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Studies on the "biology of the Family Schilbeidae (Osteichthyes : Siluriformes) in Lake Kainji, Nigeria.

Dissertation submitted for the degree of

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ABSTRACT

The biology of the Family Schilbeidae (Osteiehthyes : Siluriformes) in Lake Kainji, Nigeria was investigated. Eleven sampling stations located within the central basin of the lake were sampled monthly with static gill nets of various stretched mesh sizes, supplemented by netting in Shagunu creek with small-mesh nets.

Five schilbeid species were found. Eutropius niloticus RUPPELL and Physailia pellucida BOULENGER were the commonest and most abundant. Schilbe mystus LINNAEUS was less abundant, but was far more abundant than Siluranodon auritus (GEOFFROY ST. HILLAIRE) and Schilbe uranoscopus RUPPELL which were very rare. All species were found in a variety of habitats in the lake and adjacent inlets; but P. pellucida is pelagic and S. mystus is riverine.

The pectoral spines display rings which are shown to be annual so can be used to determine the age and growth of E. niloticus and S. mystus. Females grow faster, attain greater maximum size, live longer and attain maturity at a greater length than the males. Sex ratio varied seasonally with more females in the population than males. Sex ratios and gonad cycles provided evidence of breeding pattern for all the species except S. uranoncopus. P. pellucida spawned several times during a prolonged breeding season while others spawned once during a short breeding season from June to November.

Stomach contents showed that although every species would take a variety of food, Siluranodon auritus is phyto-plonktonivorous; Physailia pellucida feeds mainly on zooplankton, both

species of Scbilbe are mainly piscivorous and Eutropius niloticus is omnivorous. Food selection was influenced by age or size of the fish and seasonal availability of food items. Digestive enzymes showed a correlation with the dets of the species studied.

The biochemical and nutritive values of the three common schilbeids were determined and suggestions are irade for more effective harvesting of schilbeids for consumption.

GENERAL INTRODUCTION

Recent technological advances have ushered in another era in the history of mankind. Although developed countries set the technological pace, developing countries particularly in Africa are not being left behind in the technological struggle. Technological awareness has led to the development of large industries and the consequent search for power to run these industries. Hydro-electricity is considered to be one of the cheapest ways of generating power, thus the development of cheap power has led to the damming of large rivers. It is therefore not surprising that the last two decades have seen the building and completion of some large dams. Four of the largest man-made lakes are located in Africa; of these, two are located in West Africa. These are formed by the Akosombo dam and the Kainji dam built across the Volta River in Ghana and River Niger in Nigeria respectively. The completion and subsequent closure of the dams built across these two rivers has resulted in the creation of Lakes Volta and Kainji respectively.

Apart from generating electricity, other benefits from man-made lakes include development of fisheries, irrigation for agricultural purposes, improved navigation and recreational facilities. The creation of man-made lakes often affects not only the flora and fauna of the lake basin, but also the human population. There has been considerable population movement and resettlement, new roads have had to be constructed and associated medical and socio-economic problems had to be solved. To the biologist, the interest is sometimes mainly focused on the biological changes which are a consequence of the new environment, and these are often catastrophic. The notorious growth of aquatic weed in Lake Kariba a few months after the impoundment (Little, 1966) is a clear example. Ewer (1966), Little (1966),

Leentvaar (1966), White (1969), Elder (1965)and other authors have reviewed these phenomena.

It is now known that biological changes which occur in newly created impoundments follow a pattern of initial increase and later, a decline in productivity. Often in the first few years of the closure of a dam some of the existing riverine species seem to adapt to their changed environment. Some species seize the advantage of the initial rise in nutrients to increase their population while others are reduced in number or completely eliminated. The work of Petr (1969) and Lawson et al (1969) on Lake Volta shows interesting patterns in the distribution and abundance of fish populations during the year the reservoir was filling. The mormyroid species decreased in the fishermen's catches as soon as the lake started to form but Alestes sp. became abundant. There was also a decrease in characids and an increase in the cichlids. In Lake Brokopondo many rapids-dwelling fish in the former river were found dead after the inundation e.g. Plecostomus sp. (Leentvaar, 1966). Nursall (1969) noted that Catostomus catostomus decreased while Prosopium williamsoni increased. In Lake Kainji, a similar sequence was noticed, the Mormyridae which were formerly the most abundant in the catches before the impoundment (Banks et al, 1965) were reduced considerably after the closure of the dam (Lelek, 1972).

If maximum scientific information is to be derived from new impoundments, physico-chemical events, the plankton, zoobenthos and other related aspects have to be studied along with the fisheries. Before and after the formation of Lake Kainji many studies were organised and the pre-impoundment surveys covering the biology of the fish, the algae, zooplankton as well as the physical and chemical conditions of the River Niger around the Kainji Lake basin were conducted by White (1965); Imevbore (1970a,

b); Motwani & Kanwai (1970); Imevbore & Bakare (1970); Bakare (1968, 1970). After impoundment, F.A.O. -backed researches to cover the chemistry, fisheries and primary production of the lake were conducted by Henderson (1973), Lelek (1972), and Karlman (1973) respectively. Apart from the FAO, other limnological studies included those by Adeniji (1973, 1975). Fisheries work covering some major families, including the cichlids (Johnson, 1973; Otobo, 1976b; Akintunde, 1976), the Mochokidae (Willougby, 1974), Citharinidae (Arawomo, 1972, 1976), Bagridae (Ajayi, 1972), Mormyridae (Blake, 1977a, c), Characidae (Lewis, 1974a) and the Clupeidae (Otobo, 1974, 1976a) have been undertaken. General work on the fisheries of Lake Kainji since the impoundment included those of Blake (1976, 1977b); Turner (1970, 1971), Lelek (1973), Lewis (1973a, b, 1974b), Lelek & El-Zarka (1973), and Imevbore and Okpo (1975). Although some of the publications listed above contain some scattered information on the family Schilbeidae, no detailed studies on the biology of the family have been conducted since the formation of the lake about eight years ago. There is therefore need for detailed work on the family to help (1) in the understanding of the general biology of the family; (11) in the understanding of the possible trophic links existing between the Family Schilbeidae and other elements of the community in the lake and (111) in the establishment of effective management and utilization of the fish for human benefit.

The aim of the present study is to investigate some aspects of the biology of the family Schilbeidae (Osteichthyes : Siluriformes) and deal with the following topics :-

(i) Description, distribution and abundance of the species present in Kainji Lake.

(ii) Age determination and growth.

(iii) Food and feeding adaptations.

(iv) Fecundity and reproductive cycles.

(v) Biochemical composition, nutritional value and exploitation of the schilbeids in Lake Kainji.

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1.0.0. Lake Kainji, Nigeria.

The lake was created in 1968 as a result of closure of the Kainji dam built across the River Niger at Kainji Island (Fig. 1.1). The location and basic characteristics of the lake are shown in Table 1.1. The dam was closed on 2nd August 1968 and took about three months to fill.

The main features of the regional climate, geology and vegetation of the Kainji Reservoir basin were summarized by Imevbore (1970a). Rains occur annually between April and October while the dry season occupies the rest of the year.

The majority of this region is underlain by sediments of the Nupe sandstones. These are supported below by crystalline schists and gneisses which belong to the basement complex of pre-cambrian age (NEDECO & Balfour Beatty, 1961).

A large proportion of the lake basin lies within the Northern Guinea Savannah (Keay, 1965). In the northern part, particularly around Yelwa, Clayton (1957) indicated that a transitional zone between Northern Guinea Savannah and the more arid sudan zone occurs.

1.0.1. Morphology.

Morphologically the new lake can be divided into three parts; northern, central and southern. The northern part where the Niger enters the lake is a long, narrow and steep-sided area extending from Yelwa to about eight kilometres below Agwarra and comprises about 10% of the lake surface. Water flow is swift and the area is more riverine than lacustrine for most part of the year.

The central part of the lake is a large shallow basin where the old river branched into two to form the now submerged Foge

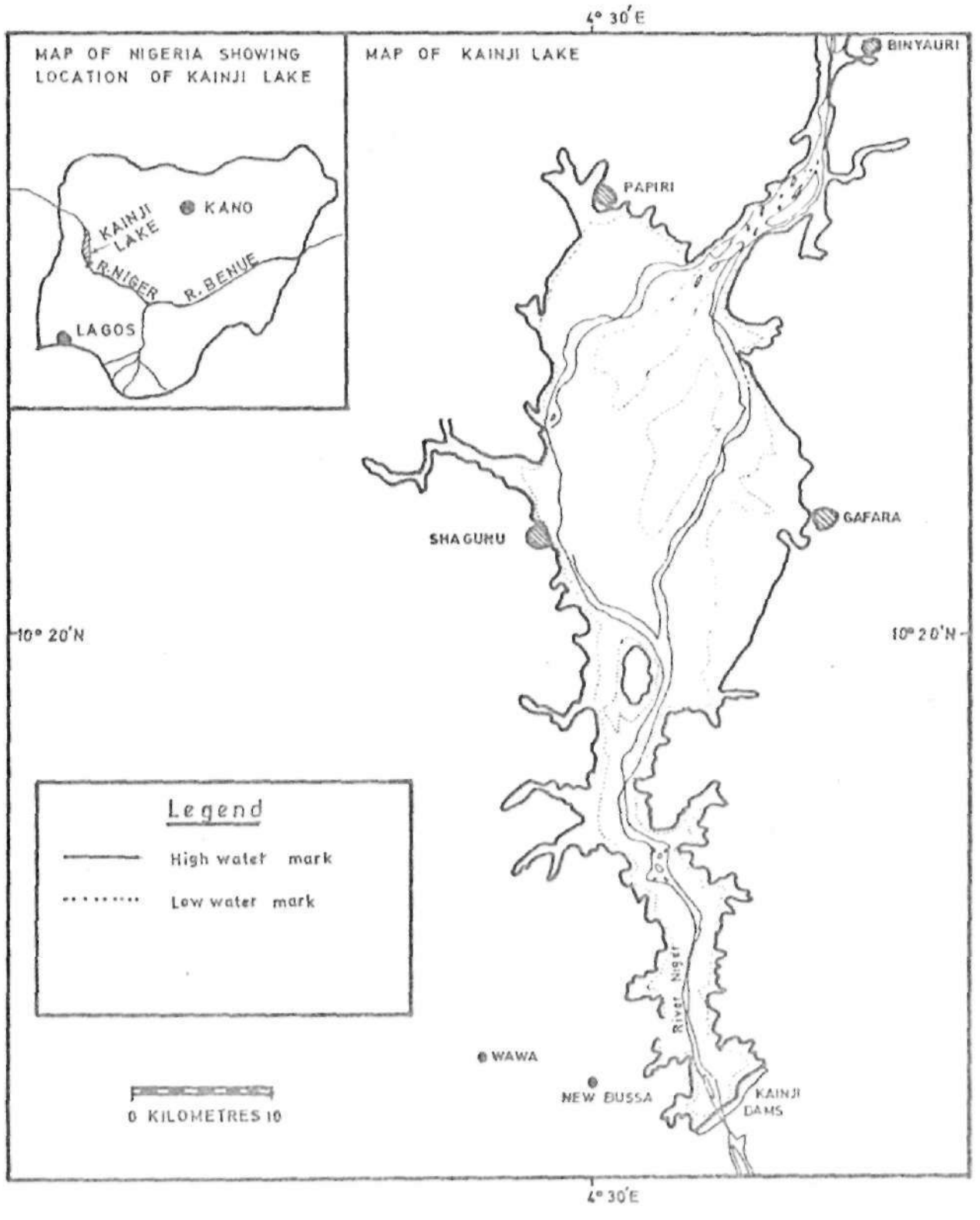


Fig. 1.1. Location of Lake Kainji, Nigeria.

Table 1.1. Location and basic characteristics of Lake Kainji, Nigeria.

Geographical location.		
Continent	:	Africa, South of Sahara
Country	:	Nigeria
Latitude	:	9^{o} 50' - 10^{o} 55' North
Longitude	:	4^{o} 25' - 4^{o} 45' East
Basic characteristics		
Length of Lake	:	136.8 km (max.)
Width of Lake	:	24.1 km (max.)
Surface area of the lake at high water	:	1280 km^2
Volume at high water	:	15.6 km^3
Volume at low water	:	6 km^3
Average volume	:	12 km^3
Max. depth	:	60 m
Mean depth at high water	:	12.3 m
Mean depth at low water	:	8.8 m
Annual fluctuation in water level	:	9 - 10 m
pH	:	6.0 - 7.6
Ratio annual outflow to volume	:	4:1
Estimated yearly precipitation	:	1100 mm
Estimated yearly evaporation	:	1900 mm
Period of circulation	:	Dec - Jan
Period of stagnation	:	February - June

Island. This basin comprises nearly 70% of the lake's total surface area. The eastern shore is shallow whereas the western shore tends to be steeper. The depth of the lake here varies from 3.3 - 20 metres (El-Zarka, 1971). The mean depth, however, is about 11 metres except in the old river channel which is about 20 metres (Karlman, 1973). During the annual drawdown part of this basin is exposed and the exposed areas are often temporarily inhabited by migrant fishermen. About 70% of the trees on this island were cleared before inundation (Imevbore, 1970a) thus leaving a very large area for fishing and making it obstruction-free for navigation. The central basin is the most important portion of the lake as far as fisheries is concerned since the majority of the annual catch is expected to be produced from here.

The third portion, the southern part of the lake, extends from the dam northwards up to around Old Bussa. The lake here is narrow, deep, steep and rocky and forms about 20% of the total surface area of the lake.

1.0.2. Hydrology

There are two seasonal period of flooding each year in Lake Kainji. The first originates from the rains in the Fouta Djallon highlands (see Fig. 1.2). The water on its way down is partially evaporated and about two-thirds of the water is lost in the swamps around Timbucktu (NEDECO & Balfour Beatty, 1961). By the time it reaches Nigeria the water is rather clear, having deposited its silt in the swamps. This flood is called the "black flood" because of the dark background of the clear water due to poor reflection of the light. The black flood occurs between November and February during the dry season.

The second water supply comes from local rains around Niamey

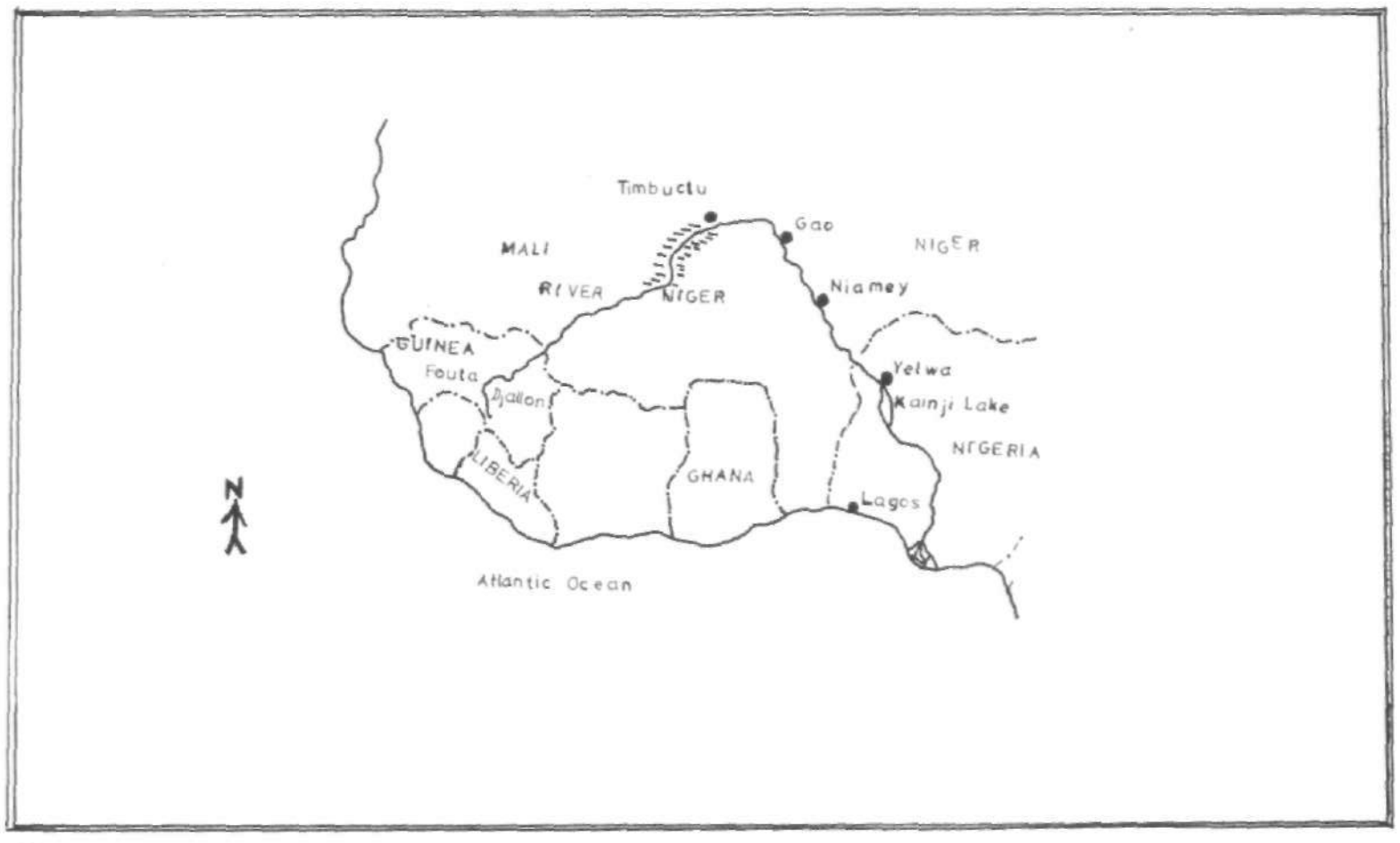


Fig. 1.2. West Africa, showing the source of River Niger at the Fouta Djallon highlands in Guinea. The marsh at Timbuctu and the position of Lake Kainji are also shown.

and run-off from local tributaries in Nigeria. These carry a lot of silt and other suspended particles which make the water turbid and whitish and so is named the "white flood". The white flood occurs between August and November.

Apart from the River Niger itself, there are several small tributaries which run into the lake. At the western side these are the rivers Kpan, Swashi, Menai, Temo and Doro; at the eastern side the rivers Wara, Wo and Malendo. The latter is the most significant of the several tributaries. Its peak discharge of around 700 m^3/sec occurs near the start of the white flood (El-Zarka, 1973).

The annual flow of water to the lake from the Niger and other inlets was estimated by El-Zarka (1973) to be around 80 billion m^3 in a year of high flow. The contribution by the black flood is relatively constant from year to year while the white flood may be reduced by as much as one third in dry years. The hydrological pattern is reflected in the discharge flow of the two floods. During the white flood, the discharge is between 4000 - 6000 m^3/sec whereas during the black flood the peak flow is about 2000 m^3/sec (El-Zarka, 1973). The annual drawdown occurs between April and August each year and during this period the lake level falls by about ten metres.

1.0.3. Physical and Chemical Characteristics.

In the deeper parts (mean depth $>$ 10m), thermal stratification occurs annually in February and towards the middle of May a distinct thermocline is formed, although in shallow areas (mean depth$<$10m) there is no significant thermal stratification or deoxygenation throughout the year. In March at the peak of thermal stratification oxygen concentration below the thermocline

drops to almost zero in the hypolimnion (Adeniyi, per. comm.). This is emphasized at the dam site by the strong odour of sulphide which escapes by aeration at the spillway. During stratification fish are often killed as a consequence of deoxygenation and asphyxiation. Transparency ranges from 8cm to 280cm (Adeniyi, per. comm.).

1.0.4. Ecological Communities

Marked blooms of blue-green algae occur annually in October and November. Then Volvox sp, Melosira sp, Microcysts sp and Anabaena are the dominant species of algae in the lake. No problem of excessive weed growth has occurred in Lake Kainji. The rotifera and crustacea provide the two important zooplankter groups in the lake. The most important species of Rotifera are Polyarthra sp, Keratella cochlearis, K. tropica, Synchaeta pectinata, Collotheca pelagica and Trichocerca sp. (Clarke, per. comm.). Bosmina longisrostris, B. meridionalis and Diaphanosoma excisum are the most important cladocera while Thermocyclops neglectus and Tropodiaptomus banforanus are the most important copepods (Clarke, per. comm.). The insects, particularly their immature stages, dominate the zoobenthos. The littoral and the profundal habitats are dominated by the chironomids and molluscs. The submerged trees are inhabited by the larvae of Povilla adusta. The emergent vegetation is principally inhabited by Odonata, Molluscs, Ephemeoptera, Chironomidae and Crustacea (Bidwell, per. comm.). The phytoplankton, zooplankton and zoobenthos provide the food for the large fish population which form the apex of the trophic pyramid. About ninety-nine species of fish have been recorded in Lake Kainji (Lelek, 1972) though by no means all are important from the commercial point of view.

