligochaeta and sometimes water insects. *Mormyrus caschive* and *M. cannume* breed during May (Pekkola, 1919).

All the stomachs of *M. caschive* examined in Uganda contained chironomid larvae mixed with mud and vegetable deprise (Worthington, 1947).

Nearly all the Mormyrids are bottom-living whose small mouth and teeth are unsuited to predatory habits. Five specimens of *M. caschive* from the Upper Nile (45-63 cm) contained a mixture of vegetable matter with chironomid larvae and considerable amount of mud in their stomachs. One from Lake No (71.8 cm) contained vegetable matter only and the stomach of two taken during the flood were full of earthworms. At Jinja on lake Victoria it was found that they commonly contained only chironomid larvae in their stomachs without any mixture of mud suggesting ability to pinch their food up and wash it free from mud before swallowing it, but this does not seem to be done always (Sandon and El Tayeb, 1953).

*Mormyrus caschive* (L), a primitive isospondyous bottom feeding Nile fish belongs to the family Mormyridae. It has along slightly curved snout
(elephant-snout) ending in a pore-like mouth with thick lips. Its food consists mainly of insect larvae embedded in the mud (Bishai, 1967).

Bottom feeders is an important group of fish in which diptera larvae especially chironomids are common in the diet together with variable quantities of other insects, crustacean and molluscan. One of the representative species is *Mormyrus caschive* (Holden, 1970).

Mormyridae, which is one of endemic families, has the most numerous genus (16) and over 200 species, and these are especially abundant in the Zaire. Mormyrids feed almost exclusively on the bottom. Insects are the most diet spread of prey and require of their predators, the least specialization in feeding habits (Lowe-McConnel, 1975).
CHAPTER THREE: MATERIAL AND METHODS

The study Area:

The White Nile originates at Lake Victoria in Uganda. It flows northwards through the Sudan (under different names) for a distance of 2530 km, until it joins the Blue Nile, which emerges from Lake Tana in the Abyssinnian Plateau. Through its course, the White Nile traverses geologically different soils, receiving contributions from various catchment areas and is subjected to various climatic conditions. Jebel Aulia reservoir, which is situated at latitude 15° 12’ N and longitude 32° 27’ E, was formed as a result of Jebel Aulia dam construction, 45 km South of Khartoum, in 1936 (Fig 1). It is a seasonal reservoir. Water is stored from July to the end of January and released gradually from February, until the basin is emptied in May (Rzoska et. al., 1955). Shallow bays scatter all around the reservoir. The bottom of the bays is covered with living and decaying aquatic weeds (Euphorbia spp., Cypreus spp., Ceratophylum spp. and water hyacinth Eichhornia crassipes- Mart- solms) which form dense mats covering vast areas along the banks of reservoir and against the wall of the dam. During July to September begins the flood, which covers the vast shallow areas adjoining the reservoir, making them as one unit. The reservoir is a major source of fresh fish that supplies the capital, Khartoum, and the nearby areas. The reservoir is 5 km long and ranges between 1 to 4 kms in width, with a maximum depth of about 12.5m. It stores $3.510^9\times m^3$ of water forming a large basin of slow flowing lake, the influence of which extends for 629 km up the stream with the maximum effect in the last 50 kms above the dam (Rzoska, et. al., 1955 and Ahmed, 1978).
Routine sampling was undertaken at Jebel Aulia reservoir. The sampling station was chosen because it is a very rich fishing ground. It was easy to contact fishermen working in the area as well as to take additional notes and specimens from fish landing. Besides, the station is at reasonable distance from Khartoum, so the material collected would reach the laboratory in a perfect condition.

3.1 Water characteristics:

Water for physical and chemical analysis was collected in polythene bottles. The bottles were opened at a depth of about 10-cm below the surface and allowed to fill. The samples were then taken to the laboratory of El-Nieleen University within a few hours after collection. The analytical methods used were mainly those described by Machreeth (1963). Water temperature in the field was recorded with a thermometer. Dissolved oxygen was measured by using Winkler method. Dissolved nitrates were measured calorimetrically using the lovibond Nessleriser (Tintometer Ltd.). Transparency was measured with standard “secchi” disc of 15-cm diameter.

3.2 Plankton:

Standard plankton nets (45 and 125 micron) were used for sampling plankton. Two horizontal samples at a length of 300 cm from the towing boat and a depth of 100 cm from the surface were taken for quantitative and qualitative determinations. The duration of the tow was 5 minutes. Plankton retained was rinsed off into polythene tubes and preserved in 4% formaldehyde. The samples were then transferred into 50-ml rounded bottom dilution flasks fitted with 0.1 and 1.0 ml plunger sampling pipettes for phytoplankton and zooplankton, respectively. The number of organisms in 0.1 and 1.0 ml were counted under microscope at \( \times 100 \) for phytoplankton and 40 \( \times \) for zooplankton. The total number of plankton in the 50 ml was then calculated.

3.3 Fish
Monthly fish samples of *Alestes baremose*, *Bagrus bayad* and *Mormyrus caschive* were collected from the reservoir from June 1998 to May 1999. Morphometry, Food and feeding habits and production of these fishes were studied. Identified were according to Boulenger (1907), Sandon (1950), Abu Gideirri (1984) and Bailey (1993).

### 3.3.1 Measurements:

The fish’s specimen was measured with standard measuring board in cm. The measurements taken were total length (TL), and standard length (SL). Corresponding weights of individual fishes were also taken to the nearest 0.1 gm using a sliding balance. The fishes were then dissected and individual alimentary canals were stretched out and preserved in 4 % formaldehyde.

### 3.3.2 Food analysis:

The stomach of each fish was weighed with and without food to determine food weight. Three portions, of cm each, were taken from the anterior, mid and hind part of each gut. These portions were assessed separately and the food items present in stomach and gut were microscopically identified as far as possible. The frequency of appearance and proportion by weight, percentage and number of food items were ascertained separately for each fish.

Freshly ingested fishes were measured to the nearest mg. In all cases attempts were made to determine the fish prey taxonomically down to species level. In the case of most *Alestes baremose* 5 milliliters of water were added to the whole contents of the gut and mixed thoroughly. One ml of the mixture was examined under the microscope and the percentage composition of each food item was by frequency of occurrence calculated.

### 3.3.3 Reproductions:

The sex of each fish sample was determined from external body morphology and confirmed anatomically by examination of the gonads. The
stage of maturity was classified according to Kesteven (1960) and Ahmed (1985) Table (1).

3. 3. 4 The breeding season and the length of first maturity:

The percentage frequency of occurrence of the different stages of maturity is used to inter the beginning and end of the breeding season for each fish.

These data, together with total fish lengths, are used to establish the length of first maturity.