C H A P T E R T W O

The species of Schilbeidae, their distribution and abundance.

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2.0.0. I N T R O D U C T I O N

The fish species in any man-made lake are those derived largely from the river which has been impounded. It is therefore expected that the number of species present in any impoundment will be influenced by the richness of the initial fish fauna of the river and its response to the new environment. Of the eight genera of Schilbeidae present in Africa, six are found in West Africa. In Lake Kainji there are four genera and five species present, in contrast with the nearest man-made lake, Lake Volta with five genera and seven species.

The proper understanding of the biology of any fish species and the establishment of good management practice depends on several factors; two of which are the knowledge of the distributional pattern and the variations in the abundance of the fish under study.

Previous studies on the distribution and abundance of the Family Schilbeidae in Lake Kainji had been based on the general studies conducted by Lelek (1972, 1973), Lewis (1973a, 1974b) and Blake (1976, 1977b). In these publications attention was focused on the distribution and abundance of the family as a whole rather than individual species within the family. It is therefore difficult to obtain detailed information on the distribution and abundance of the individual species.

In this chapter, the fish species in this study are described, their distributional pattern and abundance within the lake are considered and their geographical distribution discussed.

2.0.1. M A T E R I A L S AND M E T H O D S

1. Sampling Stations

Eleven sampling stations established around the central basin

of the lake by the University of Ife/University of Reading, Kainji Research Project team were sampled during the period of this study (Fig. 2.1). The description of the sampling stations is as seen in Table 2.1. The siting of the stations was originally governed by the following criteria :-

(i) They were chosen to coincide with some of the stations previously used by the University of Ife/University of Southampton, Kainji Research team in order to make the results comparable.

(ii) The stations were chosen to be representative of the various habitats existing within the lake.

(iii) Ease of access and nearness to the field station. The stations had to be near to the Field Stations in order that the fish might be in good condition by the time they arrived at the station.

(iv) The central basin of the lake where the sampling stations were located was considered to be the area where about 80% of the fishing operations of the lake would take place and about 70% of the total fish produced at the lake will come from this area. It was therefore considered adequate to concentrate the studies around the central basin of the lake.

As far as practicable, each station was sampled once in each month. However, the sampling programme was sometimes disrupted and not all the eleven stations could be sampled in each month. In some months sampling had to be restricted to the stations very near to the field station (e.g. Stations J, K, L, M and C). The following were some of the several typical situations which made sampling difficult or impossible :-

(i) Stormy conditions on the lake.

(ii) Heavy rains accompanied sometimes by strong winds.

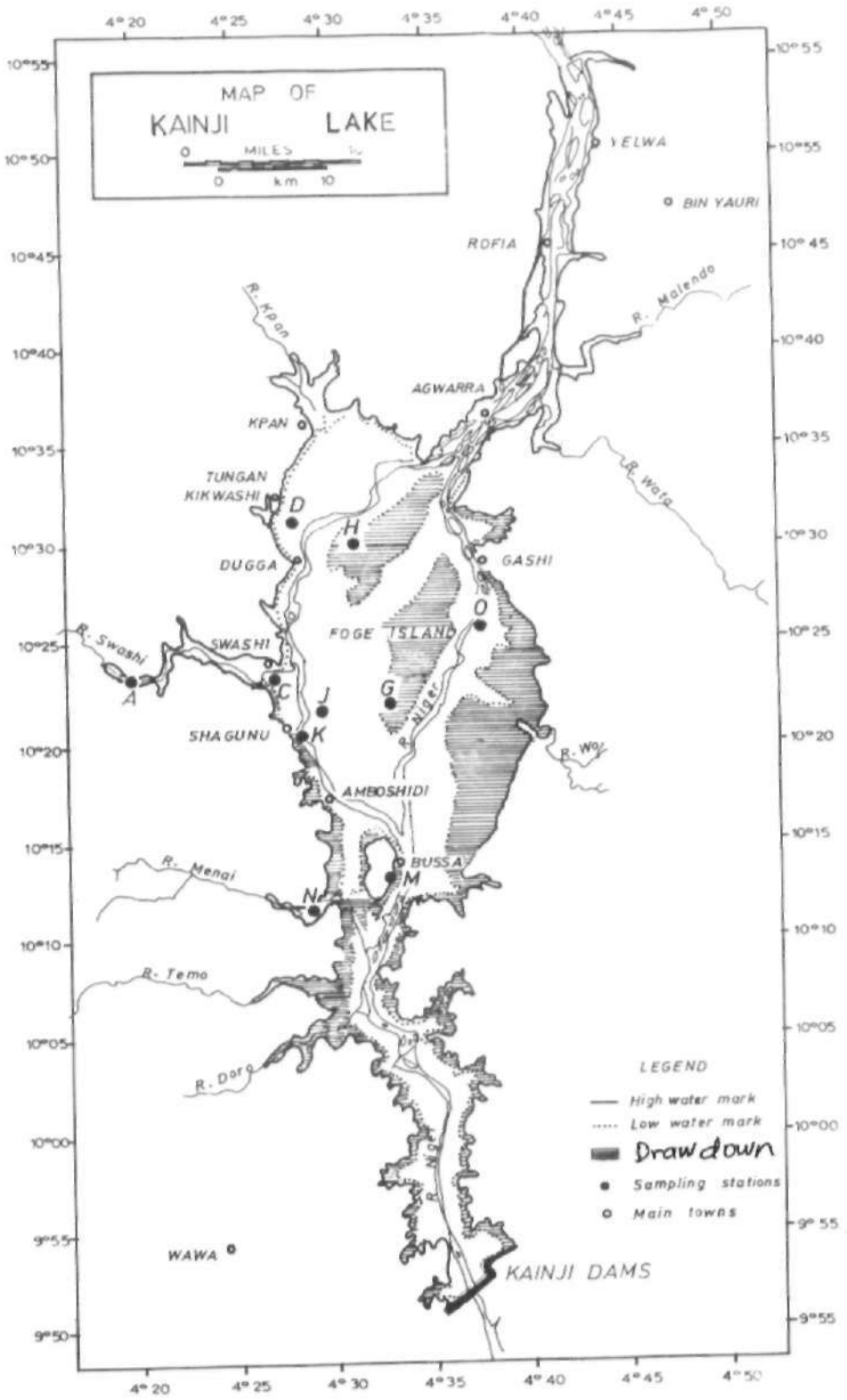


Fig. 2.1. Lake Kainji showing the sampling stations.

Table 2.1. Description of the sampling stations.

(See also Fig. 2.1)

Abbreviations used.

HW = high water

LW = low water

WF = white flood

BF = black flood

OM = other months

All measurements were rounded off to the nearest whole number or decimal point. (All measurements were in metres).

STATION	DESCRIPTION
A	A riverine station situated at the upper reaches of the River Swashi. The old river channel was clear of all obstructions. The sides of the old river channel were covered with a dense growth of *Echinochloa* sp. The bottom was muddy. Mean depth : (HW) 7 (LW) 4 Mean transparency : (WF) 1.0 (BF) 1.4 (OM) 0.9
C	Station was situated at the mouth of River Swashi. Dense submerged bush was present. The trees were usually exposed at the low water level. Mean depth : (HW) 11 (LW) 8 Mean transparency : (WF) 0.4 (BF) 0.8 (OM) 1.4
D	An inshore station located near Dugga. Bottom was muddy. Mean depth : (HW) 19 (LW) 15 Mean transparency : (WF) 0.4 (BF) 0.7 (OM) 1.3

Table 2.1. cont'd.

STATION	DESCRIPTION
G	An offshore station, situated in the uncleared region of the Old Foge Island. At low water many drowned trees were often exposed. Bottom was made up of gravel. Mean depth : (HW) 15 (LW) 12 Mean transparency : (WF) 0.4 (BF) 0.9 (OM) 1.3
H	An offshore station, situated north of station G opposite Dugga at the Foge Island. Bottom was muddy. A dense growth of Echinochloa sp. and Vossia sp. were present. Mean depth : (HW) 7 (LW) 2 Mean transparency : (WF) 0.4 (BF) 0.8 (OM) 1.3
J	An inshore station, just at the northern beach of the field station. Bottom made up of fine sand and gravel. Uniform depth of 9m at high and low water. Mean transparency : (WF) 0.4 (BF) 0.7 (OM) 1.3
K	An inshore station, just at the southern beach of the field station where boats were anchored. Bottom of the lake varies from mud, gravels to rock in some areas. Mean depth : (HW) 6 (LW) 3 Mean transparency : (WF) 0.3 (BF) 0.4 (OM) 1.3
L	An inshore station located opposite Amboshidi Village. The bottom was made up of fine mud. Mean depth : (HW) 10 (LW) 8 Mean Transparency : (WF) 0.5 (BF) 0.5 (OM) 1.3

Table 2.1. cont'd.

STATION	DESCRIPTION
M	An offshore station situated at the southern part of the central basin near Old Bussa. The bottom was made up of mud with gravel. Mean depth : (HW) 8 (LW) 7 Mean transparency : (WF) 0.5 (BF) 0.9 (OM) 1.6
N	Station situated at the middle reaches of River Menai. There was a dense growth of Echinochloa sp. at the sides farther away from the old river channel. Mean depth : (HW) 14 (LW) 8 Mean transparency : (WF) 0.5 (BF) 1.2 (OM) 1.3
O	Station located at the eastern side of the lake opposite Gafara. Bottom with fine sand and mud. Submerged trees were present. Mean depth : (HW) 5 (LW) 4 Mean transparency : (WF) 0.4 (BF) 0.7 (OM) 1.0

(iii) Lack of fuel for the boat engine.

(iv) Faulty engine or leaking boats.

(v) Badly damaged gill nets and

(vi) Occasionally insufficient personnel, caused for example by sudden illness of one of the fishing staff or boat driver.

Table 2.2 shows the number of stations sampled each month and the number of times each station was sampled between October 1974 and September 1976.

2. Sampling gears

Nylon gill nets of various selected mesh sizes were used. The main fleet of nets was made up of the following stretched mesh sizes quoted in centimetres; 3.8, 5.1, 6.4, 7.6, 8.9, 10.2, 12.7 and 17.8. The 3.8 and 5.1cm nets were 45.7m by 3.7m while the rest were 91.4m by 3.7m. One set of the fleet was set to hang from the surface of the water (usually called surface or floating nets) while the second set was to sink, but float from the bottom (usually called bottom or sinking nets). The order of the various mesh sizes in the fleet was changed randomly every month in order to eliminate positional sampling bias. Because of the annual fluctuations in the water level, it was necessary to move some of the inshore stations further offshore during the drawdown period.

In addition to the routine gill netting programme described above other methods of obtaining samples were employed as often as time and available labour permitted. The following methods were also used to obtain fish samples : Small mesh-sized gill nets :- It was noticed that the big mesh sizes used in the main fleet did not catch smaller members of the family, (for example, Physailia pellucida, and Siluranodon auritus) and the juvenile

Table 2.2. The number of stations sampled each month and the **number of times each station was** sampled between October 1974 and September 1976.

YEAR	1974												1975												1976												No of times each station was sampled
MONTHS	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S													
A	+	+	+	+	+	+		+	+	+							+			+				+													12
C	+	+	+	+	+	+	+	+	+	+		+				+		+	+	+			+	+													17
D	+	+	+	+	+	+	+	+		+							+	+																			11
G	+	+	+	+	+	+	+	+	+	+	+	+		+				+						+	+													16
H	+	+	+	+	+	+		+		+																												8
J	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+		+	+	+	+	+	+	+														22
K	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+		+	+	+	+	+	+															21
L	+	+	+	+	+	+	+	+	+	+	+	+	+	+			+		+	+	+	+		+													20
M	+	+	+	+	+	+		+	+	+		+		+			+	+	+	+				+													16
N	+	+	+	+	+	+		+	+	+				+			+	+																			12
O	+	+	+	+	+	+		+		+				+					+																			10
No of stations sampled	11	11	11	11	11	11	6	11	8	11	4	6	3	7	2		6	7	7	5	5	3	1	4	3												

forms of the bigger schilbeid species. In view of this, gill nets (usually called small nets) comprising the following stretched mesh sizes quoted in centimetres; 1.3, 2.5, 3.8 and 5.1 were used daily in Shagunu Creek. The nets were 22.8m by 2.3m except the 1.3m mesh which was 13.7m by 1.9m. The nets were bottom nets. It is interesting to note that over 80% of P. pellucida and S. auritus used in this study were caught by the small nets.

Other methods, cast net, hook and line, baited hooks on line and beach seining were tried but regretably did not catch any schilbeid, so all the fish used in this study were caught by the main fleet of gill nets and the small gill nets.

The gill nets were chosen as the main sampling gear for this study because :-

(i) They were the main fishing gear used by the University of Ife/University of Reading, Kainji Research Project team.

(ii) They were the main gear used by all previous workers on the lake, for example, Banks et al (1965), Lelek (1972), Lewis (1973a, b) and Blake (1976). In order to make my results comparable with those of the previous workers the same type of gear had to be used.

(iii) The main gear used by the native fishermen all over the lake were gill nets.

3. Sampling time

The gill nets were usually set in the evening, between 4.00 p.m. and 6.00 p.m. local time (15.00 and 17.00 G.M.T.) and lifted the following morning between 8.00 a.m. and 10.00 a.m. (7.00 and 9.00 G.M.T.). Previous experience (Arawomo, 1972; Ajayi, 1972 and Willoughby, 1974) had shown that setting the nets in the mornings

and lifting them in the afternoons or evenings had always yielded very poor catches. My trials also confirmed that daylight setting of the nets were not often very productive. Water depths and transparency were measured each time the nets were set.

4. Laboratory handling.

All the fish caught during the night by the gill nets were removed from the nets the following morning and kept in polythene bags which had been labelled according to the mesh sizes of the nets and whether the nets were floating or sinking nets. The fish were then transported to the Field Station laboratory at Shagunu.

In the laboratory, the fish were brought out of the bags and arranged according to the species, the net type and mesh sizes of the nets. The number of each species caught was recorded and where very numerous the catch was subsampled. To take a subsample, all the fish (usually the same species) were counted and weighed in a pan-balance to the nearest ten grammes; also a subsample of ten fish was selected randomly for normal analysis. In some cases where the numbers were about eleven, or up to fifteen, a sub-sample might not be taken. Each fish specimen was measured for total length and standard length, the weights and the sex were determined. Detailed description of the methods of measurements will be made in Chapter three. After the routine measurements were made involving all the fish species caught, the schilbeids were removed for further analysis.

2.0.2. The fish species

The Family Schilbeidae (Osteichthyes : Siluriformes) is a group of catfish which are elongated and strongly compressed laterally except at the head region which is short, broad and dorso-

ventrally compressed. Generally they possess four pairs of unbranched circum-oral barbels. These are pairs of maxillary, nasal, outer and inner mandibulary barbels. The anal fin is very long and present in all species in contrast to the dorsal fin, which is very short and in, one genus, completely absent. Adipose fins may be present or absent.

The Family Schilbeidae is found in African and Asian freshwaters (Greenwood, 1957; Hora, 1938 & 1941). There are eight African genera and several species have already been described (see Boulenger, 1911; Pellegrin, 1913, 1929; Hora, 1938, 1941; Trewavas, 1943; Thys van den Audenaerde, 1964).

Four genera represented by five species occur in Lake Kainji. The classification of the species present in Lake Kainji is based on the work of Berg (1940). The following description of the five species was based on the examination of freshly killed fish caught by the static gill nets. Table 2.3 summarizes the major characteristics of the species. Further description and a key to the species found in West African freshwaters can be found in Trewavas (1943), Irvine (1947), Daget (1954), Blache et al (1964), Reed et al (1967), Holden & Reed (1972) and Lowe-McConnell (1965 & 1972). The fish illustrations are taken from Lewis (1973b).

1. Siluranodon auritus (GEOFFROY St. HILLAIRE 1827)

(Fig. 2.2)

Local Hausa name : Balo

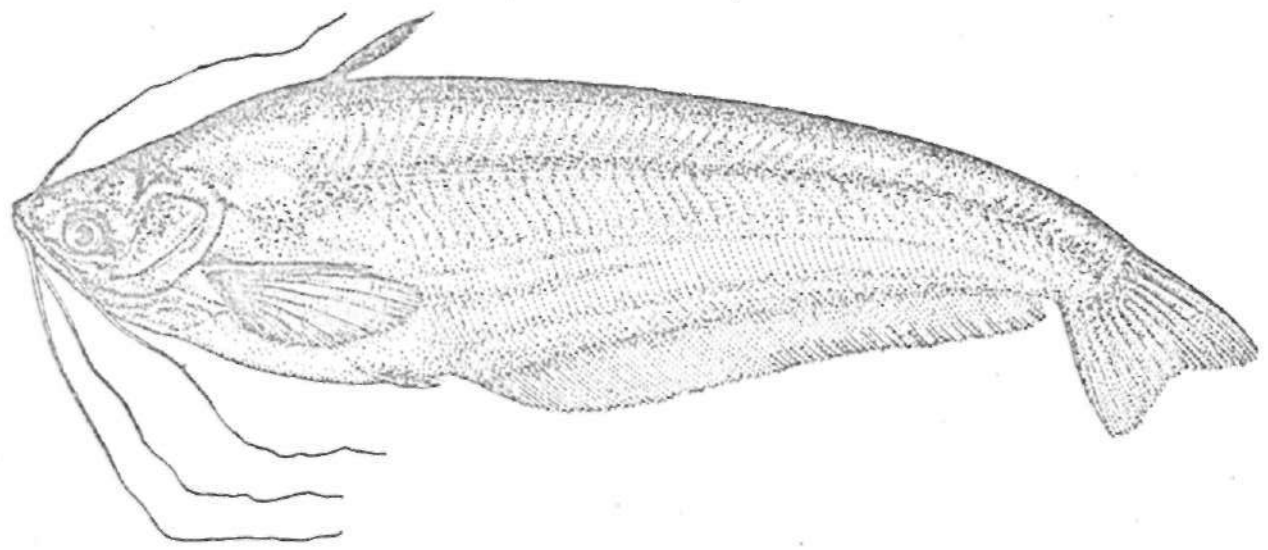
Common English name : Flagfin catfish

A small schilbeid with no adipose fin, the dorsal fin is present but without the stiffening spine. The dorsal and pectoral fins are black. Teeth are lacking on both the jaws and palate. The barbels are much longer than those of any other schilbeid

Table 2.3. Check-list of Morphological Characteristics of the Species.

Species / Characters	Siluranodon auritus	Physailia pellucida	Eutropius niloticus	Schilbe mystus	Schilbe uranoscopus
Teeth in jaws	-	+	+	+	+
Teeth also in palate	-	-	+	+	+
Adipose dorsal fin	-	+	+	-	-
Rayed dorsal fin	"	-	+	+	+
Anal fin count	74-78	61-75	54-61	57-63	?
Dorsal fin count	?	-	1 spine + 6 branched rays	1 spine + 6 branched rays	?
Vertebra count	45-47	49-51	45-48	42-47	?
Gill rakers (lower)	30	25-29	14-15	12-14	?

+ Present - Absent ? Not determined " Dorsal fin present but no spine.



Siluranodon auritus

Fig. 2.2

present in Lake Kainji other than P. pellucida. The body is silvery-grey on the sides with two silvery-brown longitudinal bands running along the lengths of each side of the body. In this way they resemble the young of Schilbe mystus.

Standard length of up to 13.7cm for a weight of 27 grams has been found in the lake. This is a very rare species found in the creeks and inlets to the lake. It feeds on algae and immature insects.

2. Physailia pellucida, BOULENGER 1901 (Fig. 2.3)

Local Hausa name : Nama wuri or Balo.
Common English name : Glass Catfish.

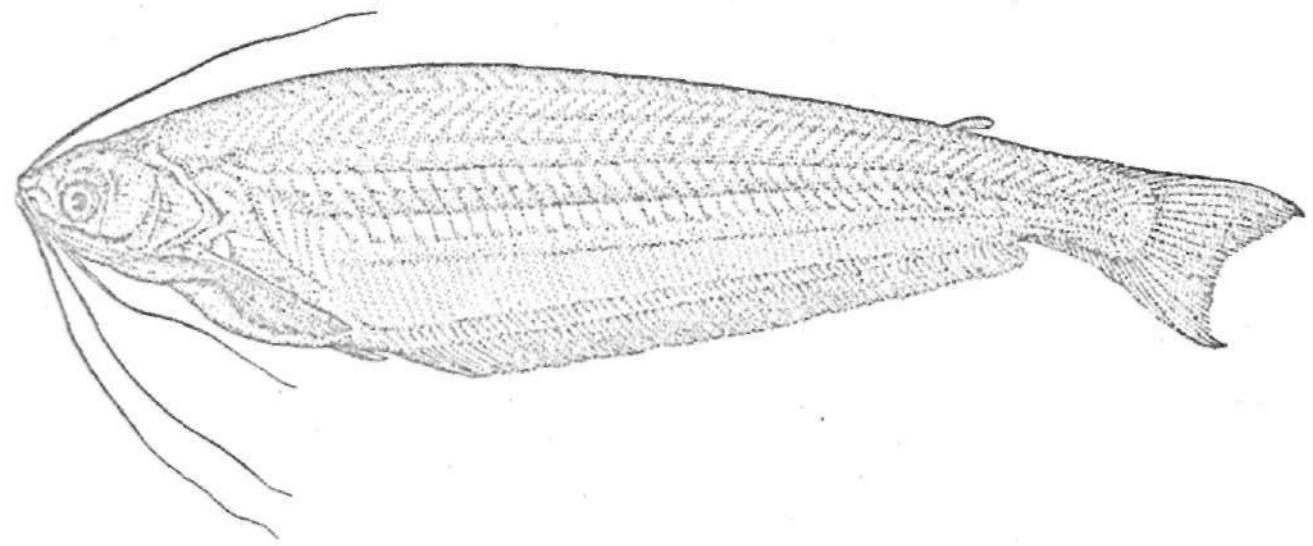
A small schilbeid with transparent body. Dark spots of melanophores are scattered around the body, but are concentrated along the back. An adipose fin is present, but there is no dorsal fin. The pectoral fins are with spines. The caudal is forked and has pointed lobes of equal lengths. The tail is bent down at an angle to the body. Teeth are present on the jaws but not on the palate. The barbels are nearly as long as those of Siluranodon auritus. It grows to about 14.0cm and weighs up to 22.0g in Lake Kainji.

Very common in open water, usually found in mixed shoals with the clupeids (Pellonula afzeliusi and Sierrathrissa leonensis), feeding mainly on immature stages of insects.

3. Eutropius niloticus (RUPPELL 1829) (Fig. 2.4)

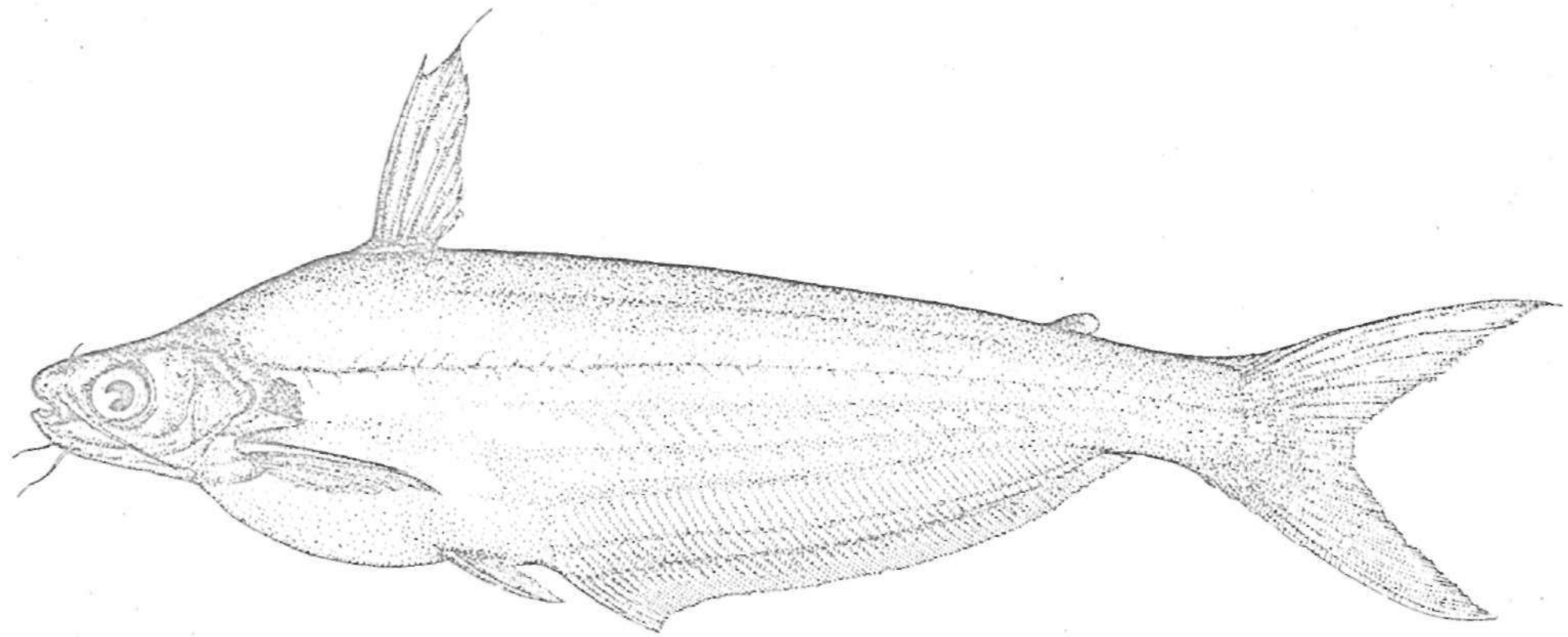
Local Hausa name : Balo
Common English name : Silver catfish.

A large member of the schilbeids in Lake Kainji which posse-



Physailia pellucida

Fig. 2.3



Eutropius niloticus

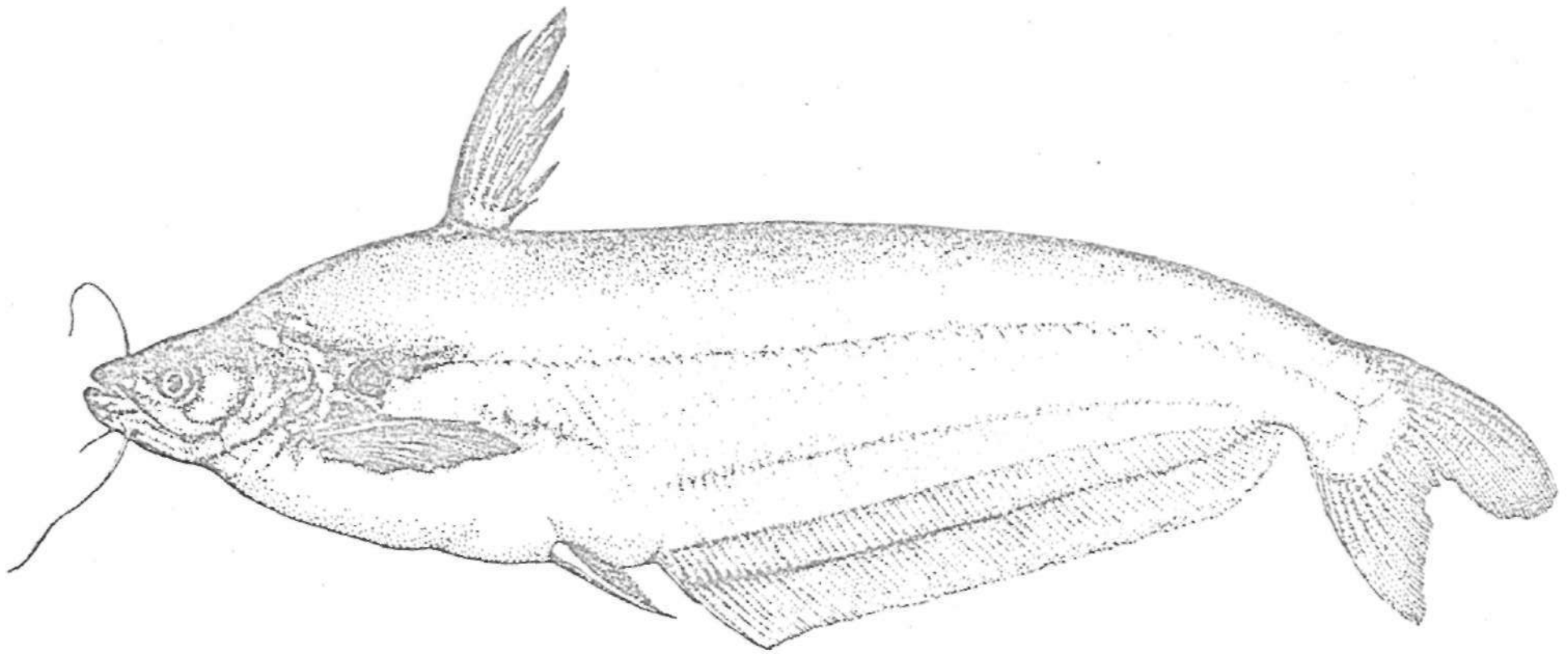
Fig. 2.4

sses a dorsal fin with serrated spine. A tiny adipose fin is also present. The caudal fin is forked and bends down slightly at an angle to the body. All fins are usually clear, but tinted forms were sometimes found in the samples. Teeth are present both on the jaws and palate. The barbels are short in comparison with those of Siluranodon auritus and Physailia pellucida. Body colour is bluish-grey dorsally and silvery white on the sides. There is a black mark behind the operculum on both sides. The eyes are larger than those of other schilbeids found in Lake Kainji. The Kainji species attains a standard length of up to 28.9cm and a weight of 260g. A very common species found abundantly in all parts of the lake. Both adults and juveniles are omnivorous, although insects constituted the bulk of their food.

4. Schilbe mystus (LINNAEUS 1762) (Fig. 2.5)

Local Hausa name : Mazo (or Balo)
Common English name : Butter fish.

A larger member of the group which grows to a length of up to 25cm and a weight of 200g. Closely resembles Eutropius niloticus but differs distinctly in not possessing an adipose fin. The caudal fin is forked and bends at an angle to the body. The barbels do not extend beyond the gill cover. The large rounded snout has the lower jaw projecting slightly. Head almost as broad as long and carries two small eyes. Adult forms are silver coloured on the sides, white on the belly and greyish on the back. There is a dark spot above the base of the pectoral fin. Juvenile forms are marked with three longitudinal black bands, the upper and lower of which are continued on to the caudal fin. Teeth are present on the jaws and palate.



Schilbe mystus

Fig. 2.5

A fairly common species found in the riverine areas of the lakes and inshore stations. The young ones are mainly insectivorous while adults are piscivorous.

5. Schilbe uranoscopus, RUPPELL 1832 (Fig. 2.6)

Local Hausa name : Mazo (or Balo)
Common English name : Butterfish.

The largest of the schilbeids in Lake Kainji growing to about 35.4cm standard length and weighing up to 610g. This species was thought to be absent in Lake Kainji by the previous workers e.g. Banks et al (1965), Lowe-McConnell (1972) and Daget (1954). It was Lelek (1972) and Lewis (1973a, b, 1974b) who noted its presence in Lake Kainji. Resembles Schilbe mystus in most respect but differs by having larger eyes, narrower heads and shorter barbels (Fig. 2.7). The body is more compressed and relatively deeper than that of S. mystus. Caudal fin with round lobes.

A very rare species in Lake Kainji. Adults are piscivorous.

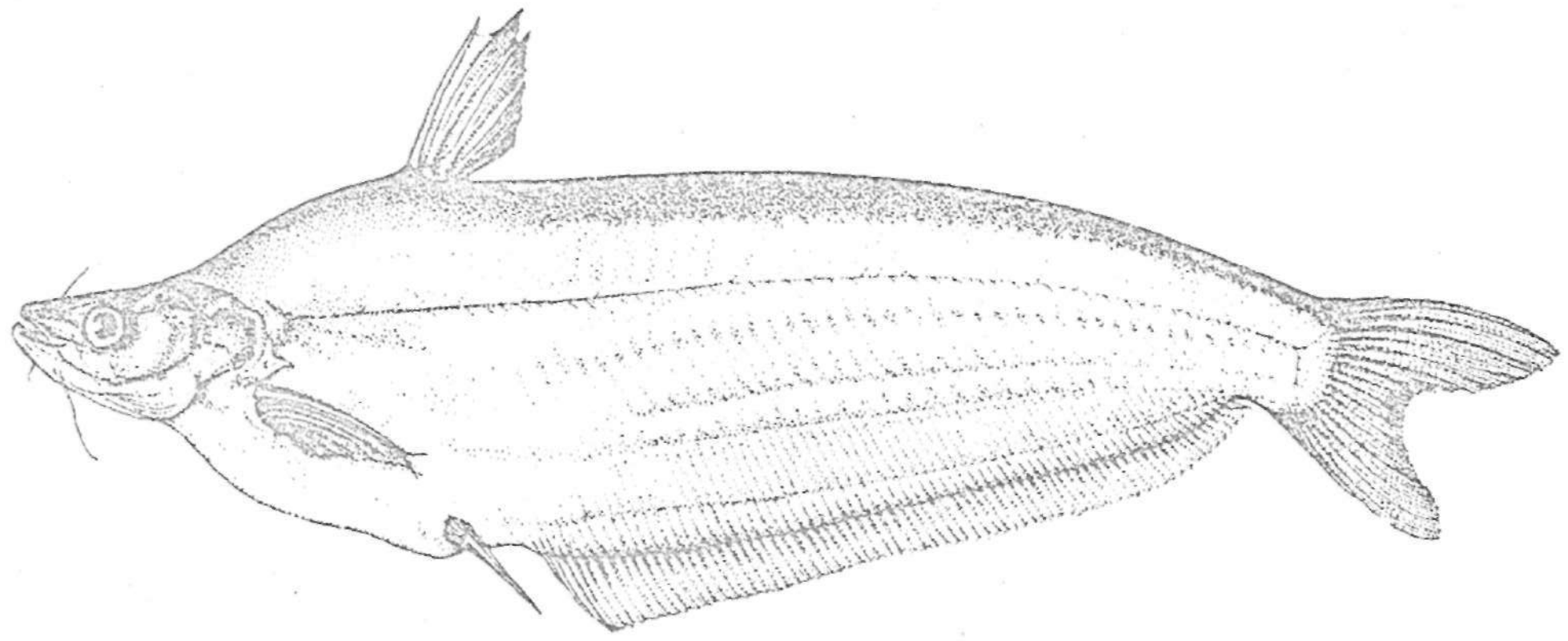
2.0.3. R E S U L T S

(A) A B U N D A N C E

A.1. The relative abundance of species.

The result of the total catch from the main fleet of nets for the whole period of study (Table 2.4) shows that E. niloticus formed the bulk of the catch while S. mystus formed about 7.9%. The other species combined formed less than 1%.

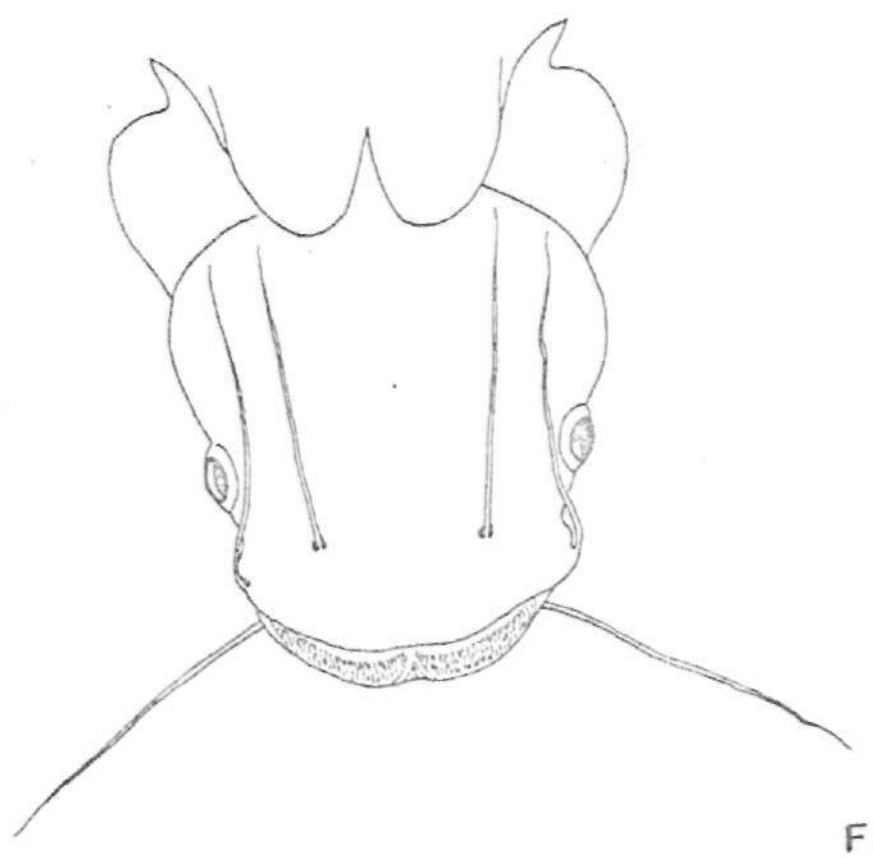
The small nets showed a different pattern. P. pellucida contributed the highest proportion of the catch (69.0%), E. niloticus formed about 25.4% while S. mystus and others formed less than 6%.



Schilbe uranoscopus

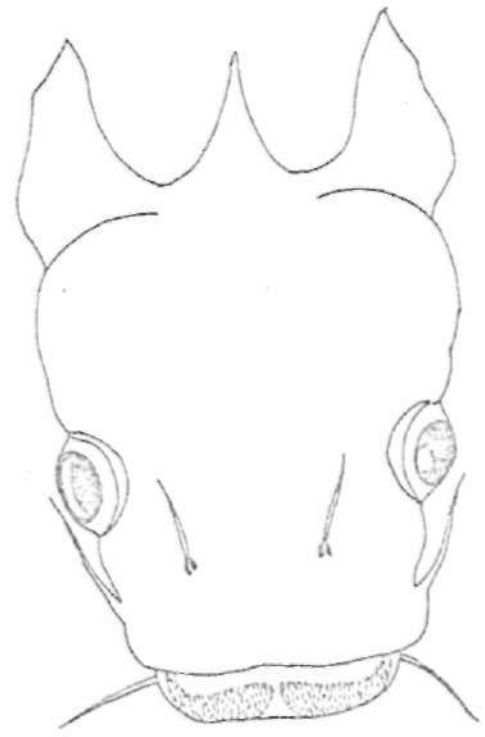
Fig. 2.6

S. mystus



A

S. uranoscopus



B

Fig. 2.7

Table 2.4. Total numbers and wet weights of schilbeids caught during the whole sampling period.
(Main Fleet from October 1974 to September 1976)
(Small nets from November 1974 to April 1976)

	Main fleet			Small nets		
	Total No.	Total wt. (Kg)	Sampling occasions	Total No.	Total wt. (Kg)	Sampling occasions
Siluranodon auritus	0	0.0	166	48	0.4	232
Physailia pellucida	17	0.2	166	3411	17.2	232
Eutropius niloticus	1958	84.6	166	1258	17.3	232
Schilbe mystus	170	5.9	166	224	3.8	232
Schilbe uranoscopus	3	0.02	166	4	0.06	232

In terms of weights, E. niloticus accounted for more than three-quarters of the catch while P. pellucida and S. mystus accounted for 13.5% and 7.5% respectively. Siluranodon auritus and Schilbe uranoscopus formed less than 1% of the total weights.

A.2. Net selectivity.