**Statistical analysis:**

Statistical Packages for Social Sciences (SPSS) were used to perform one-way analysis of variance (ANOVA) and regression analysis used in the present study.

---

**Table 1: Gonad maturity stages in the three studied species following Kesteven, s plan (1960).**

<table>
<thead>
<tr>
<th>Maturity stage</th>
<th>Morphology of the gonads</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Testes and ovaries translucent grey-red</td>
</tr>
<tr>
<td>2</td>
<td>Mesenteric fat deposit in the body cavity in slight quantities</td>
</tr>
<tr>
<td>3</td>
<td>Testes and ovaries opaque, ovaries reddish white due to high vascularization, eggs visible to the naked eye, testes pale orange. In both gonads whitish granulated mesenteric fat in median quantity.</td>
</tr>
<tr>
<td>4</td>
<td>Ovaries are hard, swollen distending the body cavity.</td>
</tr>
<tr>
<td></td>
<td>Description</td>
</tr>
<tr>
<td>---</td>
<td>-------------</td>
</tr>
<tr>
<td></td>
<td>Eggs completely rounded yellowish oranges. Testes smooth, opaque, creamy. The vascularization is conspicuous both gonads.</td>
</tr>
<tr>
<td>5</td>
<td>Testes large pure white and swollen with milt. Ovaries are translucent; lie free within the ovary lumen. Gondola products are extruded by slight pressure.</td>
</tr>
<tr>
<td>6</td>
<td>Ovaries and testes not yet fully empty.</td>
</tr>
<tr>
<td>7</td>
<td>Testes falabby, loose, with small pockets of residual milt. Ovaries deflated reduced in size and containing residual eggs.</td>
</tr>
</tbody>
</table>
CHAPTER FOUR: RESULTS

4. 1 Physical and chemical properties of water and planktons of Jebel Aulia Reservoir during June 98 and May 1999.

The percentage of physicochemical properties of water and plankton density showed in Table (2).

The present investigation showed that there are two temperature maxima; one towards the end of the dry season in June and the second is from late September to October. Two temperature minima are also observed, the first one is in January and the second one is during July.

Light is a limiting factoring only either at greater water depths or when turbidity is high. The low values of transparency recorded from May to August are attributed to the high silt during flooding.

Low pH values were recorded during flooding months (June to September) probably as a result of CO₂ release that accompanied the annual breakdown of plankton production. High values were recorded during winter months (October to December).

Dissolved oxygen is an important limiting factor in aquatic ecosystems. Absence or very low levels commonly limits the distribution of plants and animals. The maximum-recorded value recorded to this study (December).

High carbon dioxide concentrations in this study were recorded during the flood months (June to September).

Qualitative community of plankton and zooplankton showed in Table (3). The present work indicates that plankton density starts to increase from October (immediately after flood season) and reaches a maximum during December. The subsequent drop may be attributed to the decline in transparency due to the blooming.
Table 2: Percentage of physicochemical properties of water and planktons of Jebel Aulia Reservoir during June 98 and May 1999:
Table 3: Qualitative community of phytoplankton and zooplankton at Jebel Aulia Reservoir during June 98 and May 1999:

<table>
<thead>
<tr>
<th>Phytoplankton</th>
<th>Zooplankton</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Melosira granulats</em></td>
<td><em>Moina dubia</em></td>
</tr>
<tr>
<td>Anabaena spp</td>
<td>Ceriodaphnia spp</td>
</tr>
<tr>
<td>Volvox spp</td>
<td>Keratella spp</td>
</tr>
<tr>
<td>Eudorina spp</td>
<td>Diaphnosa excisum</td>
</tr>
<tr>
<td>Pandorina spp</td>
<td>Bosmina langitostris</td>
</tr>
<tr>
<td>Pediastrum spp</td>
<td>Cyclopida spp</td>
</tr>
<tr>
<td>Spirogyra spp</td>
<td>Thermodiaptomus spp</td>
</tr>
<tr>
<td></td>
<td>Daphnia spp</td>
</tr>
</tbody>
</table>
4. 2 The effect of physical and chemical characteristics on plankton:

Inter correlation between the below environmental parameters including plankton density ranged from negative correlation (air temperature and air temperature and dissolved oxygen, air temperature and plankton density, water temperature and transparency, water temperature and dissolved oxygen, water temperature and plankton density, transparency and free CO₂, transparency and dissolved oxygen, transparency and pH value, transparency and nitrate, free CO₂ and dissolved oxygen, free CO₂ and nitrate, dissolved oxygen and pH value, pH value and nitrate, pH value and plankton density, nitrate and plankton density) to positive correlation (air temperature and water temperature, air temperature and free CO₂, air temperature and pH value, air temperature and nitrate, water temperature and free CO₂, water temperature and pH value, water temperature and nitrate, transparency and plankton density, free CO₂ and pH value, free CO₂ and plankton density, dissolved oxygen and nitrate, dissolved oxygen and plankton density) Table (4). However, the correlation between air temperature and water temperature was highly significant (p< 0.001) and that between air temperature and dissolved oxygen is significant (p< 0.05).
Table 4: Correlations between some environmental parameters and plankton density.

<table>
<thead>
<tr>
<th>Correlates</th>
<th>Air °C</th>
<th>Water °C</th>
<th>Transparency</th>
<th>Free CO₂</th>
<th>Dissolved O₂</th>
<th>pH value</th>
<th>Nitrate</th>
<th>Plankton density</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air °C</td>
<td>1.000</td>
<td>0.755**</td>
<td>-0.378</td>
<td>0.389</td>
<td>-0.663*</td>
<td>0.528</td>
<td>0.197</td>
<td>-0.507</td>
</tr>
<tr>
<td>Water °C</td>
<td>0.755**</td>
<td>1.000</td>
<td>-0.272</td>
<td>0.311</td>
<td>-0.536</td>
<td>0.304</td>
<td>0.150</td>
<td>-0.075</td>
</tr>
<tr>
<td>Transparency cm</td>
<td>-0.378</td>
<td>-0.272</td>
<td>1.000</td>
<td>-0.495</td>
<td>-0.0294</td>
<td>-0.395</td>
<td>-0.221</td>
<td>0.236</td>
</tr>
<tr>
<td>Free CO₂</td>
<td>0.389</td>
<td>0.311</td>
<td>-0.495</td>
<td>1.000</td>
<td>-0.124</td>
<td>0.481</td>
<td>-0.162</td>
<td>0.335</td>
</tr>
<tr>
<td>Dissolved O₂</td>
<td>-0.663*</td>
<td>-0.536</td>
<td>-0.294</td>
<td>-0.124</td>
<td>1.000</td>
<td>-0.435</td>
<td>0.197</td>
<td>0.169</td>
</tr>
<tr>
<td>pH value</td>
<td>0.528</td>
<td>0.304</td>
<td>-0.395</td>
<td>0.481</td>
<td>-0.435</td>
<td>1.000</td>
<td>-0.470</td>
<td>-0.031</td>
</tr>
<tr>
<td>Nitrate</td>
<td>0.197</td>
<td>0.150</td>
<td>-0.221</td>
<td>-0.162</td>
<td>0.197</td>
<td>-0.470</td>
<td>1.000</td>
<td>-0.425</td>
</tr>
<tr>
<td>Plankton density</td>
<td>-0.507</td>
<td>-0.075</td>
<td>0.236</td>
<td>0.335</td>
<td>-0.031</td>
<td>-0.425</td>
<td>1.000</td>
<td></td>
</tr>
</tbody>
</table>

** very highly significant  
* significant
4.3 Body length - weight relationship:

The relationship between length and weight of the body for each of the three species was found to be very highly significant (p< 0.001) Table 5.