The gill nets were highly selective for size of fish being retained. Analysis of the lengths of fish caught by the various mesh sizes of the gill nets (Fig. 2.8) shows that the 1.3cm and 2.5cm gill nets were highly selective for the smaller schilbeids (e.g. Physailia pellucida and Siluranodon auritus) and the young forms of the larger schilbeids. The 3.8cm and 5.1cm nets were also highly selective for the bigger schilbeids e.g. Eutropius niloticus and Schilbe sp. Thus the main fleet of nets caught more Eutropius niloticus than any other schilbeid and the small nets caught more Physailia than others. In view of the selective nature of the nets, the results obtained with the main fleet of nets and small nets are presented separately.

A.3. Seasonal abundance of species.

Only for E. niloticus were there sufficient data for the computation of the seasonal abundance of species in the main catch. Fig. 2.9 shows the seasonal abundance of E. niloticus as percentage of the total catch for that species after correcting to unit effort. Within a period of twelve months, two seasons of high and of low numbers were found to occur. The first period of high numbers, October to December coincided with the beginning of the dry season while the second in June and July fell within the rainy season and the drawdown period. Low numbers were found in January to May and in August and September. The factors

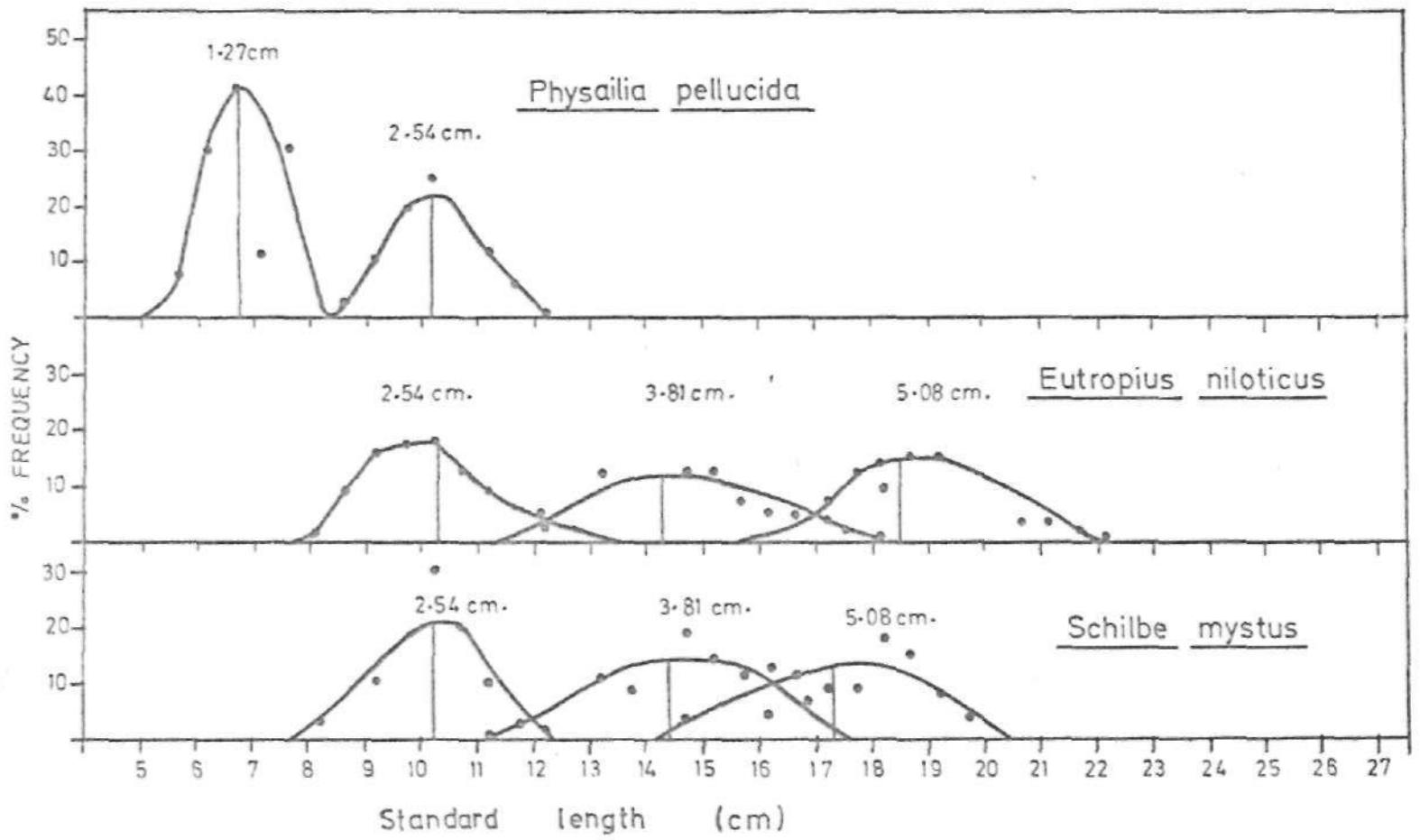


Fig. 2.8. Mesh sizes and schilbeid species taken.

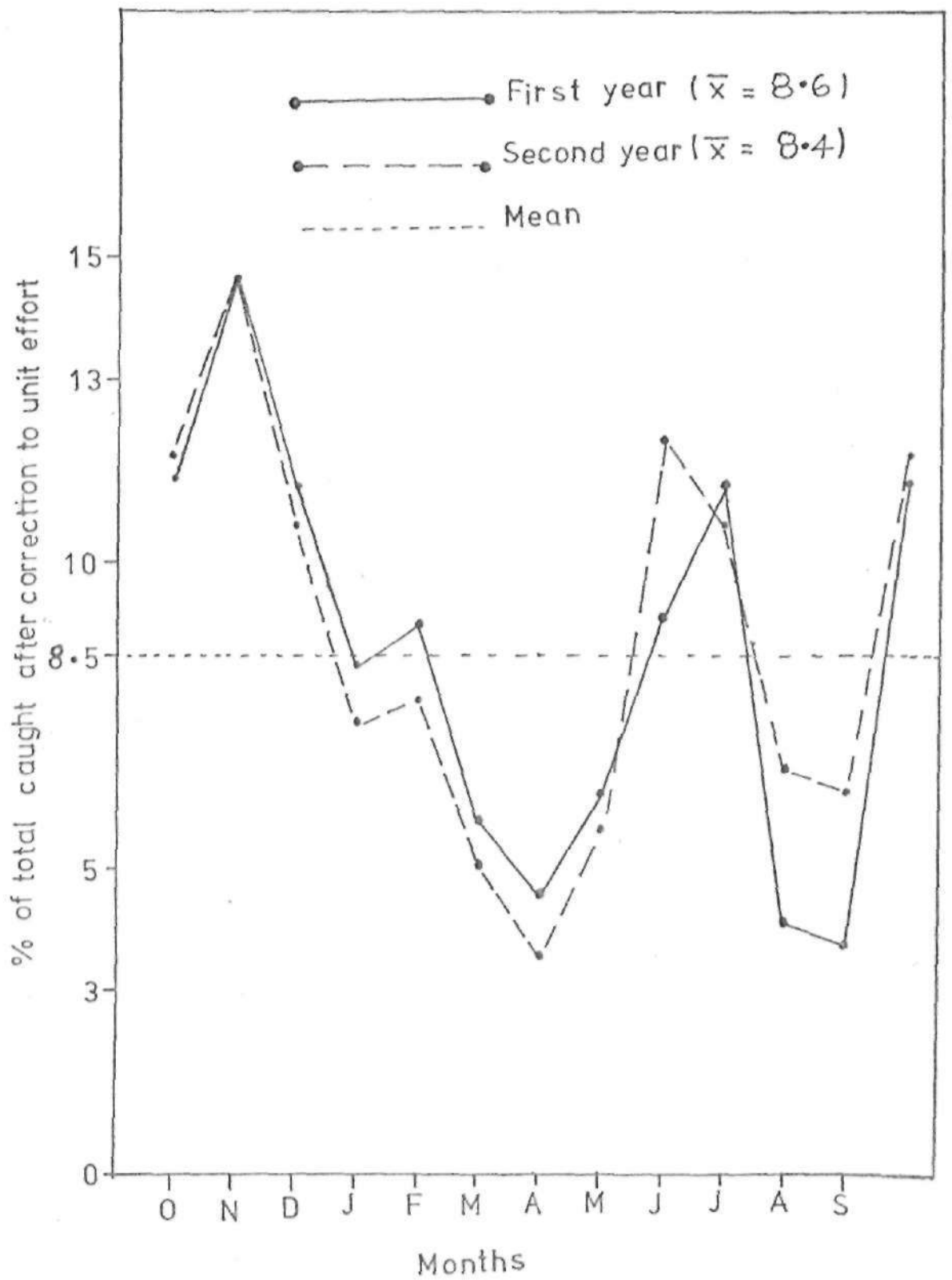


Fig. 2.9. Seasonal variation in the abundance of Eutropius niloticus caught with main nets.

responsible for the low numbers in January to May might be due to the relatively clear water (Black flood) which made the nets very visible to the fish, hence the possibility of escaping from being caught in the net. In August and September two possible factors might be responsible for the low numbers. Firstly the heavy storms which occurred at this period rolled the nets together and thereby reduced the surface areas of the nets. Secondly it is possible that some of the fish might have migrated to the breeding ground.

The catches from the small nets were also analysed for seasonal variations in the abundance of species. The following three species had sufficient numbers for analysis, P. pellucida, E. niloticus and S. mystus (Fig. 2.10). Physailia pellucida dominated the small net catch except for the period March to August when it was virtually absent. The factor responsible for the low number of P. pellucida during the drawdown period might probably be due to the migration of the fish to deeper parts of the lake because most of the creeks are exposed during this period and the depth of water in the creeks at this period might be too shallow for P. pellucida. P. pellucida is predominantly pelagic in habit (Reynolds, 1971a). For E. niloticus the catch with the small nets was relatively constant, which is in contrast to the main fleet which showed marked seasonal fluctuations. As the small nets is selectively catching small fish in the creek, this showed that there is a clear difference in behaviour of juveniles and adults. The catch for S. mystus remained very low in number throughout the sampling period. The decline of S. mystus in the lake is fully discussed in discussion section. Appendices 1 - 6 show the monthly variations in numbers and weights of the species for the sampling period, October 1974 to September 1976.

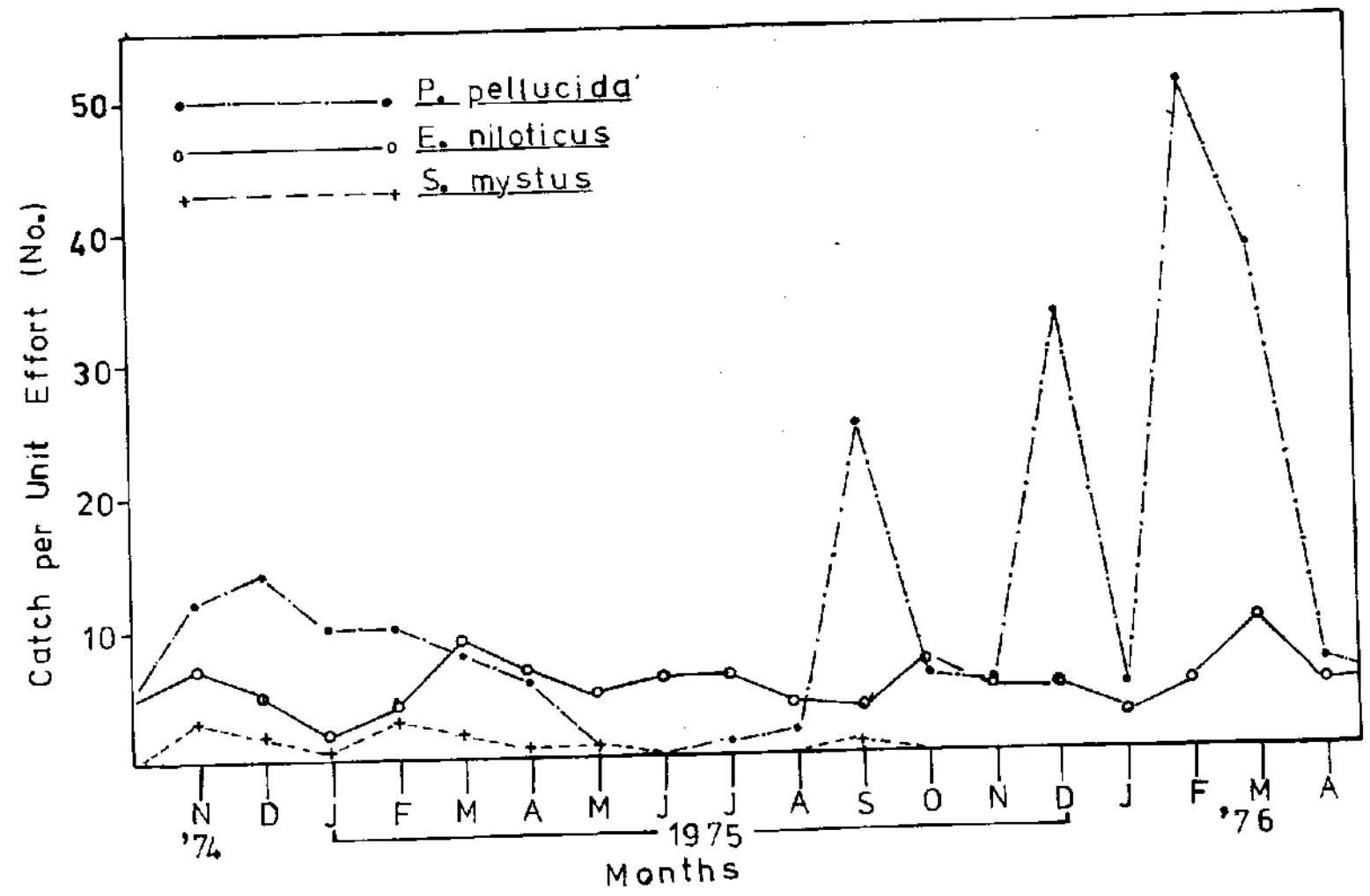


Fig. 2.10. Seasonal variation in the abundance of schilbeid species caught with small nets. (catch per unit effort).

A.4. Seasonal abundance of the family Schilbeidae in relation to the total fishery.

Figure 2.11 shows the trends in the abundance of the Family Schilbeidae in the total fish caught each month for the period of 1971 to 1976 excluding 1973. The data used for the period 1971 to 1972 are Lewis (1973a). The family often constituted a significant portion of the total gill net catches for each month. Although fluctuations did occur from year to year, it could still be seen that the schilbeids formed at least 10% of the total catch in most of the months and in some months they constituted over 40% of the catch.

The main features are :-

(i) In 1971 during the later parts of the rains, the schilbeids were caught in high numbers and formed nearly 50% of the total catch for those months.

(ii) In 1972, '74 and '75 there was no much variation in the relative monthly catch within each year. However, the schilbeids formed above 30% of the total catch in 1974. Mean % composition were 19.7, 32.1, 15.4 respectively.

(iii) In 1976 the % fell considerably to a mean composition of about 12.6%.

The variations shown in those years were due to the fluctuations in the number of other families caught in the gill nets. The general trends are discussed in the next section (Section A.5).

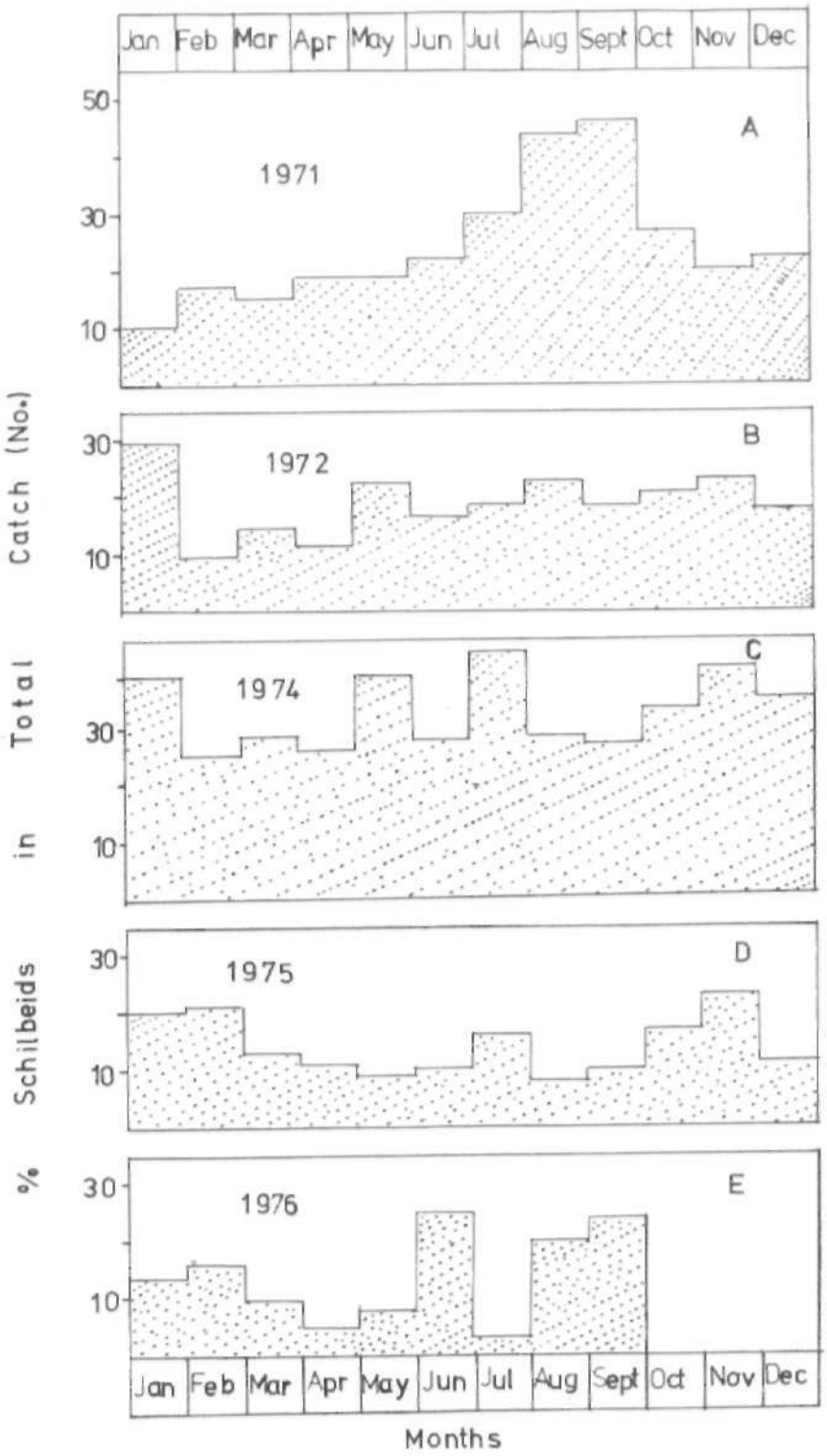


Fig. 2.11. The abundance of the Family Schilbeidae in relation to the total fishery 1971 to 1976. (1971 and 1972 data from Lewis (1973a)).

A.5. Variations in the abundance of Family Schilbeidae in relation to the total fishery from 1965 to 1976.

A glimpse at the relative yearly contribution of the Family Schilbeidae to the annual catch gives an idea of the changing pattern of abundance of the family from year to year (Table 2.5).

Since the impoundment of the Niger, the position of the Family Schilbeidae in the total fishery of Kainji Lake has changed significantly. Before the impoundment, Banks et al (1965) made a survey of the fish population in the Kainji Reservoir basin. In their own assessment, the schilbeids formed about 6% of the total catch while the Family Mormyridae contributed the highest proportion representing about 35%. With the formation of the lake and resultant changes in habitat coupled with the availability of more food by subsequent drowning of large acres of land, the composition of the fishery in Lake Kainji changed radically. The Family Mormyridae fell in importance and the Family Citharinidae dominated the catch immediately after the impoundment. The dominance of the Family Citharinidae was short lived, for in 1970 the Characids, largely made up of Hydrocynus and Alestes species, dominated the catch (Lewis, 1974b; Lelek, 1972, 1973). The importance of the schilbeids increased significantly after impoundment. In 1969, a year after the inundation, the Family Schilbeidae constituted about 20% of the total experimental gill net catches, thus closely following the Citharinidae which formed the highest with 23%. In 1970 to 1972 the characids and the schilbeids dominated the catch. The mean percentage composition for Characids was about 36% while the Family Schilbeidae formed about 22%.

In 1974 the schilbeids constituted the highest portion of the total catch (Appendix 7). The importance of the schilbeids fell

Table 2.5. Abundance by % number of major fish families present in the River Niger (1965 - 1966) and Lake Kainji (1968 - 1976).

Source of information	Banks et al (1965)	Motwani & Kanwai (1970)	Lelek (1975)	Imevbore & Okpo (1975)	Lelek (1972)	Lelek (1972)	Lewis (1973a)	Lewis (1973a)	This study	This study	This stud
Year when samples were taken	1965	1966	1968/69	1969	1969	1970	1971	1972	1974	1975	1976
Major Families \ Where samples were obtained	River Niger	River Niger	Lake	Lake	Lake	Lake	Lake	Lake	Lake	Lake	Lake
Schilbeidae	6.8	8.0	8.5	0.4	19.9	23.3	22.8	21.4	32.6	14.3	12.6
Polypteridae	3.4	0.0	0.0	0.0	0.2	0.1	0.5	0.5	0.4	0.9	0.2
Mormyridae	35.2	20.7	8.0	1.0	1.0	2.4	2.1	3.9	8.3	8.5	7.7
Characidae	2.1	36.3	17.0	2.0	12.3	39.0	40.5	30.7	15.6	17.8	13.8
Citharinidae	16.1	6.1	35.0	74.0	23.1	5.7	4.6	7.8	2.1	12.8	4.3
Cyprinoidae	1.4	3.3	5.0	4.0	9.1	5.9	3.7	3.1	2.0	4.3	5.7
Mochokidae	30.3	18.0	14.0	11.0	13.2	11.8	11.4	16.5	21.0	20.3	19.8
Bagridae	1.8	7.2	3.0	2.0	4.5	7.5	9.4	12.8	8.9	12.5	28.8
Cichlidae	0.6	0.0	2.0	2.0	0.7	0.3	0.6	0.8	3.9	2.2	1.5
Centropomidae	0.8	0.0	7.5	2.0	16.0	4.2	2.9	2.2	2.9	6.7	5.6
Others	1.4	1.4	0.0	0.0	0.1	0.0	0.1	0.1	0.7	0.7	0.1

in the year 1975 and '76. In those years they only constituted 14.3% and 12.6% of the total catch respectively. Despite the fall, the schilbeids could still be considered to form significant proportion of the catch when compared with other families in the lake. The catches for the year 1975 and 1976 (Appendices 8 & 9) were generally low for most families except the Family Mochokidae which had been showing a steady increase in number and hence in the proportion of the catch since 1972.

(B) D I S T R I B U T I O N

B.1. Distribution within the Lake.

Table 2.6 shows the frequency of occurrence of each species in samples at all the stations. This method was used to determine the presence of the species in each station and in the sampling zones. For the study of distributional patterns, the stations were re-arranged into four zones as seen in Table 2.7.

The results (Table 2.6) shows that E. niloticus was found in samples whenever the nets were set in zones II and IV and in about 96% of the samples in zone III. The frequency of occurrence in zone I was low (27%). P. pellucida had a very low frequency of occurrence in all the zones, however zones II and III had the highest while no specimen was found in the riverine, zone I. S. mystus had the highest representation in zone I and the lowest in zone II. The inshore and the offshore stations were intermediate with 48% and 37% respectively. The S. uranoscopus found were from stations K and H. There was no Siluranodon auritus in the main nets.

Another way to view the distribution is to look at the abundance of each of the species in different zones. The results

Table 2.6. Frequency of occurrence of species in the sampling stations.

Zones	I	II		III				IV			
Sampling Stations	A	C	N	D	K	J	L	G	H	M	O
No. of samples	12	17	12	11	21	22	20	16	8	16	10
S. auritus	0	0	0	0	0	0	0	0	0	0	0
P. pellucida	0	2	3	2	1	4	2	1	0	1	0
E. niloticus	4	17	12	11	19	22	19	16	8	16	10
S. mystus	7	5	4	4	17	6	10	0	3	8	3
S. uranoscopus	0	0	0	0	1	0	0	0	1	0	0

Table 2.7. Sampling stations re-grouped into zones

ZONES	STATIONS	CHARACTERISTICS
I	A	Station at the Upper reaches of River Swashi. Lotic in nature most of the year.
II	C and N	Stations situated at the mouth of rivers - mostly lentic.
III	D, K, J, L	Inshore stations of the Lake.
IV	G, H, M, O	Offshore stations of the Lake.

in Table 2.8 shows that the number of E. niloticus in samples was increasing as from zone I to IV. P. pellucida and S. mystus showed an inverse relationship to the distribution exhibited by E. niloticus. There was a decrease in number from zone I to IV. Taking the two methods into consideration, the distribution of the species can be summarized. E. niloticus is widely distributed within the lake but is more abundant in the offshore areas. S. mystus is found in a variety of habitats but was found to be most common at the riverine inlets to the lake. Although this result shows that P. pellucida is found widely distributed in the lake, except at the riverine station, reports elsewhere (Otobo, per. comm; Roest (1975), Reynolds (1971a) have shown that they are truly pelagic species found in mixed shoals with the clupeids. The numbers obtained for other species were too small for any consideration. However the specimens of Siluranodon auritus and Schilbe uranoscopus in the samples were obtained mostly from the creek.

B.2. Geographical distribution

The geographical distribution of the species found in Lake Kainji, is shown in Table 2.9. According to Roberts (1975) the Family Schilbeidae is found in seven of the ten Ichthyofaunal provinces in Africa. Siluranodon auritus and P. pellucida are found only in Sudan province. Schilbe mystus is found in all the seven provinces, while its relative S. uranoscopus is found only in Nilo-Sudan and Zairean provinces. Eutropius niloticus is found in Nilo-Sudan, Zairean and EastCoast provinces. This distributional pattern shows that the five species are mainly Nilo-Sudanic and this leads to the suggestion that the species probably might have originated in the Nilo-Sudan province and

Table 2.8. Abundance of species based on catch per unit effort (c/e)

Zones	I	II		III				IV				Summary of c/e in			
Sampling Stations	A	C	N	D	K	J	L	G	H	M	O	each zone			
No. of Samples	11	17	12	11	21	22	20	15	8	16	10	I	II	III	IV
S. auritus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
P. pellucida	0	0.1	0.3	0.2	0.1	0.2	0.1	0.1	0	0.1	0	0	0.2	0.1	0.1
E. niloticus	1.0	10.2	4.9	10.2	6.1	10.1	16.6	17.4	29.0	12.7	20.3	1.0	7.6	10.7	19.9
S. mystus	2.6	0.5	2.1	1.0	2.2	0.4	1.0	0	0.9	0.6	0.4	2.6	1.3	1.1	0.3
S. uranoscopus	0	0	0	0	0.1	0	0	0	0.3	0	0	0	0	0.1	0.3

Table 2.9. The occurrence of Kainji species of Schilbeids in other water bodies in Africa.

A. Major Natural Lakes in Africa.

	Siluranodon auritus	*Physailia pellucida*	*Eutropius niloticus*	*Schilbe mystus*	*Schilbe uranoscopus*
Albert			+4	+4	
Bangwenlu				+4	
Chad	+5		+4	+4	+7
Edward				+4	
Kioga				+8	
Mweru				+4	
Ngami				+5	
Rudolf					+7
Rukwa				+7	
Victoria				+4	

Table 2.9. Cont'd.

B. Major Rivers in Africa

	Siluranodon auritus	Physailia pellucida	Eutropius niloticus	Schilbe mystus	Schilbe uranoscopus
Gambia			+5	+4	
Kubango				+7	
Logone				+7	+7
Mayo - Kebbi		+3			
Niger	+4	+4	+4	+4	+6
Nile	+4	+4	+4	+4	+4
Queme		+2	+5	+5	
Semiliki			+8	+7	
Senegal				+5	
Shari					+7
Volta	+4	+1	+5	+5	
Zaire				+4	
Zambezi				+4	

Table 2.9. Cont'd.

C. Major man - made Lakes.

	S. auritus	P. pellucida	E. niloticus	S. mystus	S. uranoscopus
Kainji	+6	+6	+6	+6	+6
Kariba				+11	
Kossou		+10		+10	
Nasser	+9		+9	+9	+9
Volta	+1	+1	+1	+1	

References

1. Roberts, T. (1967)
2. Daget, J. (1954)
3. Blache, J. (1964)
4. Boulenger, G. A. (1911)
5. Daget, J. & Iltis, A. (1965)
6. Lelek, A. (1972)
7. Mok, M. (1974)
8. Worthington, E. B. (1929)
9. Latif, A. F. A. (1976)
10. Roest, F. C (1975)
11. Balon, E. K. (1974)

spread later to other provinces.

2.0.4. D I S C U S S I O N

Eutropius niloticus and Physailia pellucida were common and abundant while S. mystus was fairly common but not as abundant as the two species mentioned above. Siluranodon auritus and Schilbe uranoscopus were rare in the lake.

The presence of Schilbe uranoscopus in Lake Kainji was first documented by Lelek (1972). Apart from Lewis (1973a, b), all previous workers failed to record the presence of this species in Lake Kainji. Their failure might be due not to the absence of the species in the River Niger but rather because it was scarce. Most of the surveys on the Niger before the inundation in 1968 covered a very short period, and the chances of coming across a scarce species was very small. Also the two Schilbe species are very alike, and careful observation is needed to separate them. It is possible that the species was not in the Middle Niger before the impoundment but migrated from other tributaries to the lake. Whatever the origin, the lacustrine environment was not favourable enough for its establishment for although Lewis (1973b) described S. uranoscopus and Siluranodon auritus as common species in Lake Kainji, this study has found them to be rare.

The trend in the abundance and the changes in species composition of the Schilbeids from the formation of the lake show that E. niloticus has successfully established itself in the lake while the status of S. mystus is declining. Banks et al (1965) and Motwani and Kanwai (1970) showed that the number of Schilbe mystus in the river was higher than that of E. niloticus. After the formation of the lake, both species took the advantages created by the initial surge in food supply and the enlarged

habitat to increase their populations. S. mystus maintained its high number while E. niloticus was gradually increasing its own number too. Lelek (1973) noted a higher catch per unit effort (c/e) for S. mystus and a lower c/e for E. niloticus. This upward trend in the abundance of S. mystus was not maintained, however, for a long period. As from late 1970 Lelek (1973) noted a gradual decline in the number of S. mystus in the catches. The c/e for S. mystus fell below that of E. niloticus in February 1971 and since then S. mystus has never had a higher number than that of E. niloticus in the lake (Table 2.10). The data for 1971/72 by Lewis (1973a) show that E. niloticus maintained its gradual rise in population and has since outnumbered all the other schilbeids in gill-net catches. S. mystus now forms less than 10% of the catch while E. niloticus sometimes forms over 80% of the total schilbeids and about 30% of the total fish caught. The initial rise and fall of S. mystus population can be explained as follows. It is a known phenomenon both in the tropics (e.g. Lake Kainji (Lelek, 1973) Kariba (Harding, 1964), and Volta (Petr, 1969) and temperate man-made lakes (e.g. Cimljansk (Domanevsky, 1962) and Kuibychev (Sharonov, 1962)) that with the establishment of lacustrine conditions predators become more abundant. The new environment permits a high survival of newly spawned fish and thus provides an enormous source of food supply for predatory fish. It is likely that such rich supply of food accounted for the higher c/e recorded for S. mystus in the year 1969 to early part of 1971. It can be concluded that S. mystus was better adapted to riverine than lacustrine conditions, an adaptation which influenced its present distribution in the lake. It will be recalled that S. mystus had the highest c/e and frequency of occurrence in the riverine parts of the lake. The initial decline in the number of E. niloticus during the early stages of the

Table 2.10. Changes in the species composition of the Family **Schilbeidae from** the river (1965 - 1966) to Lake (1971 - 1976).

	% of Total Schilbeids Caught							
Year of investigation	1965	1966	1969	1970	1971/72	1974	1975/76	1975/76
S auritus	-	-	5.1	-	0.1	-	-	1.0
P. pellucida	-	3.2	23.1	-	2.7	0.3	0.8	69.0
E. niloticus	41.7	21.2	5.1	1	81.2	96.2	91.0	25.4
S. mystus	58.3	75.6	66.6	2	15.2	2.4	8.0	4.5
S. uranoscopus	-	-	-	-	0.8	1.2	0.2	0.1
REFERENCES	Banks et al (1965)	Motwani & Kanwai (1970)	Imevbore & Okpo (1975)	Lelek (1973)	Lewis (1973a)	Blake (1976)	This study (Main nets)	This study (Small nets)

Catch per unit effort in Kg.

formation of the lake in 1969 to early 1971 might be due to the absence of insects during this period. Usually as the lake fills up, rheophilic insects cannot tolerate the new environment, and it therefore takes some years before benthic lacustrine insects can establish themselves in the lake. Thus there will be a decline in number of specialized insect feeders such as E. niloticus. Moreover Povilla adusta which formed a considerable part of the food of E. niloticus was not very abundant in the lake initially. The large number of drowned trees formed a substrate for the burrowing nymphs of this ephemeropteran but it is likely that the nymphs could not penetrate the hard wood until after some years when the trees become soft through the decaying processes in the lake. Comments on the trends in the abundance of P. pellucida might not depict the true status of this species in Lake Kainji. P. pellucida has always been under-estimated in the catches and all the previous workers e.g. Banks et al (1965), Motwani and Kanwai (1970), Turner (1971) and Lelek (1972) used gill nets which depicted P. pellucida as an insignificant part of the catch. Evidences from my small nets and trawling records of the Kainji Lake Research Institute show that the number of P. pellucida is higher than that of all the other schilbeids combined. It was expected that the number of P. pellucida and possibly S. auritus should rise considerably at the early developing period of the lake because of the abundance of phyto- and zooplankton which often provide a rich supply of food for these species, but there was no evidence from records to show that they actually did.

Shagunu Market Surveys were also undertaken in order to compare the fluctuations in the number of schilbeid species coming into the commercial catch and to compare the results with mine. The data for July 1974 to July 1975 were collected by Blake (1976) while those for August 1975 to September 1976 were collected

during this study (Table 2.11). The results show similar pattern of abundance to this study. E. niloticus, S. mystus and P. pellucida were common while Siluranodon auritus and S. uranoscopus were infrequent. The similarity was partially expected because of the similarity of methods of capture, although the local fishermen used other gears (e.g. cast-nets, fish traps, baited hooks etc) in conjuction with the gill nets.

There is little information available on the abundance of the family schilbeidae from other water bodies in Africa. However, the few available reports showed that Eutropius species are always the most abundant wherever they occur with the other species of schilbeids. Petr (1969) noted a higher number of E. niloticus in Lake Volta and Reynolds (1970) who compared the abundance of P. pellucida and S. auritus in Lake Volta found the former was very abundant and common while the latter was less common. In Lake Nasser, E. niloticus and S. mystus were very abundant and common and were of commercial value while the other schilbeids (Siluranodon auritus and S. uranoscopus) were less common in samples (Latif, 1976).

Although the three common species can be found in any part of the lake, there are variations in density from one habitat to the other. E. niloticus is very common in the offshore stations, S. mystus is riverine in habit. The pattern of distribution of P. pellucida was distorted by the sampling gear but mid-water trawling records show that it is truly pelagic although it was also found in various parts of the lake. P. pellucida is always found with the clupeids whenever they both occur in the same body of water. Both are pelagic, and possess the same schooling and migratory behaviour (Reynolds, 1971a; Roest, 1975).

The pattern of distribution exhibited by the species in Lake

Table 2.11. Frequency of occurrence of fish species in Shagunu Market between July 1974 and September 1976.

	Jul. 1974 - Jul 75[+]	Aug 75 - Sept 76[++]
	Blake (1976)	This study
Siluranodon auritus	5	10
Physailia pellucida	27	29
Eutropius niloticus	50	54
Schilbe mystus	29	50
Schilbe uranoscopus	1	13

\+ 50 markets

++ 56 markets

Kainji is similar to those recorded by other workers (see Reynolds, 1970; Roest, 1975; Hopson (1967). The distribution of the species remained almost the same after the impoundment. Lelek (1973) reported that E. niloticus and S. mystus were mostly riverine while Lewis (1973b) recorded patterns of distribution similar to the findings of this study. Siluranodon auritus was restricted to the creeks and small inlet to the lake. It was caught during the drawdown period at the mouth of River Shagunu. Hopson (1967) also noted that Siluranodon auritus was common at the mouth of River Yobe which runs into Lake Chad. Reynolds (1970) also commented that "there appeared to be riverine influence upon the distribution of Siluranodon auritus".

This account of the distribution and abundance of schilbeidae is derived primarily from gill net capture and the limitations of the method must be borne in mind. The mesh size of the gill nets will determine the sizes of the fish in samples. The bigger the mesh, the less the probability of catching small sized species and juveniles.

The shape of the fish and its behaviour often determine whether it will be retained by the net or not. Spiny fishes like the family Mochokidae and Bagridae are likely to be caught more easily in gill nets than spineless fish or fish laterally compressed like Citharinus sp, Distichodus sp, Tilapia and Sarotherodon sp.

The type of nets or fishing gear is also of some consequence. Cast nets capture more of Tilapia and Sarotherodon species than any other nets, Beach seining often yielded more Lates niloticus and Citharinus citharus and midwater and bottom trawling nets yielded more of Sierrathrissa leonensis, Pellonula afzeliusi and Physailia pellucida.

Netting efficiency is modified by weather and by the transparency of the water. Sometimes during the rains, there were wind-induced storms in the lake. The resulting waves caused the gill nets to roll up and thereby reduce the surface area of the nets. This factor might be responsible for the low catch of the schilbeids during the rain storms. Moreover it was possible that fish might migrate to calm sheltered areas of the lake (e.g. deep areas, or areas with vegetation) and thus caused artificial scarcity in some parts of the lake. Underwater visibility is usually impared in turbid water (Willoughby, 1974; Adeniji, 1975). Fish are more vulnerable to the net in turbid water than in clear water where they can see the net and escape being caught. It was therefore, expected that more fish would be captured during the whiteflood regime than the blackflood. This was not reflected in the catch because the three important schilbeids species had their highest numbers during the blackflood when the water was clear. Hydrological factors will also affect the availability of the fish. Fluctuations in water level will affect the distribution of food and hence the distribution and abundance of fish species. It is also a widely held view that when the volume of water is reduced, the fish will be concentrated and their numbers will become higher in catches. This might account for the high number of E. niloticus in catches during the drawdown period. Adeniji (1975) noted high catches when the water level began to fall.

During the annual oxygen stratification fish move from the deoxygenated hypolimnion to the oxygenated epilimnion and the shallow areas of the lake (Adeniji, 1975). Although it was observed that the number of schilbeids fell gradually during the stratification period, there was no evidence to support the idea that the gradual fall in the number was actually caused by

stratification. Vertical distribution of crustacean zooplankton in the lake is restricted to the epilimnion and the thermocline during this period (Adeniji, 1975). P. pellucida, a crustacean zooplankton feeder would be restricted to these layers during this period. P. pellucida was caught in high numbers in February and March 1976 with the small nets at the creeks near the Field Station.

C H A P T E R T H R E E

Age and growth determinations

C O N T E N T S

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3.0.1. I N T R O D U C T I O N

In the management of any animal species, accurate information on age and growth is needed along with other life-history information. The methods employed in assessing the age of fish have been reviewed by several workers including Buckmann (1929), Roumsefell and Everhart (1953), Lagler (1956), Chugunova (1959), De Bont (1967) and Tesch (1968).

The use of scales to determine the age of fish has been accepted for many years. In scaleless fish, such as the siluroids, age has been determined from year marks (=annuli) found in hard structures such as otoliths, opercular bones, vertebrae, fins and spines (Sneed, 1951; Cuerrier, 1951; Marzolf, 1955; and Van der Waal & Schoonbee, 1975). It is now well established in temperate parts of the world that rings observed in various hard structures are annual in nature. In areas with less distinct seasonal fluctuations in climatic regime, such as the tropics, the annual periodicity of rings laid down in hard tissues of some fish is still questionable (De Bont, 1967), but recent work has indicated that some tropical fish species do lay annual rings in scales and other hard tissues. This recent work includes that on Hydrocynus vittatus Castelnau by Balon (1971), Sargochromis codringtoni (Boulenger) by Holcik (1974), Synodontis zambezensis Peters by Chitravadivelu (1974), Tilapia rendalli Boulenger by Bastl (1974), Clarias gariepinus Burchell by Pivnicka (1974), Eutropius depressirostris Peters by Gaigher (1969) and Cerny (1974) and Schilbe mystus Linnaeus by Frank (1974). With the exception of these last three papers it seems that there is no other published account on age and growth of schilbeids in African freshwater. This chapter deals with age and growth determinations of the three common schilbeids in Lake Kainji.