The predictive equation were:

Y= a + bx

Where Y = body weight, a = point of intercept, b = regression coefficient, and x = body length.

\[
A. baremose \ Y = 1.084 + 2.874 \ X \\
M. caschive \ Y = -239.744 + 15.740 \ X \\
B. bayad \ Y = -740.634 + 39.574 \ X
\]

Pearson correlation between standard length and body weight was highly significant (p<0.001) r= 0.950 for A. baremose; r = 0.853 for B. bayad and r = 0.746 for M. caschive (r = coefficient correlation). In the three species the growth is allometric as the b value is significantly (p<0.05-p<0.001) greater than 3. Data matrices (Tables 6, 7 and 8) showed highly significant correlation (p< 0.001) between the various parameters in A. baremose (Table 6). While in B. bayad and M. caschive different levels of significance (p> 0.05 to p<0.001) were observed (Tables 7 and 8). In B. bayad and M. caschive some of the parameters were negatively correlation
Table 5: The relationship between standard length and body weight of the three studied species

<table>
<thead>
<tr>
<th>Species</th>
<th>F</th>
<th>DF</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Alestes baremose</em></td>
<td>3350.042</td>
<td>363</td>
<td>0.000</td>
</tr>
<tr>
<td><em>Bagrus bayad</em></td>
<td>844.496</td>
<td>318</td>
<td>0.000</td>
</tr>
<tr>
<td><em>Mormyrus caschive</em></td>
<td>388.362</td>
<td>311</td>
<td>0.000</td>
</tr>
</tbody>
</table>

0.000 = Very highly significant

where F = F-test

DF = Degree of freedom

P = probability
Table 6: Data matrix for the correlation between various parameters in *Alestes baremose*. 

<table>
<thead>
<tr>
<th>Correlates</th>
<th>Body weight</th>
<th>Stage of gonads maturity</th>
<th>Standard length</th>
<th>Total food weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Body weight</td>
<td>1.000</td>
<td>0.733**</td>
<td>0.950**</td>
<td>0.345**</td>
</tr>
<tr>
<td>Stage of gonads</td>
<td>0.733**</td>
<td>1.000</td>
<td>0.75**</td>
<td>0.293**</td>
</tr>
<tr>
<td>maturity</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Standard length</td>
<td>0.950**</td>
<td>0.75**</td>
<td>1.000</td>
<td>0.352**</td>
</tr>
<tr>
<td>Total food weight</td>
<td>0.345**</td>
<td>0.293**</td>
<td>0.352**</td>
<td>1.000</td>
</tr>
</tbody>
</table>
Table 7: Data matrix of pearson correlation for various correlates in *Bagrus bayad*. 
Table 8: Data matrix of pearson correlation for various correlates in *Mormyrus caschive*. 
4. 4 Food:

Statistical analysis (Table 9) indicated that the relationship between food items and the body weight for each of the three species was very highly significant as indicated by the 2-tailed t-test (p<0.001) and the data matrices Tables (6, 7 and 8).

The predictive equation for the different food items for each of the three species were as follow:

a- *Alestes baremose*:

\[ \text{Body weight} = 2.528 - 7.46 \times 10^{-0.02} \times \text{total food weight} \]

**b**- *Mormyrus caschive*:

\[ \begin{align*} 
\text{Body weight} &= 202.795 + \text{69.742 weight of dragon fly larvae} \\
\text{Body weight} &= 202.795 + 2.871 \text{weight of plant remains}, 
\end{align*} \]

The correlation between body weight and dragon fly larvae, higher plant remains was very highly significant (p< 0.001). Insignificant correlation (p>0.05) between body weight and weight of worms, and between body weight and weight of insect larvae was found.

**c**- *Bagrus bayad*:

\[ \text{Body weight} = 375.773 + 3.524 \text{weight of fish and mollusca}. \]

The correlation was very highly significant (p< 0.001). Incontrast insignificant correlation (p>0.05) was found between body weight and weight of insects and shrimps.

Pearson correlation between body weight and total food weight for each of the three species was very highly significant (p < 0.001) \( r = 0.544 \) for *M. caschive*; \( r = 0.520 \) for *B. bayad* and \( r = 0.950 \) for *A. baremose* (see Data matrices Tables 6, 7 and 8).
Table 9: The relationship between body weight and total food weight for the studied fish.
Table 10: Statistical analysis of the different parameter of *Alestes baremose* (One – sample test):
Table 11: Statistical analysis of the different parameters of *Bagrus bayad* (One-sample test)

P<0.001 is very highly significant
Table 12: Statistical analysis of the different parameters of *Mormyrus caschive*

(One-sample test):
One-sample test correlation of different measured parameters in *A. baremose* (Table 10); *B. bayad* (Table 11) and *M. caschive* (Table 12) were very highly significant (p<0.001).

### 4.4.1 Feeding apparatus:

Observation and examination of mouth, jaws, teeth and alimentary canal was carried out for the purpose of knowing the feeding habits. This is because the modifications of organs intimately associated with the manner of obtaining food and the nature of the diet. The morphology of the alimentary canal of *A. baremose* (Plate 4), *B. bayad* (Plate 5) and *M. caschive* (Plate 6) were examined. The buccal cavity and the mouthparts of *B. bayad* are indications of piscivorous feeding habit. There are two bands of small granular teeth in the upper jaw on the premaxillary and vomero-pterogoid bones respectively.

There are proper stomach pocket-like shape and small intestine. *Mormyrus caschive* have small mouths at the end of the snout the teeth are small and few. There is a rounded stomach and the intestine is surrounded by dense fat deposit (Plate 6).

Teeth of *A. baremose* are small and little pointed, often have more than one cusp, and set in two rows along each jaw. The gill rakers are rather long, cylindrical and closely set. The stomach shape is pocket-like and the intestine is thin (Plate 4).
Plate 4: Digestive system of *Alestes baremose*
Plate 5: Digestive system of *Bagrus bayad*

Liver  Stomach  Intestine
Plate 6: Digestive system of *Mormyrus caschive*
4.4.2 Food items:

The present investigation was based on the examination of the gut contents of 992 specimens, 363 of which belonged to *A. baremose*, 318 to *B. bayad* and 311 to *M. caschive*.

4.4.2.1 Food items of *A. baremose* (Table 13):

The following food items has been recorded in *A. baremose* and the results are represented as follow:

- **Plankton:** Phytoplankton and zooplankton were found in the stomach of *A. baremose*. Their abundance was at its maximum during October to January after which it began to decline. Their overall percentage amounts to 24.4 and 23.2 respectively of the total items eaten as measured by the occurrence method.

- **Worms:** Worms were encountered from August to March, they form 19.9 % of the total items of stomach content.

- **Insects:** Insects larvae and pupae were found in the stomach of *A. baremose* during October to March when they form about 14.9 % of the total food items eaten.

- **Mollusca:** Shells of the lamellibranchs were found in the stomachs of fishes collected from March to June, this form only 6.3 %.

- **Sorghum dura:** Sorghum was detected in June to August samples and it form 4.8 %.

- **Higher plant remains:** Were encountered from July to September and it forms 3.0 % of the total content of the stomach.

- **Fish fries and remains:** These comprised 2.3 % of stomach content.

- **Unidentified food (highly digested) amounted to 1.2%.*
Table 13: The occurrence of different food items of *Alestes baremose*. 
4.4.2.2 Food items of *Bagrus bayad* (Table14):

For *Bagrus bayad* the following food items has been recorded:

**Fish and its remains:** These were found in the stomach of *B. bayad* all the year round. Stomachs of big size fishes (35 cm or more in total length) contained one specimen of fishes, in contrast smaller fishes contained more than one fry in the stomach. Most of the fishes eaten by *B. bayad* were *Alestes spp.* and *Hydrocynus spp.* Sometimes other species such as Tilapias ...etc were found. Their overall percentage amounted to 46.8 % of the contents of the stomach.

**Insects (adults, larvae and pupae):** These were found in the stomach of *B. bayad* during cold months (October to February). Their overall percentage amount to 26.8 % of the contents of the stomach.

**Mollusca:** Bivalves and snails were found in the stomach of *B. bayad* during April to June. It forms 18.4 % of the contents of the stomach.

**Shrimps:** These were found during July and August in the stomach of *B. bayad* and amounted to 6.1 % of the stomach contents.

**Unidentified (highly digested) amounted to 2.0 %**
Table 14: The occurrence of different food items of *Bagrus bayad*. 

<table>
<thead>
<tr>
<th>Food Item</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Item 1</td>
<td>20%</td>
</tr>
<tr>
<td>Item 2</td>
<td>30%</td>
</tr>
<tr>
<td>Item 3</td>
<td>15%</td>
</tr>
<tr>
<td>Item 4</td>
<td>25%</td>
</tr>
<tr>
<td>Item 5</td>
<td>10%</td>
</tr>
</tbody>
</table>
4.4.2.3 Food items of *Mormyrus caschive* (Table 15):

The food items of *M. caschive* are represented as follow:

**Dragon flies larvae:** The larvae were found in the stomach of *M. caschive* all the year round. But their abundance was at its maximum during the cold months (October to February). They formed 25.5 % of the contents of the stomach.

**Worms:** Chironomid larvae and other worms such as Hirodinea and Oligochaete were found all year round but their abundance was at its maximum during the flood months (July to September) and it formed 24.4 % of the content of the stomach.

**Terrestrial insect’s larvae and remains:** were found all the year round and their maximum abundance was during (July to September). They form 22.1 % of the stomach of *M. caschive*.

**Higher plant remains:** These were found in the stomach of *M. caschive* during flood and cold months (August to November) and form 8.2 % of the stomach contents.

**Mud and soil:** Mud was found nearly in all stomachs of *M. caschive* during flood months (July to September). Its occurrence amounted to 16 %, while sand grains amounted to 2.9 % and were found throughout most months of the year.

**Unidentified food amounted to 0.9%.

Table 15: The occurrence of food items of *Mormyrus caschive.*
4.4.3 Variation of food in different months:

The examination of the food contents for the whole year showed that food type varies from one month to the other. This variation may be related to the natural conditions of environment.

A stomach does not contain all the above-mentioned items (Tables 13, 14 and 15) at one time. Some items were found all the year round but others appear in certain months. In Tables (13, 14 and 15) the percentages have been calculated according to the occurrence of a specific item during a certain month. In addition, there is a variation in the amount of food found in the stomach of each species even in the same season.

4.4.4 Different food items for different size groups:

_Alestes baremose_, although showed omnivorous type of food, it seems that it shifts from large dependence on plankton to dependence on fish with increase in size (Table 16).

From Table (17) it is apparent that _B. bayad_ is exclusively carnivorous fish feeding mainly on fish, insects, molluscs and shrimps in that order at all size groups. With the increase of fish size there is an increasing tendency to consume more fish than other food items. With increase in size group, _M. caschive_ tends to rely on food of animal origin more than of plant origin (Table 18).
Table 16: Percentage of different food items by No for different group sizes of *Alestes baremose*.

<table>
<thead>
<tr>
<th>Group sizes cm</th>
<th>Food items</th>
<th>Plankton</th>
<th>Sorghum dura</th>
<th>Higher vegetation</th>
<th>Insects</th>
<th>Worms</th>
<th>Mollusca</th>
<th>Fish remains</th>
<th>Unidentified</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.7 - 16.7</td>
<td></td>
<td>59.8</td>
<td>9.7</td>
<td>3</td>
<td>6.7</td>
<td>18.2</td>
<td>0.6</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>16.8 - 27.8</td>
<td></td>
<td>46.0</td>
<td>4.7</td>
<td>2.9</td>
<td>16.6</td>
<td>20</td>
<td>6.1</td>
<td>2.4</td>
<td>1.3</td>
</tr>
<tr>
<td>27.9 - 39</td>
<td></td>
<td>37.0</td>
<td>0</td>
<td>3.1</td>
<td>21.4</td>
<td>21.5</td>
<td>12.2</td>
<td>4.5</td>
<td>0.3</td>
</tr>
</tbody>
</table>

Table 17: Percentage of different food items by No for different group sizes of *Bagrus bayad*.