3.0.2. M A T E R I A L AND M E T H O D S

1. Methods of obtaining fish samples and basic fishery data.

The methods of obtaining fish samples were described in Chapter Two. After the fish had been separated into species, the following measurements were made

(i) TOTAL LENGTH (in cm) :- length from the tip of the snout to the tip of the longest lobe of the caudal fin when the margins of both lobes are pressed together.

(ii) STANDARD LENGTH (in cm) :- length from the tip of the snout to the point of attachment of caudal rays of the hypural bone.

(iii) WEIGHT (in g) :- the weight of each specimen was determined to the nearest 0.1g on a spring balance.

The sex and gonad condition were determined as explained in Chapter Five.

2. Examination of various hard tissues for ageing purposes.

Opercular bones, vertebrae, hypural bones, otoliths, pectoral and dorsal spines were removed from the fish and boiled in labelled test tubes for about five minutes. The muscles adhering to them were cleaned off and the tissues were air dried at room temperature (= $23\pm2^{o}C$) for about twenty-four hours. They were stored in envelopes on which was recorded information on sex, gonad development, length (T.L. and S.L), weight, date and place of capture of the individual specimen. All the materials stored were later examined to determine their suitability for ageing the fish species. The pectoral and dorsal spines were found satisfactory for ageing *E. niloticus* and *S. mystus*. The pectoral spines were

eventually used as the main tissue for ageing both species. None of the tissues was found suitable for ageing P. pellucida.

3. Preparation and sectioning of pectoral spines.

The left and right pectoral spines were fixed and decalcified by a method modified after Perry (1967) (see Appendix 10). The spines were sectioned manually with the aid of razor blades. Sectioning was done from the base of the spine. Usually the first few millimetres of the base which are deeply indented and so do not show clear annuli were cut off before sectioning. Sections which were more than 0.5mm thick were not examined.

Sections of spines were transferred to a clean slide containing one or two drops of water. They were examined under a stereo binocular microscope aided by reflected light and a micrometer mounted in the eyepiece of the microscope was used to measure the spine radius from the centre of the lumen (along line CD, Figure 3.1) to the outside edge of each opaque band and to the edge of the spine. Line CD was fixed by eye at angle 90^{o} to line AB.

Chapter 3

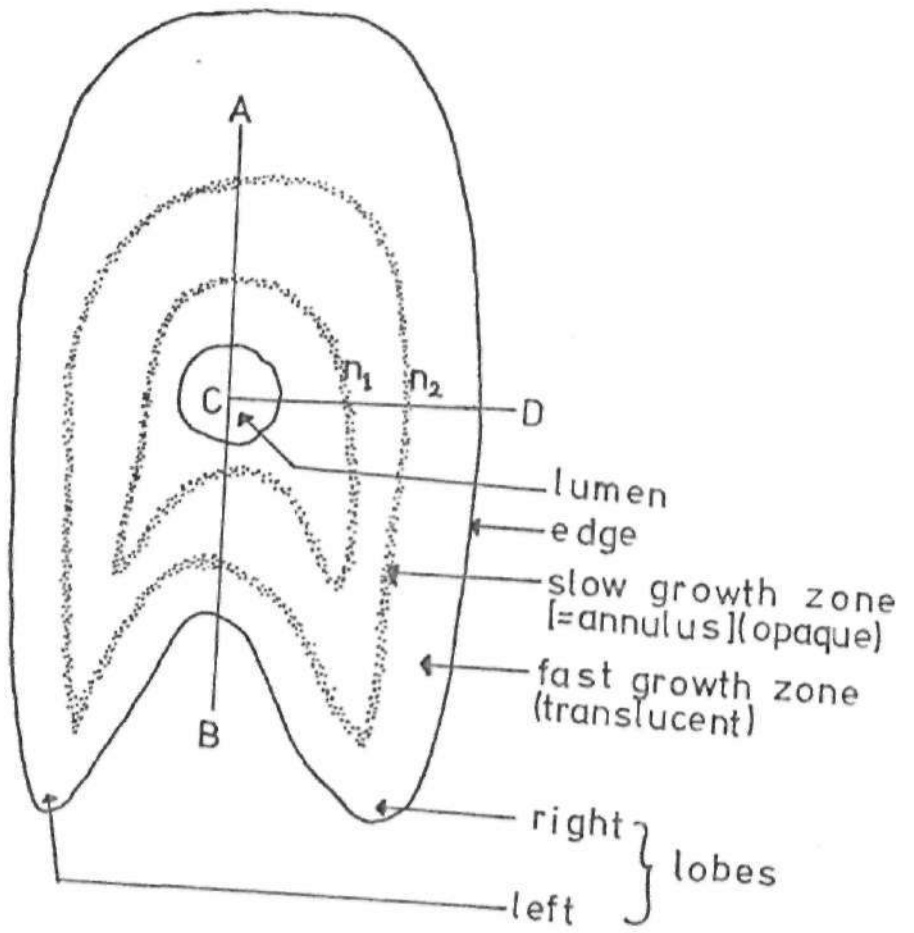
Figure 3.1.

Diagrammatic representation of transverse section of a pectoral spine from a two year old Eutropius niloticus.

C - D = line along which spine was measured (from the centre of the lumen to the edge = total radius).

n_1 = radius at first annulus (measured from the centre of the lumen to n_1).

n_2 = radius at second annulus (measured from the centre of the lumen to n_2).


A
C
n_1
n_2
D
B
lumen
edge
slow growth zone
[=annulus](opaque)
fast growth zone
(translucent)
right
lobes
left

3.0.3. R E S U L T S

1. AGE DETERMINATION

(a) Description of pectoral spines

On examination using reflected light, sections of spines showed alternate translucent zones and opaque bands (Plates 1 and 2). The translucent zone which represents a period of fast growth is wide; while the opaque band which represents a period of no growth or slow growth is very narrow (Figure 3.1, Plates 1 and 2). A complete season's growth comprises a wide translucent zone and a narrow opaque band. The narrow opaque band is formed once a year (see next section), thus is interpreted as 'year mark' or 'annulus'. A fish which has not completed a year's growth (0+) will only have the translucent zone (Plate 4).

(b) Validity of age determination using pectoral spines.

(i) As the number of spine rings increases, the average length of the fish increases; suggesting that the rings are added systematically as growth proceeds (Appendix 11, 12, 13, 14).

(ii) Examination of the pectoral spines from monthly samples showed that the opaque bands (annuli) were formed once a year (Figures 15 & 16). The time when the opaque bands are formed was determined by examination of spine sections. The distance of the last opaque band from the edge were measured and the percentage of those with opaque bands very near the edge (i.e one or two micrometer readings from the edge) were noted. The Figures show that the periods when the majority of the fish examined had their opaque bands very close to the edge were July to October for Eutropius niloticus (Fig. 3.15) and June to September for Schilbe mystus (Fig. 3.16). Thus the opaque bands are laid once in a year during the periods specified above; so can be interpreted as year marks or annuli.



PLATE 1. Transverse section of a pectoral spine of *Eutropius niloticus*.

Date captured = June 14, 1975
Sex = Female
Standard length = 25.5cm
Weight = 220g
Gonad condition = IV
Age (years) = 4+

(Note the smooth edges of spine sections of *Eutropius niloticus* in contrast to those of *Schilbe mystus* which are scalloped.)

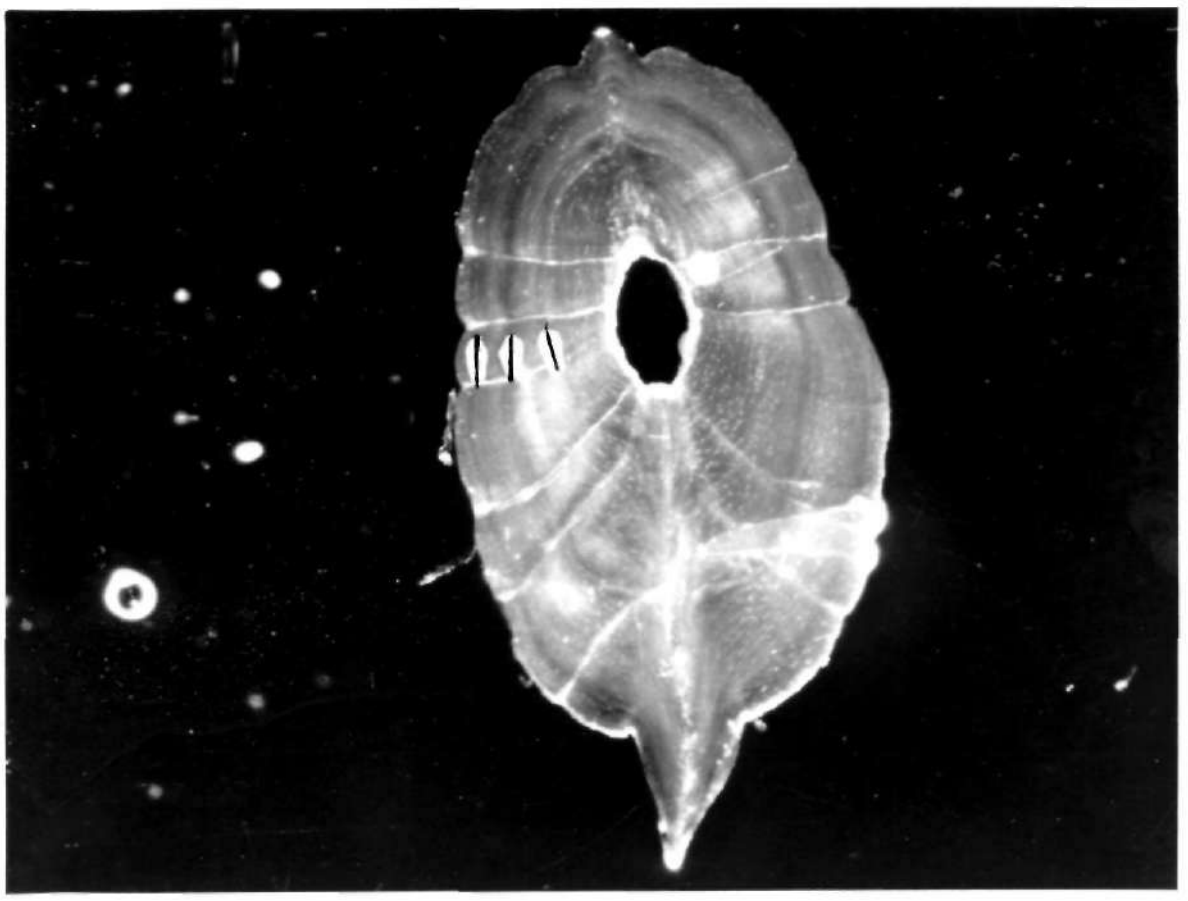


PLATE 2. Transverse section of a pectoral spine of Schilbe mystus.

Date captured = August 12, 1975
Sex = Female
Standard length = 16.1cm
Weight = 51g
Gonad condition = II
Age (years) = 3+

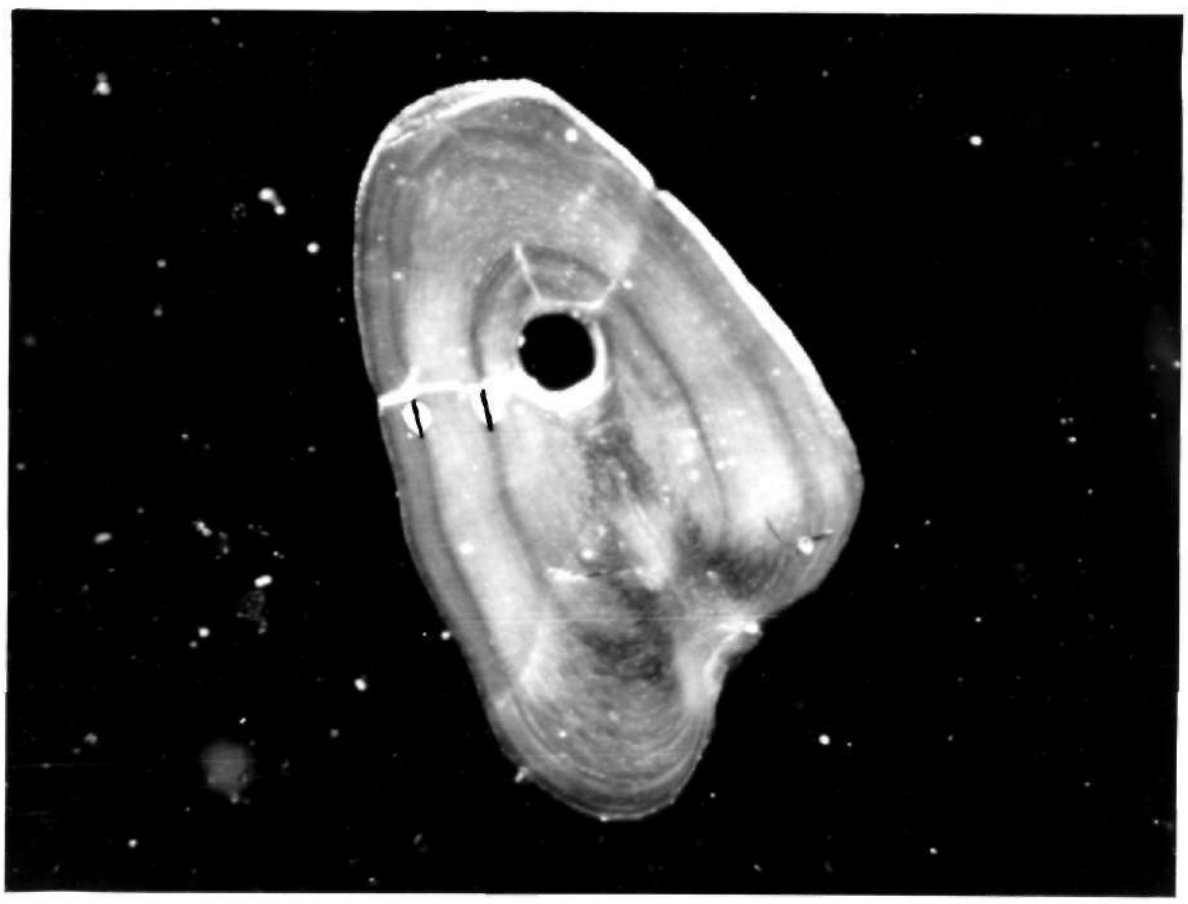


PLATE 3. Transverse section of a pectoral spine of Eutropius niloticus.

Date captured = February 18, 1975
Sex = Male
Standard length = 13.5cm
Weight = 29g
Gonad condition = II
Age (years) = 2+

(iii) Back-calculated lengths based on the assigned ages bear a rational relationship to observed lengths at the time of capture (Appendices 15, 16).

(iv) The results of age readings from the spine specimens of length groups were comparable (Appendices 11, 12, 13 & 14).

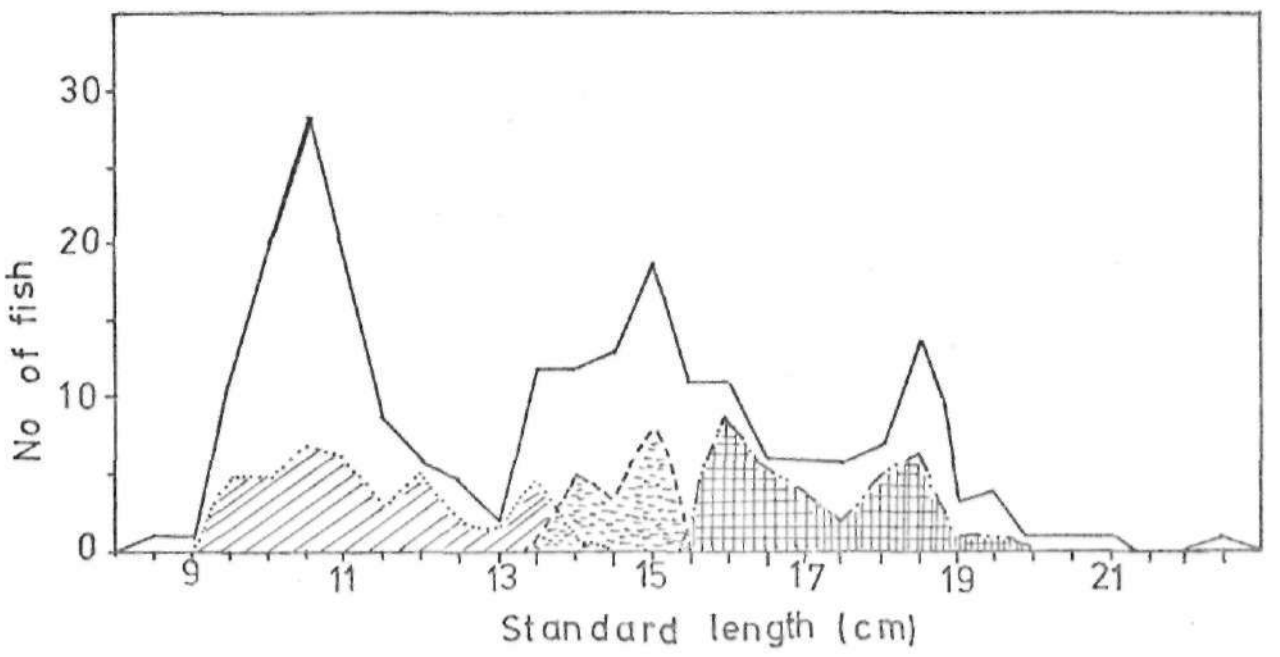
(v) The length frequency distribution of all the samples were plotted graphically. The age distribution observed by examination of transverse sections of spines were also plotted on the same graphs belonging to each species and sex (Figures 3.2 & 3.3). Agreement between these two length frequency distributions is often used to validate age determined from hard structures (Le Cren, 1947). In species where there is no considerable overlap of lengths among the age groups there is, usually, agreement between the age groups assessed from length-frequency distribution of all fish in the sample and length-frequency distribution of fish assigned to each age group. This is true of Schilbe mystus (Figure 3.2). In species where there is considerable overlap of lengths among the various age groups there is usually no agreement, e.g. Eutropius niloticus, (Figure 3.3).

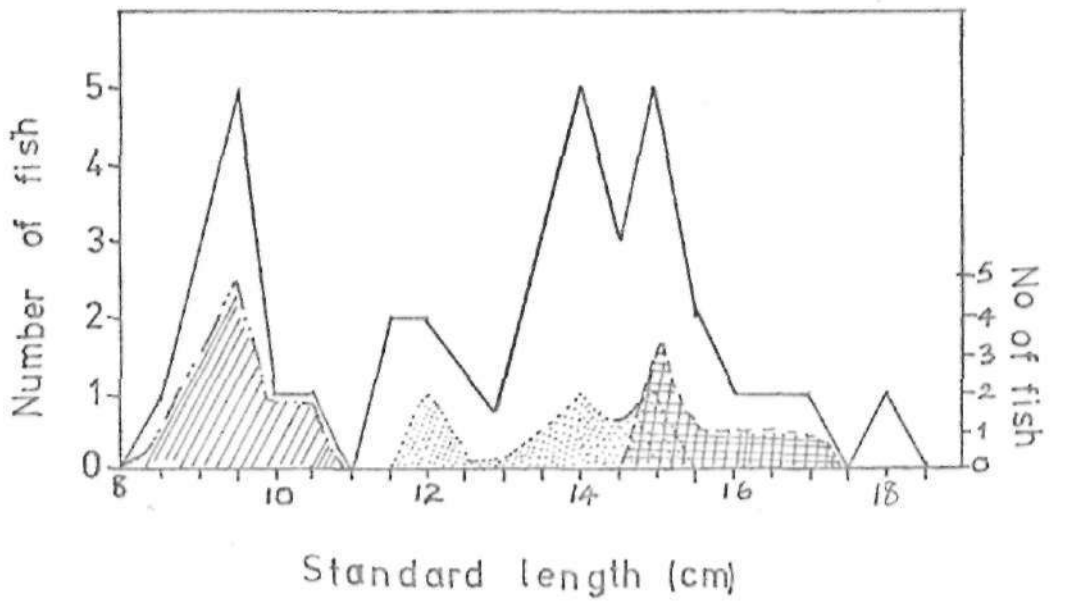
Plates 1 - 4 show sections of spines from various age groups of Eutropius niloticus and Schilbe mystus.