<table>
<thead>
<tr>
<th>Group sizes cm</th>
<th>Food items</th>
<th>Fish</th>
<th>Insects</th>
<th>Mollusca</th>
<th>Shrimps</th>
<th>Unidentified</th>
</tr>
</thead>
<tbody>
<tr>
<td>22.5 - 39.2</td>
<td></td>
<td>29.3</td>
<td>31.8</td>
<td>29</td>
<td>5.8</td>
<td>4.1</td>
</tr>
<tr>
<td>39.3 - 56</td>
<td></td>
<td>50.0</td>
<td>22.6</td>
<td>18</td>
<td>7.6</td>
<td>1.8</td>
</tr>
<tr>
<td>56.1 - 73</td>
<td></td>
<td>60.7</td>
<td>26.0</td>
<td>8.3</td>
<td>5.0</td>
<td>0</td>
</tr>
</tbody>
</table>
Table 18: Percentage of different food items by No for different group sizes of *Mormyrus caschive*.

<table>
<thead>
<tr>
<th>Group sizes cm</th>
<th>Food items</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Dragon fly larvae</td>
<td>Worms</td>
<td>Terrestrial insects</td>
<td>Higher vegetation</td>
<td>Mud</td>
<td>Soil</td>
<td>Unidentified</td>
</tr>
<tr>
<td>21 - 38.2</td>
<td>7.9</td>
<td>42.2</td>
<td>15</td>
<td>8.2</td>
<td>23</td>
<td>3</td>
<td>0.7</td>
</tr>
<tr>
<td>38.3 - 55.5</td>
<td>20.6</td>
<td>20</td>
<td>30.6</td>
<td>14</td>
<td>12</td>
<td>2</td>
<td>0.8</td>
</tr>
<tr>
<td>55.6 - 79</td>
<td>47.9</td>
<td>11</td>
<td>20.7</td>
<td>2.5</td>
<td>13</td>
<td>3.7</td>
<td>1.2</td>
</tr>
</tbody>
</table>
4.4.5 Fullness of stomach:
The degree of fullness of the stomach of each of the three species was given in Table 19. For *A. baremose* almost empty was the highest percentage (38.3 %) and lowest was almost full (2.8 %). In case of *B. bayad* the highest was semifull (38.1 %) and the lowest was almost full (4.7%). In *M. caschive* the highest was semifull (39.9 %) and the lowest was empty (5.1 %) Table 19.

4.5 Reproduction:

4.5.1 Morphology:

In *B. bayad* and *M. caschive* the gonad consist of a pair of elongated organs lying along the dorsolateral wall of the body cavity. While in females of *M. caschive* there is a single elongated ovary lying along the dorsolateral wall of the body cavity (Plate 6). The gonads of *M. caschive* and *B. bayad* were very small at immature stages, while, in *A. baremose* these are invisible to the naked eye.

In the three studied species males attain maturity at relatively smaller sizes than females. The spawning season coincides with onset of the flood season in July.

4.5.2 Sex ratio:

The sex ratio in three species was as follow:

The sex ratio of male to female was 1.39: 1 in *B. bayad*; 1.16: 1 in *M. caschive* and 0.96: 1 in *A. baremose* (Table 20). The ratio is close to unity in case of *A. baremose* and *M. caschive*.
Table 19: The degree of fullness of stomach of the studied fishes.

<table>
<thead>
<tr>
<th>Species</th>
<th>Empty</th>
<th>Almost empty</th>
<th>Semifull</th>
<th>Almost full</th>
<th>Full</th>
<th>Turgid</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Alestes baremose</em></td>
<td>14.9</td>
<td>38.3</td>
<td>28.7</td>
<td>2.8</td>
<td>15.4</td>
<td>0.0</td>
</tr>
<tr>
<td><em>Bagrus bayad</em></td>
<td>19.5</td>
<td>13.5</td>
<td>38.1</td>
<td>4.7</td>
<td>24.2</td>
<td>0.0</td>
</tr>
<tr>
<td><em>Mormyrus caschive</em></td>
<td>5.1</td>
<td>21.9</td>
<td>39.9</td>
<td>11.3</td>
<td>18</td>
<td>3.9</td>
</tr>
</tbody>
</table>

Table 20: Sex ratio of the studied fishes.

<table>
<thead>
<tr>
<th>Species</th>
<th>% of sex</th>
<th>Sex ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Male</td>
<td>Female</td>
</tr>
<tr>
<td><em>Alestes Baremose</em></td>
<td>49</td>
<td>51</td>
</tr>
<tr>
<td><em>Bagrus Bayad</em></td>
<td>58.2</td>
<td>41.8</td>
</tr>
<tr>
<td><em>Mormyrus Caschive</em></td>
<td>53.7</td>
<td>46.3</td>
</tr>
</tbody>
</table>

4.5.3 Gonad maturity stages:

One-sample test showed that gonad maturity for each of the three species was very highly significant (p< 0.001) Tables (10, 11 and 12).
Pearson correlation between body weight and gonads maturity was highly significant in cases of *A. baremose* (r = 0.733) and *B. bayad* (r =0.153), insignificant in case of *M. caschive* (r = 0.007) Tables (6, 7 and 8).

### 4.5.4 The breeding season:

*Alestes baremose* has two breeding seasons. The beginning of breeding season is in January but it extends to October with two peaks during March and July (Fig. 2). The spawning period extends from April to September (Fig. 3) Appendix table (1).

In *Bagrus bayad* the beginning of breeding season is in February to June with a peak during May (Fig. 4). The spawning period extend from August to November (Fig. 5) Appendix table (2).

The breeding season of *Mormyrus caschive* is in January and extends to June with a peak during May (fig. 6). The spawning period from July to September (Fig 7) Appendix table (3).

### 4.5.5 The length of first maturity:

In *Alestes baremose* the length of first maturity (50% mature, 50% immature) ranged between 50.7 to 14.1 cm in total length (Table 21).

In *Bagrus bayad* 22.5 to 35.1 cm in total length is the first length of maturity. The percentage of immature fishes is 51.1 and mature fishes is 48.9 (Table 22).

In *Motmyrus caschive* the first length of maturity is very difficult because their stage one is not found in all collected fishes.
Table 21: The length of first maturity of *Aletes baremose*.

<table>
<thead>
<tr>
<th>Stages of maturity</th>
<th>5.7 – 14.1</th>
<th>14.2 – 22.6</th>
<th>22.7 – 31.1</th>
<th>31.2 – 39.6</th>
<th>Total No</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>40</td>
<td>25</td>
<td>12</td>
<td>4</td>
<td>81</td>
</tr>
<tr>
<td>2</td>
<td>20</td>
<td>37</td>
<td>38</td>
<td>23</td>
<td>118</td>
</tr>
<tr>
<td>3</td>
<td>11</td>
<td>34</td>
<td>27</td>
<td>38</td>
<td>110</td>
</tr>
<tr>
<td>4</td>
<td>5</td>
<td>14</td>
<td>6</td>
<td>7</td>
<td>32</td>
</tr>
<tr>
<td>5</td>
<td>3</td>
<td>5</td>
<td>3</td>
<td>4</td>
<td>15</td>
</tr>
<tr>
<td>6</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>7</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>% of immature: mature</td>
<td>50.6: 49.4</td>
<td>21.7: 78.3</td>
<td>13.6: 86.4</td>
<td>4.9: 95.1</td>
<td>363</td>
</tr>
</tbody>
</table>
Table 22: The length of first maturity of *Bagrus bayad*

<table>
<thead>
<tr>
<th>Stages</th>
<th>22.5 – 35.1</th>
<th>35.2 – 47.8</th>
<th>47.9 – 60.5</th>
<th>60.6 – 73.2</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>23</td>
<td>8</td>
<td>7</td>
<td>1</td>
<td>39</td>
</tr>
<tr>
<td>2</td>
<td>17</td>
<td>37</td>
<td>48</td>
<td>43</td>
<td>145</td>
</tr>
<tr>
<td>3</td>
<td>5</td>
<td>16</td>
<td>19</td>
<td>20</td>
<td>60</td>
</tr>
<tr>
<td>4</td>
<td>0</td>
<td>5</td>
<td>8</td>
<td>11</td>
<td>24</td>
</tr>
<tr>
<td>5</td>
<td>0</td>
<td>13</td>
<td>11</td>
<td>12</td>
<td>36</td>
</tr>
<tr>
<td>6</td>
<td>0</td>
<td>4</td>
<td>5</td>
<td>5</td>
<td>14</td>
</tr>
<tr>
<td>% of immature: mature</td>
<td>51.1: 48.9</td>
<td>9.6: 90.4</td>
<td>4.1: 95.9</td>
<td>1.1: 98.9</td>
<td>311</td>
</tr>
</tbody>
</table>
CHAPTER FIVE: DISCUSSION

Physical and chemical characteristics of water:

The physical and chemical properties of water are the basic abiotic environmental factors of any aquatic habitat. In this study the correlation between air temperature and water temperature is highly significant (p<0.001) Table 3. Water temperature is an important factor, which influence growth, reproduction and maturity of fishes. It also affects the development of aquatic micro and macro organisms, the principle components of the fish food chain (Bishai, 1962). The present investigation showed that there are two temperature maxima; one towards the end of the dry season in June and the second is from late September to October. Two temperature minima are also observed, the first one is in January and the second one is during July. These observations confirm those recorded by Ahmed (1985) at Jebel Aulia.

Light is a limiting factor only either at greater water depths or when turbidity is high. The low values of transparency recorded from May to August are attributed to the high silt during flooding. According to Brook and Rzoska (1954), Prowse and Talling (1958), Holden and Green (1960), Tebutt (1983), WHO (1984) and Ahmed (1985) as silt starts to precipitate, the light penetrates deeper. This leads to an increase in primary productivity. The present work indicates that plankton density starts to increase from October (immediately after flood season) and reaches a maximum during December. The subsequent drop may be attributed to the decline in transparency due to the blooming. Brook and Rzoska (1954) and Prowse and Talling (1958) support the opinion that the density of suspended material such as plankton and abundant detritus could explain the turbidity. Tebutt (1983) and WHO (1984) relate turbidity to the small particles in water. Ahmed (1985) showed that there
is significant relationship between light penetration and the productivity of the primary producers, phytoplankton.

Low pH values were recorded during flooding months (June to September) probably as a result of CO₂ release that accompanied the annual breakdown of plankton production. High values were recorded during winter months (October to December). This coincides with the increasing plankton densities. This is in harmony with Rabinowitch (1951 and 1956), Ruttner (1953), Brook and Rzoska (1954), Talling (1956) and Prowse and Talling (1958). During an earlier study Ahmed (1985) found that high pH values were recorded after the flood season.

Dissolved oxygen is an important limiting factor in aquatic ecosystems. Absence or very low levels commonly limits the distribution of plants and animals. The maximum-recorded value recorded to this study (December) coincides the of maximum plankton density. This confirms the findings of Brook and Rzoska (1954), Talling (1957), Prowse and Talling (1958), Bishai (1962) and Ahmed (1985) who attributed the increase of dissolved oxygen amount in the dam region to the maximum development of phytoplankton. In this study low concentrations of dissolved oxygen were apparently related to the increase in water temperature, extremes of pH and high concentration of CO₂. Brown (1957) and FAO (1975) found that the depletion of dissolved oxygen is due to decay of organic matter; high temperature; extremes of pH and high concentrations of CO₂.

High carbon dioxide concentrations in this study were recorded during the flood months (June to September). This agrees with Doudorff (1957) and confirms the findings of Bishai (1961). Increase in CO₂ may leads to decrease in dissolved oxygen and pH values. Thus the biota may negatively be affected.
Feeding apparatus:

The present findings show that *B. bayad* is a generalized predator feeding mainly on small fish, crustacean and insect larvae. Studies made by Pekkola (1919), Sandon and El Tayeb (1953) and Adam (1977) indicated similar observations. *Mormyrus. caschive* as well as *A. baremose* seem to be omnivorous feeders as they feed on insects, molluscs, worms, plant matter and mud. This agrees with Pekkola (1919) and Worthington (1947) and Sandon and El Tayeb (1953). The tendency of *M. caschive* and *A. baremose* to feed on plant matter is an indication of flexibility in their feeding habits (Daget, 1954). It is worth mentioning that in *A. baremose* the plankton constitutes major components of the food to the extent that it can be considered as a planktofagus fish.

Teeth of *A. baremose* are small and little pointed, often have more than one cusp, and set in two rows along each jaw. This agrees with the findings of Sandon (1950) and Sandon and El Tayeb (1953) who, in addition reported that there are 30-38 gill-rakers on the lower part of the first gill arch, 14 teeth in the upper jaw and 10 in the lower one. The gill rakers are rather longing, cylindrical and closely set. The stomach shape is pocket-like and the intestine is thin (Plate 4).

The buccal cavity and the mouthparts of *B. bayad* are indications of piscivorous feeding habit, which agrees with the observation recorded by Sandon (1950), and Sandon and El Tayeb (1953). There are two bands of small granular teeth in the upper jaw on the premaxillary and vomeroppterogoid bones respectively. There is proper stomach (pocket-like) and small intestine. The buccal cavity of *Bagrus spp*, the grasping wide-gap mouth, the sharp teeth, the jaws and the hard edged - jaws are all adapted to swallow the whole prey. Gill rakers are shorting, few and not adapted to strain off food organisms. The stomach is well differentiated and the
intestine is short, elastic and thick walled. Both last characteristics indicate carnivorous feeding habit

*Mormyrus caschive* has small mouths at the tip of the snout. The teeth are small and few. There is a rounded stomach and dense fat deposits (Plate 6) surround the intestine. These are in accordance with the description given by Sandon (1950) and Sandon and El Tayeb (1953)

**Food types:**

The present study has shown that *A. baremose* feeds on phytoplankton such as *Melosira spp, Anabaena spp, Volvox spp, and Spirogyra spp*; zooplankton such as Crustacean spp, *Diaphnosoma spp, Bosminia spp, Cyclops* and *Keratella*, (Table 2); insects larvae, pupae and adults; sorghum Dora; higher plant remains; worms; mollusca (bivalves and snails) and fish remains. Phytoplankton and zooplankton being the more common items as its overall percentage of the total food items is 47.6 by number. Thus *A. baremose* can be described as an omnivorous fish. This confirms the finding of previous investigators (Boulenger, 1907; Pekkola, 1919; Sandon and El Tayeb, 1953).