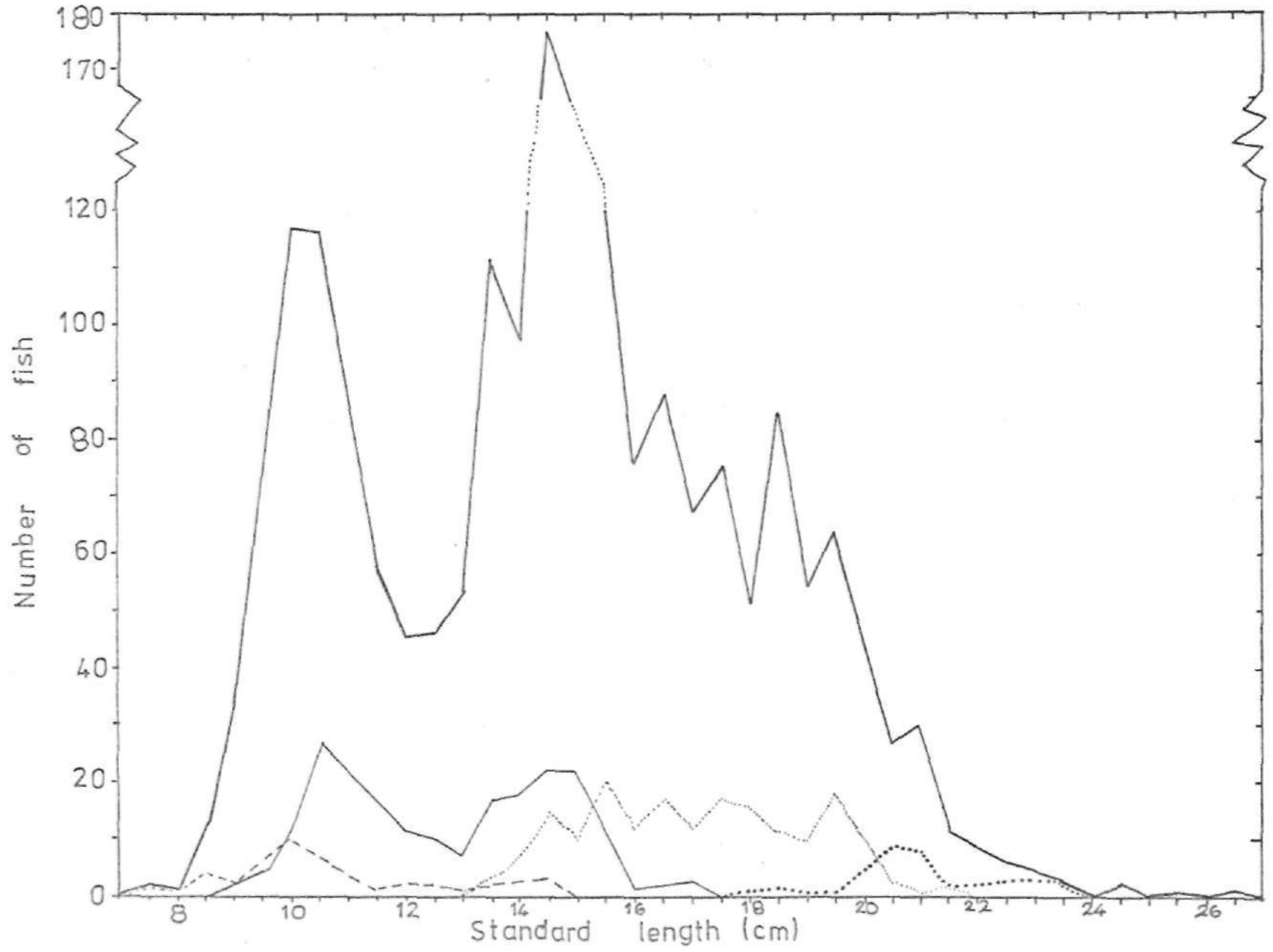
2. GROWTH STUDIES OF EUTROPIUS NILOTICUS AND SCHILBE MYSTUS.

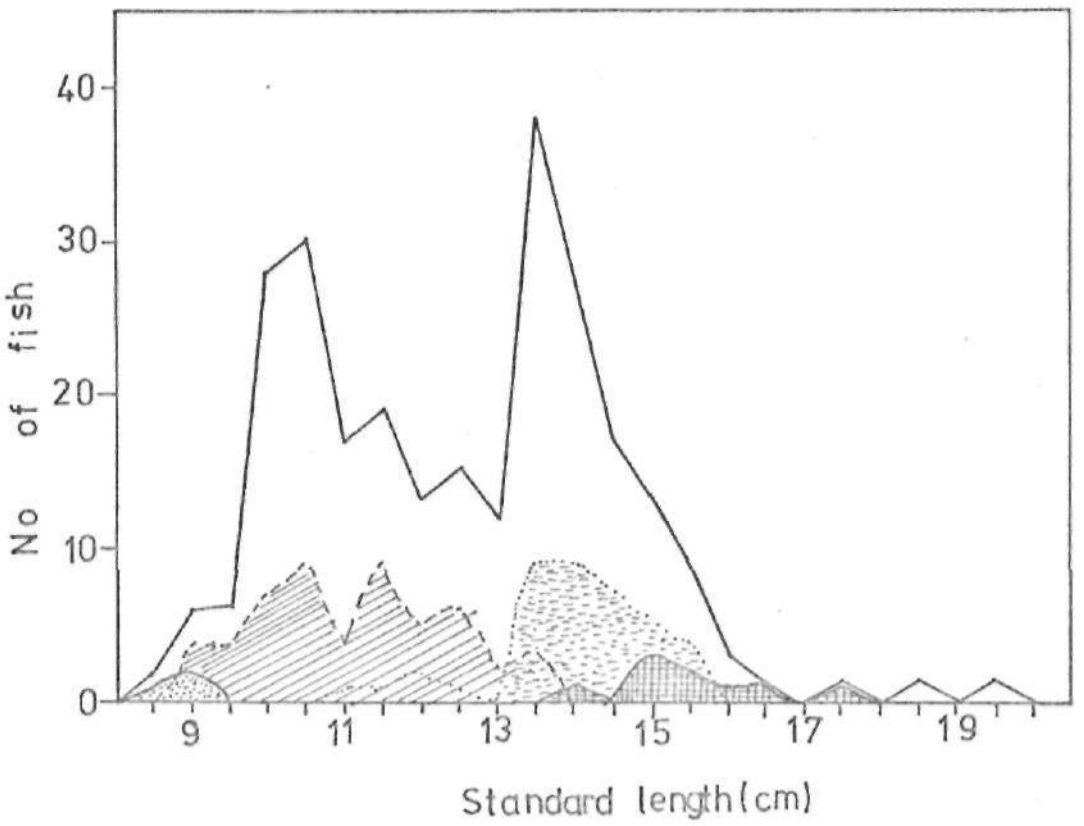
(a) Seasonal distribution of lengths.

The length-frequency histograms (Figures 3.4 & 3.5) show the length-frequency distribution in each month. In view of the gill net selectivity, the pattern of seasonal growth did not show clearly.


No of fish
30
20
10
0
9
11
13
15
17
19
21
Standard length (cm)


Number of fish
5
4
3
2
1
0
8
10
12
14
16
18
No of fish
Standard length (cm)


180
170
120
100
80
60
40
20
0
Number of fish
8
10
12
14
16
18
20
22
24
26
Standard length (cm)


40
30
20
10
0
No of fish
9
11
13
15
17
19
Standard length(cm)

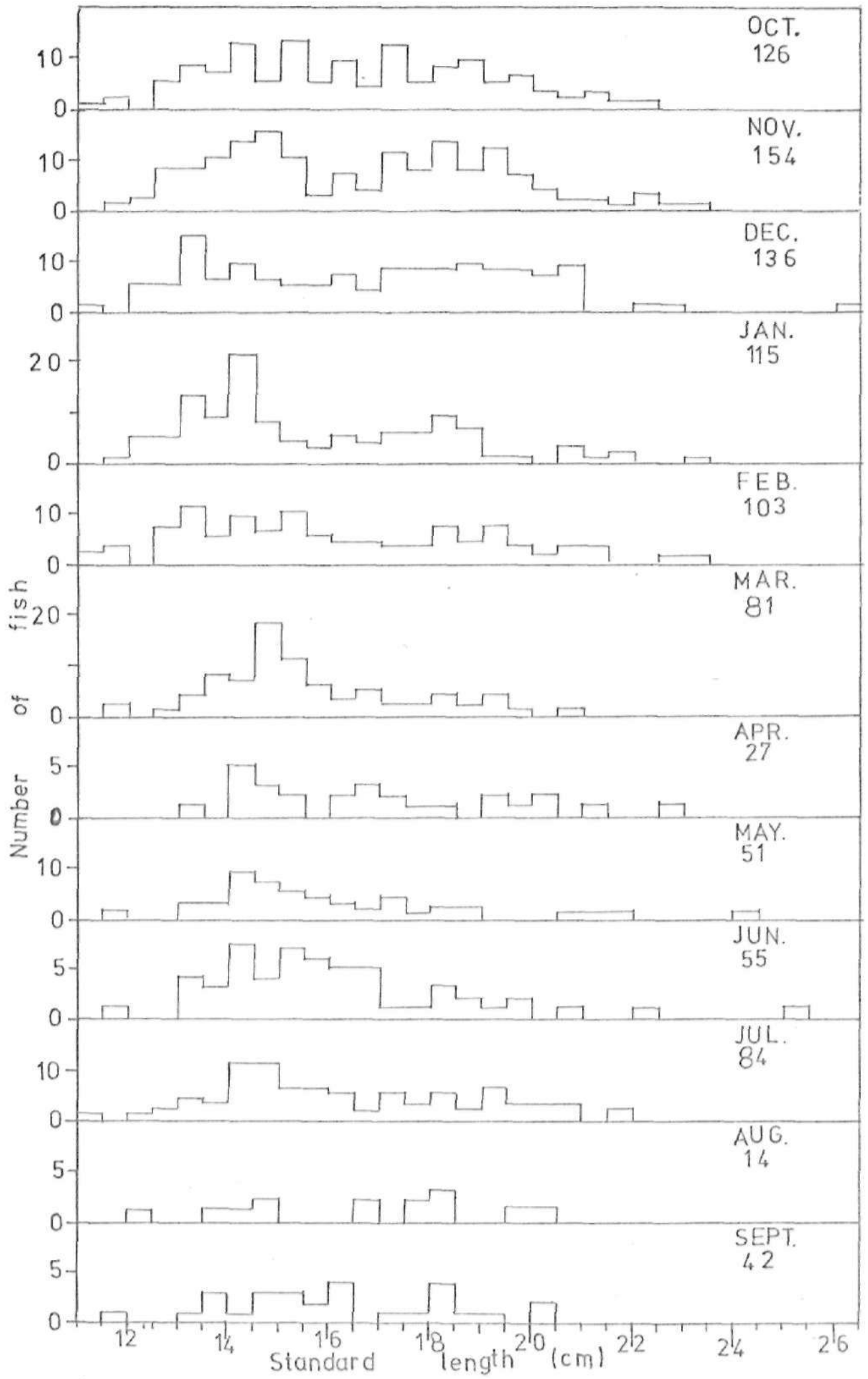
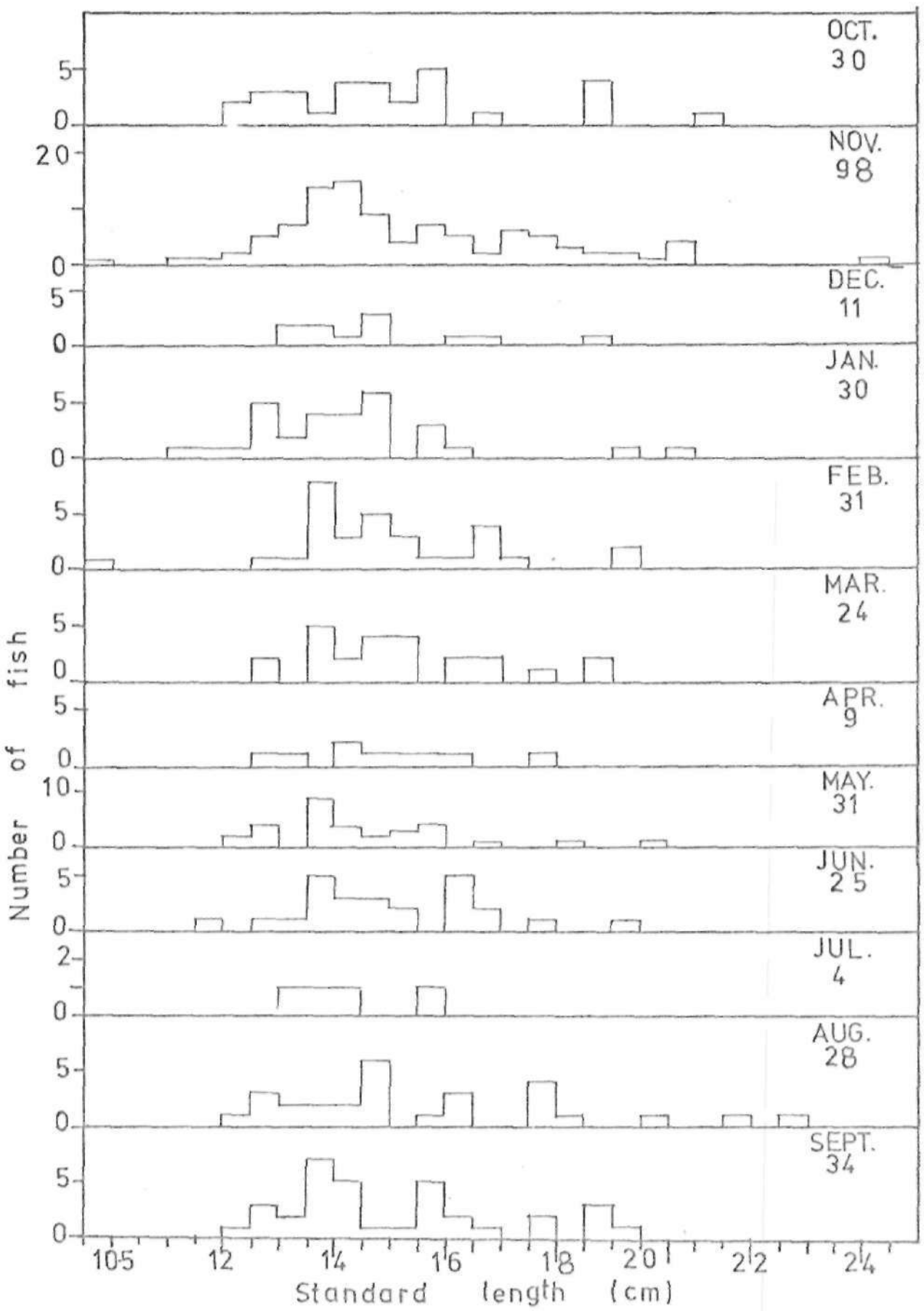
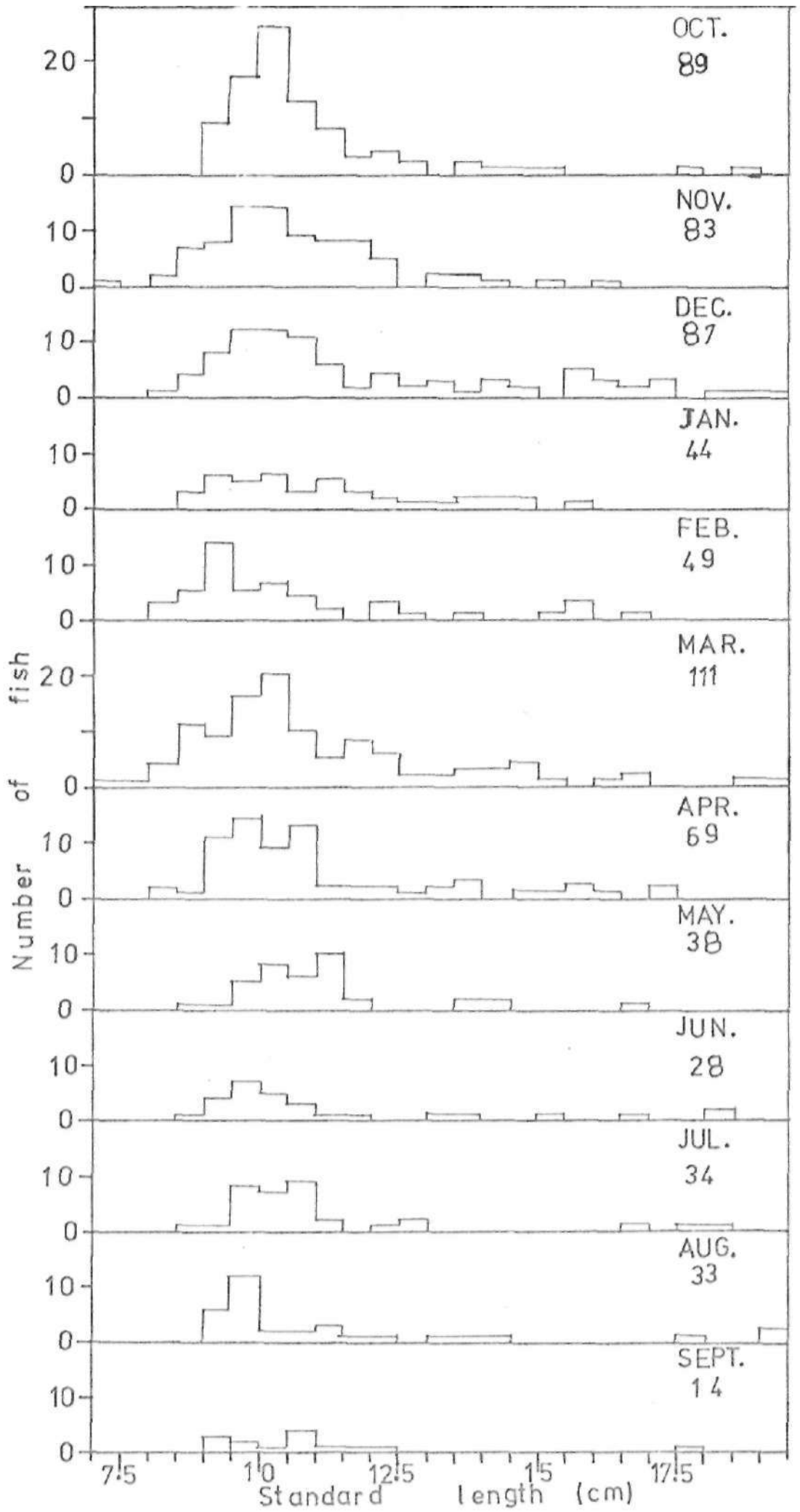
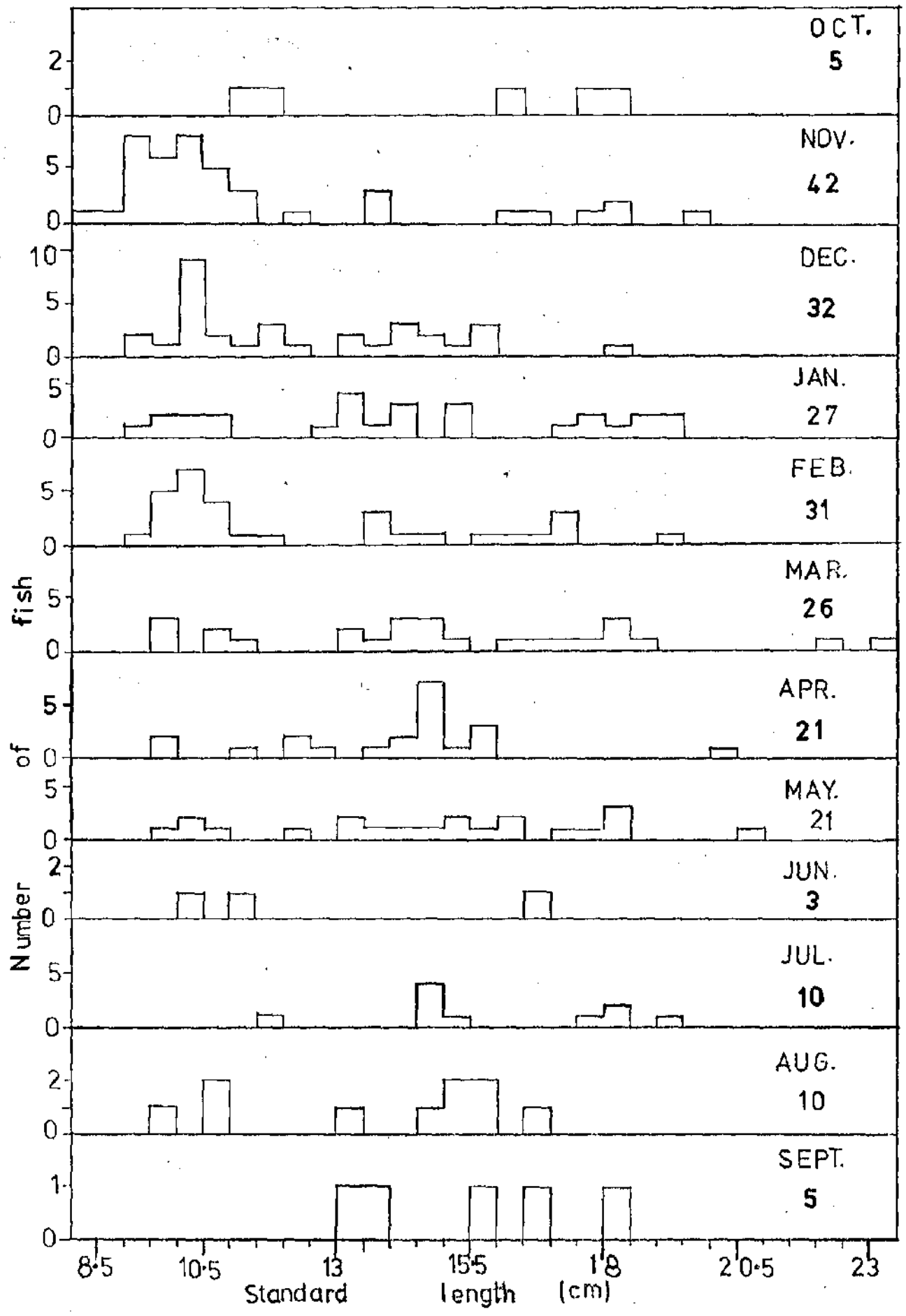

OCT.
126
NOV.
154
DEC.
136
JAN.
115
FEB.
103
MAR.
81
APR.
27
MAY.
51
JUN.
55
JUL.
84
AUG.
14
SEPT.
42
Number of fish
Standard length (cm)
12
14
16
18
20
22
24
26

Figure 3.4b.