Boulenger (1907) stated that *A. baremose* feed on insects rather than other fish, while Pekkola (1919) concluded that they feed on crustaceans, chironomids larvae and coleopteran. Sandon and El Tayeb (1953) showed that some *A. baremose* feed on crustacean, chironomids larvae, coleopteran and vegetable matter at some occasions; some feeds on aquatic insects probably (Hemiptera); some feed on coarse vegetable matter only and others feed on planktonic crustacean (*Moina spp* and *Ceriodaphnia spp*), in addition to chironomid larvae. According to the present study, the presence of fish remains in the stomach contents of *Aletes spp* has been noticed, a matter that had also been recorded by Sandon and El Tayeb (1953) suggesting that this species is piscivore. Hamza (1980) concluded that *A. baremose* are surface feeders with no apparent food
selection as they feed on different food items which vary according to their availability. El Obeid (1993) reported that *A. baremose* is herbivore that feed largely on plants, vegetables and green algae.

There are monthly variations in the food composition of *A. baremose*. Phytoplankton and zooplankton are found all the year, with the highest peak of occurrence during October to January and the lowest in June to August. This agrees with Brook and Rzoska (1954); Brook and Prowse (1955); Talling (1956) and Prowse and Talling (1958). Hamza (1980) mentioned that *Alestes spp* change their diet seasonally. Daget (1954) showed that *Aletes spp* change from feeding on insects and seeds or even higher vegetation during rising water to feeding on phytoplankton as the water beings to recess. As the type of food varies in proportion to the length of the fish, it has been noticed that specimen of 5.7-16.7 cm total length feed largely on phytoplankton and zooplankton while longer ones feed less on phytoplankton and zooplankton. Fishes of all lengths except those over 27.8-cm long feed on sorghum. Old fish (more than 16.7 cm long) feed on other fish, while younger ones never feed on fish. This agrees with Daget (1954) who found that there is a tendency for food preference to change, as individuals grow older. The diet of juvenile fish often differs widely from that of the adults of the same species. Adam (1976) reported that the feeding habits of fish vary according to age, season and locality. Generally, fishes are capable of varying their food with quite wide limits especially when their usual food is in short supply. In this study insects found in the stomachs of the studied species were at their maximum during October and January.

This study revealed that *B. bayad* feeds on fish (*Alestes spp, Hydrocynus spp, Tilapia spp* and other); insect larvae and their remains; mollusca (bivalves and gastropods); shrimps; mud and soil grains. The overall percentage of fishes being used as the common item of food is 46.7 % according to the occurrence method. The present finding indicates
that *B. bayad* is carnivorous feeder. Holden (1970) suggested that *B. bayad* is one of macro predators consuming large invertebrates notably decapods crustaceans, insects and other fishes. Hamza (1980) reported that Bagrus *spp.* appears to be the main predatory fish in the White Nile, feeding principally on *Aletes spp.* and *Tilapia spp.* She stated that *B. bayad* is a terminal carnivores predator with a tendency to scavenge on dead fish, and that the size of the prey varies according to the size of the predator. Bailey (1993) showed that *B. bayad* and *B. docmac* are widely distributed in the Nile and its tributaries. They are of predatory nature, feeding on insects, crustacean, mollusca and fish. El Obeid (1993) recorded that *B. bayad* are carnivorous, predate on invertebrates and vertebrates of many kinds.

It is noticed that the food of *B. bayad* varies monthly. Fish and its remains are found all the year, but they are at their highest level of occurrence during April to August and at the lowest in September to January. This coincides with the peak of fry abundance shown by Adam (1976) who found that most of the fish larvae and fry were encountered in plankton nets during April to August. At this time the fry feed abundantly on planktonic organisms existing on surface water. Hanna and Schiemer (1993) reported that in Jebel Aulia reservoir juveniles of *Aleste* migrate down stream into the reservoir at periods of water storage and this coincides with periods of increasing primary productivity, as evidenced by Sechi disk reading and zooplankton counts. Insects and their larvae, pupae and remains found in the stomachs are at their maximum level during December to January and form 26.8 %, while molluscs form 18.4 % and shrimps 6.1 %. The type of food varies according to the length of fish. Thus it was noticed that younger fishes (22.5-39.2) feed principally on molluscs while larger fishes feed less on molluscs. The present investigation contradicts the findings of Sandon
and El Tayeb (1953) that *B. bayad* feed exclusively on fishes of all lengths.

The present study showed that *M. caschive* feeds mainly on water insects (dragon fly larvae); worms; terrestrial insects; higher plant remains; mud and soil. Dragon fly larvae constitute 25.5% of the total food items by number. The small mouth at the end of the snout which the fish pokes around in mud, catching worms and insects larvae facilitates the feeding habits. Similar observations were reported by Pekkola, (1919) who stated that many of the large Mormyrids are bottom fishes and their snouts are specially developed to enable them to procure food such as worms (chironomids larvae and oligochaeta) and insect larvae from mud, but some with larger mouthes feed principally on fish, while Worthington (1947) concluded that all the stomachs of *M. caschive* examined in Uganda contained chironomid larvae mixed with mud and vegetation debris. Sandon and El Tayeb (1953) showed that nearly all the Mormyrids are bottom-living fishes whose small teeth do not suit the predatory habits. Also they showed that stomachs of *M. caschive* from Lake Victoria contained only chironomid larvae without any mixture of mud. This indicates that *M. caschive* is able to pinch their food up and wash it free from mud before swallowing it. Bishai (1967) recorded that *M. caschive* are bottom feeders and their foods consist mainly of insect larvae embedded in the mud. Holden (1970) recorded that *M. caschive* is one of the bottom feeders that feeds mainly on diptera larvae, especially chironomids, in addition to insects, crustacean and molluscs. Lauzanne (1972) classified *M. caschive* under euryphagic species that feeds on a wide variety of foods. Hamza (1980) and El Obeid (1993) reported that *M. caschive* is omnivores; feeding on mixed diet of invertebrates and plant matter. In this study dragon fly larvae has been found in *M. caschive* stomach all the year round with a maximum level of occurrence
during October to January and a minimum level in April to July. In addition, the worms and terrestrial insects found in the stomachs are at their maximum level during June to October. Higher plant remains have been found during August to November and during January and April. This coincides with the peak of flooding season.

Type of food change with the length of fish. The stomach of *M. caschive* of 55.6 - 79 cm total length contained a great deal of water insects (dragon fly larvae) while stomach of smaller fishes contained few of them. Terrestrial insects were numerous in stomach of *M. caschive* of 38.3 - 55.5 cm and worms in stomachs of specimens of 21 - 38.2 cm total lengths. Lowe-Mc Connel (1975), however, pointed out that stomachs of 5 specimen of *M. caschive* from the Upper Nile (15 - 63 cm) contained a mixture of vegetarian matter with chironomid larvae and considerable amount of mud, a specimen from lake No (71.9 cm) had vegetarian matter only, and another one from Khartoum (about 26 cm) taken during the flood was full of earth worms.

**Reproduction:**

**Sex ratio:**

In this study females dominated the population of *A. baremose* in Jebel Aulia reservoir but males dominated the population of *B. bayad* and *M. caschive* (Table 20). However the sex ratio does not significantly deviated from unity in at least *B. bayad* and *M. caschive*. Ahmed and El Moghraby (1984) reported that females dominated the population in *Barbus bynni*. The discrepancy in sex ratio may be due to differences in natural mortality between sexes as stated by Ahmed and El Moghraby (1984) or to segregation of sexes in various periods of the year, including segregation resulting from sex differences in size of mortality. The ratio may be dependent on the interaction of the populations with the environment. Meryll (1964) pointed out that changes in the quantity and quality of the food supply are the main causes of deviations from the 1:1 sex ratio.
Hardisty (1954 and 1960) to bring reported a good supply of food about an increase in the proportion of females.

**The spawning season:**

The spawning seasons of *A. baremose* extend from January to October with two peaks in March and July. The first peak may take advantage of the low water level in the basin where the primary productivity is high and food is available for the offsprings. The second peak coincide with flooding season in which the breeding could be influenced by environmental factors. Brown (1957) and Ware (1977) recorded that the summer/autumn breeding season in *Tilapia nilotica* could be influenced by a multitude of interacting factors such as changes in water temperature, depth, availability of food…etc. It is widely accepted that among the natural environment variables, food is probably the most important single factor affecting the productivity of the population and the viability of the spawn. Nawar (1957) stated that environmental factor governs the onset of oogenesis in the ovaries and maturation of the testes. Of these temperature seems to plays the most important role for all fishes of the Nile. Internal physiological rhythms and of external seasonal rhythm controls the reproductive activity of fishes.

The spawning seasons of *B. bayad* and *M. caschive* are during flooding season which may also be affected by the fluctuation of water temperature, depth and availability of food.

**Gonads:**

In *B. bayad* and *M. caschive* the gonads consist of a pair of elongated organs, lying along the dorsolateral walls of the body cavity. This agrees with the case in other tropical fishes, e.g. Ahmed and El Moghraby (1984) on the *Barbus bynni*. In females of *M. caschive* however, there is a
single elongated ovary lying along the dorsolateral wall of the body cavity (Plate 6). The gonads of *M. caschive* and *B. bayad* were very small at immature stages, while, in *A. baremose* these are invisible to the naked eye. This confirms the findings of El Azrag (1981) who recorded that in *A. baremose* no external morphological characteristics appeared as assign of maturity.

In the three studied species males attain maturity at a relatively smaller sizes than females. This agrees with the findings of Abu Gideiri (1962) on *Synodontis scall*, and Ahmed and El Moghraby (1984) on *Barbus bynni*. Gonads of mature fishes begin to ripen in May when the water temperature approaches its annual maximum. This confirms the findings of Nawar (1957) who recorded that the sudden, gonadial activity in *A. baremose* during April coincides with the period when temperature starts to rise.

The spawning season coincides with onset of the flood season in July. This confirms the findings of Nawar (1957) who found that the breeding season of *A. baremose* was during June to August, *B. bayad* from April to May and *M. caschive* during May to June. Bishai (1977) concluded that *A. dentex* spawn during April and August, while, Pekkola (1919) recorded that May is the spawning season of *B. bayad* and *M. caschive*.

**Length of first maturity:**

The length of first maturity in *A. baremose* ranged between 5.7 to 14.1 cm (total length); while in *B. bayad* it ranged between 22.5 to 35.1. In *M. caschive* the length of first maturity was not found in any of the specimens collected.
CHAPTER SIX: CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

1. The correlation between some environmental factors and plankton ranged from negative (water temperature and density of plankton, pH and dissolved oxygen) to positive (dissolved oxygen and nitrogen). The correlation between air temperature and water temperature was very highly significant (p< 0.001) and that between air temperature and dissolved oxygen is significant (p<0.05).

2. *Aletes baremose* is an omnivorous feeders, which feeds mainly on planktonic communities; insects; worms; higher vegetation; seeds; mollusca and crustacean spp. *Bagrus bayad* is a carnivorous and feeds mainly on fish; crustacean; insects and molluscs. *Mormyrus caschive* is a bottom feeder. It feeds mainly on water insects (dragon fly larvae); terrestrial insects; mollusca and higher vegetation.

3. One-sample test showed avery highly significant correlation (p<0.001) between body weight and different types of food in *B. bayad* as well as *M. caschive*. 
4. There are strong correlation between standard length and body weight; body weight and stage of gonads maturity for each of the three species (p<0.001).
5. There are different sizes groups of the studied species may have different preference of food type.
6. The sex ratio in *B. bayad* and *M. caschive* was in favour of males; but in *A. baremose* was in favour of females.
8. There seems to be two spawning seasons for *A. baremose* (March and July) and one spawning season for *B. bayad* and *M. caschive* (during flooding).
9. The length of first maturity in *A. baremose* ranged between 5.7 to 14.1 cm (total length); while in *B. bayad* it ranged between 22.5 to 35.1. In *M. caschive* the length of first maturity was not found in any of the specimens collected.

**6.2 Recommendations:**

1. Measurements of the physical and chemical characteristics of water and plankton communities should be done routinely work.
2. Studies on food and feeding habits should be associated with histophysiological investigations.
3. Studies on reproduction should concentrate on the breeding season, fecundity and their relation with growth parameters.
CHAPTER SEVEN: REFERENCES


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Appendix table 1: Frequency number and percentage of spawning season in *Alestes baremose*.

Appendix table 2: Frequency number and percentage of spawning season in *Bagrus bayad*.
Appendix table 3: Frequency number and percentage of spawning season in *Mormyrus caschive*.