(Eutropius niloticus.) Monthly length frequency distribution of females caught in the main nets during 1975/76 period.


OCT.
30
NOV.
98
DEC.
11
JAN.
30
FEB.
31
MAR.
24
APR.
9
MAY.
31
JUN.
25
JUL.
4
AUG.
28
SEPT.
34
Number of fish
Standard length (cm)
10.5
12
14
16
18
20
22
24


OCT.
89
NOV.
83
DEC.
87
JAN.
44
FEB.
49
MAR.
111
APR.
69
MAY.
38
JUN.
28
JUL.
34
AUG.
33
SEPT.
14
20
10
0
Number of fish
7.5
10
12.5
15
17.5
Standard length (cm)


OCT.
5
NOV.
42
DEC.
32
JAN.
27
FEB.
31
MAR.
26
APR.
21
MAY.
21
JUN.
3
JUL.
10
AUG.
10
SEPT.
5
fish
of
Number
2
0
5
0
10
5
0
5
0
5
0
5
0
5
0
2
0
5
0
2
0
1
0
8·5
10·5
13
15·5
18
20·5
23
Standard
length
(cm)

(b) Standard length - spine relationship.

Log - log conversions were made and regression co-efficients were calculated for each species. The relationship was described by the formula :

$$\text{Log } L = \log a + b \log S \qquad (1)$$

where L = standard length (cm) of fish at the time of capture.

S = total spine radius (micrometer readings) at the time of capture.

a = constant

and b = an exponent.

The result of the analysis gave the following relationship :- (r = Correlation co-efficient).

Eutropius niloticus

(Female) Log L = 0.5308 + 0.5701 log S (r = 0.803).

(Male) Log L = 0.5659 + 0.5060 log S (r = 0.673).

Schilbe mystus

(Female) Log L = 0.3288 + 0.7205 log S (r = 0.855).

(Male) Log L = 1.0084 + -0.0005 log S (r = 0.891).

Figures 3.6 & 3.7 show the relationship between the standard lengths of fish and sections of pectoral spines.

(c) Back-calculations of lengths at earlier ages.

Back-calculations were first made based on a direct proportion formula (Lea, 1910) :-

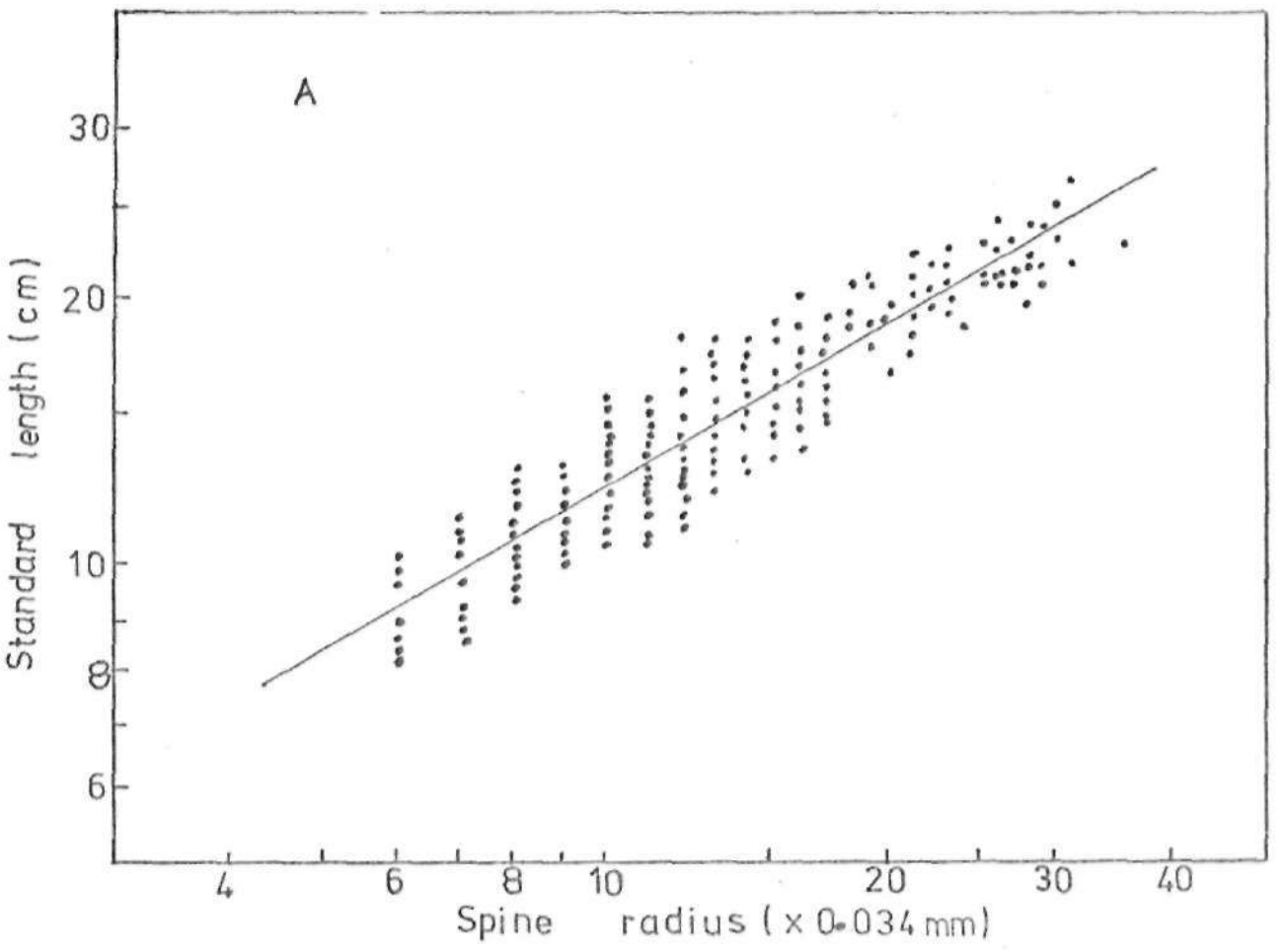
$$L_n = \frac{S_n L}{S} \qquad (2)$$

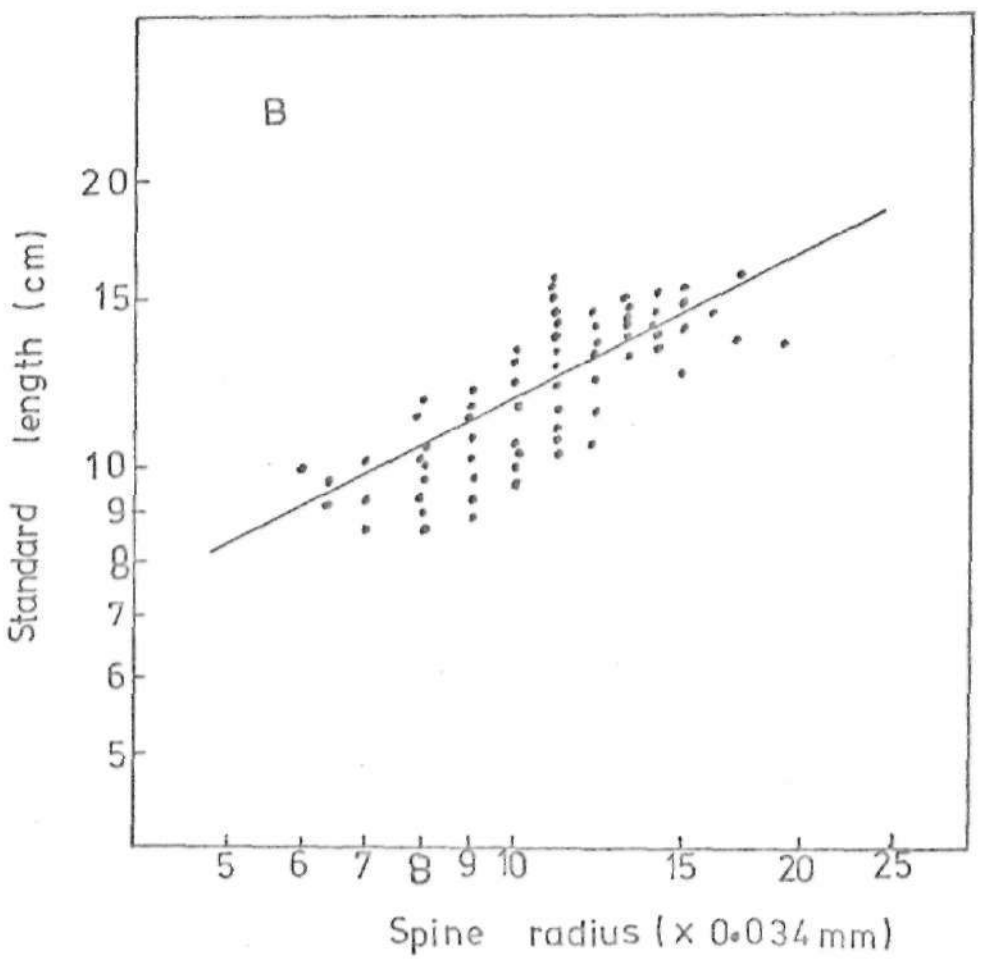
where L_n = standard length (cm) of fish at annulus 'n'

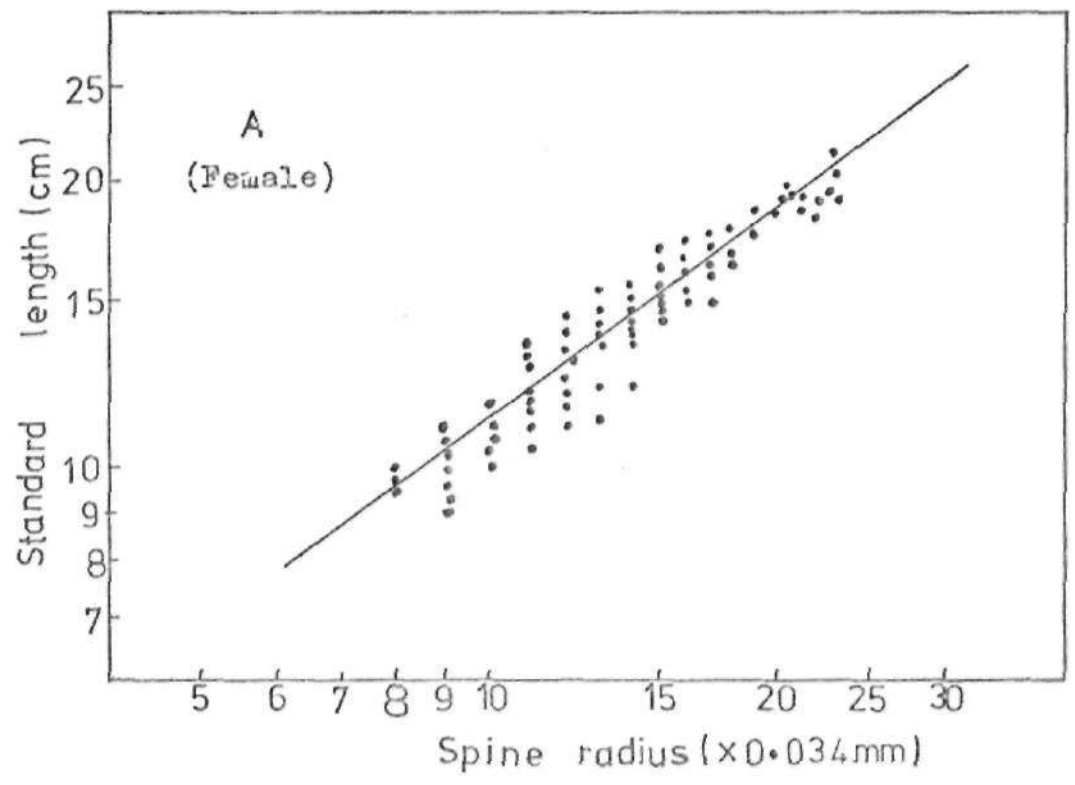
L = length of fish (cm) when caught.

S_n = radius of annulus 'n'

and S = total spine radius.


A
Standard length (cm)
30
20
10
8
6
4
6
8
10
20
30
40
Spine radius (x 0·034 mm)


B
Standard length (cm)
20
15
10
9
8
7
6
5
5
6
7
8
9
10
15
20
25
Spine radius (x 0·034 mm)



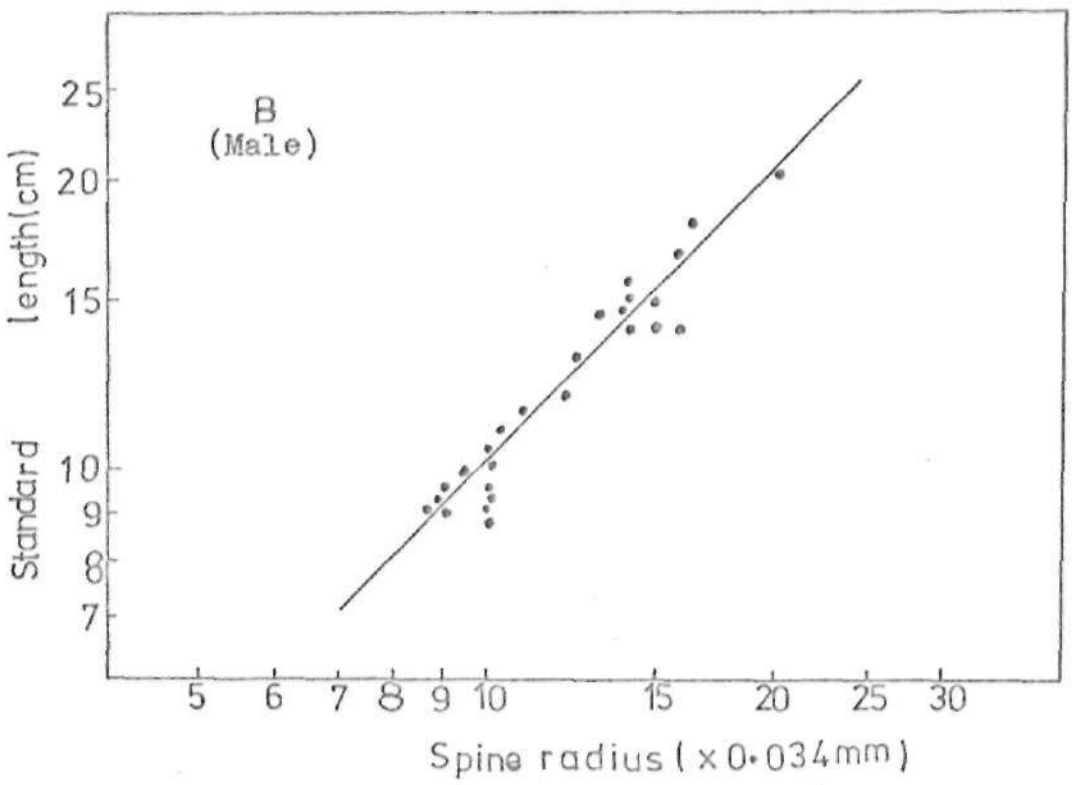


Fig. 3.7. Relationship (log-log) between fish length and spine radius of Schilbe mystus.

Because the spines were found not to grow in direct proportion to the body length corrections were therefore made for allometric growth. The method of correction used was that of Le Cren (1947). Appendices 17 and 18 show the results of calculations based on direct proportion formula and correction by Le Cren (1947) method. Corrected mean standard lengths were calculated for each age and these are given in Tables 3.1 and 3.2. The degree of error resulting from uncorrected back-calculation were also assessed (Appendices 17 & 18).

The mean lengths of females and males of each age group were tested for significant differences ('t' test) in order to verify differences in growth rate. The result (Appendix 19) showed highly significant differences between the mean lengths of females and males. Therefore females grow faster than males of the same age.

(d) Annual growth in length and weight.

Mean back-calculated standard lengths of each group were plotted from data on Tables 3.1 and 3.2 in order to follow the growth pattern of the two species through the life span (Figures 3.8 & 3.9). The mean growth in weight was obtained by conversion of the mean length data into weights using the length-weight regression co-efficients (see later). The graphs show that the females grow faster in length and weight than males of the same age. The females also live longer than the males as shown by analysis of annuli.

Calculated mean yearly increases in lengths and weights are shown in Table 3.3. Tables of yearly increases in lengths shows a pattern of fastest growth in the first year of life (0 - 1) and a decreasing pattern as the year of life advances. In E. niloticus, about 56% and 69% of the total mean growth in length were accomplished in the first year by females and males respectively. In

Table 3.1. Back-calculated lengths (cm) for age of female and male Eutropius niloticus.

Age at capture	Sex	Number of fish examined	Mean length at age 1	2	3	4
1+	Female	211	10.3			
	Male	52	8.9			
2+	Female	187	12.4	15.1		
	Male	41	10.2	12.4		
3+	Female	35	12.9	16.6	19.7	
	Male	9	10.0	12.4	14.2	
4+	Female	3	14.2	17.5	20.0	22.4
	Male	-	-	-	-	-
Mean length	Female		12.5	16.4	19.9	22.4
	Male		9.7	12.4	14.2	-

Table 3.2. Back-calculated lengths (cm) for age of female and male Schilbe mystus.

Age at capture	Sex	No of fish examined	Mean Length at age 1	2	3	4
1+	Female	24	10.9	-	-	-
	Male	8	8.4	-	-	-
2+	Female	47	10.6	14.1	-	-
	Male	7	9.4	13.3	-	-
3+	Female	2	10.0	14.2	17.1	-
	Male	-	-	-	-	-
Mean length	Female		10.5	14.2	17.1	-
	Male		8.9	13.3	-	-

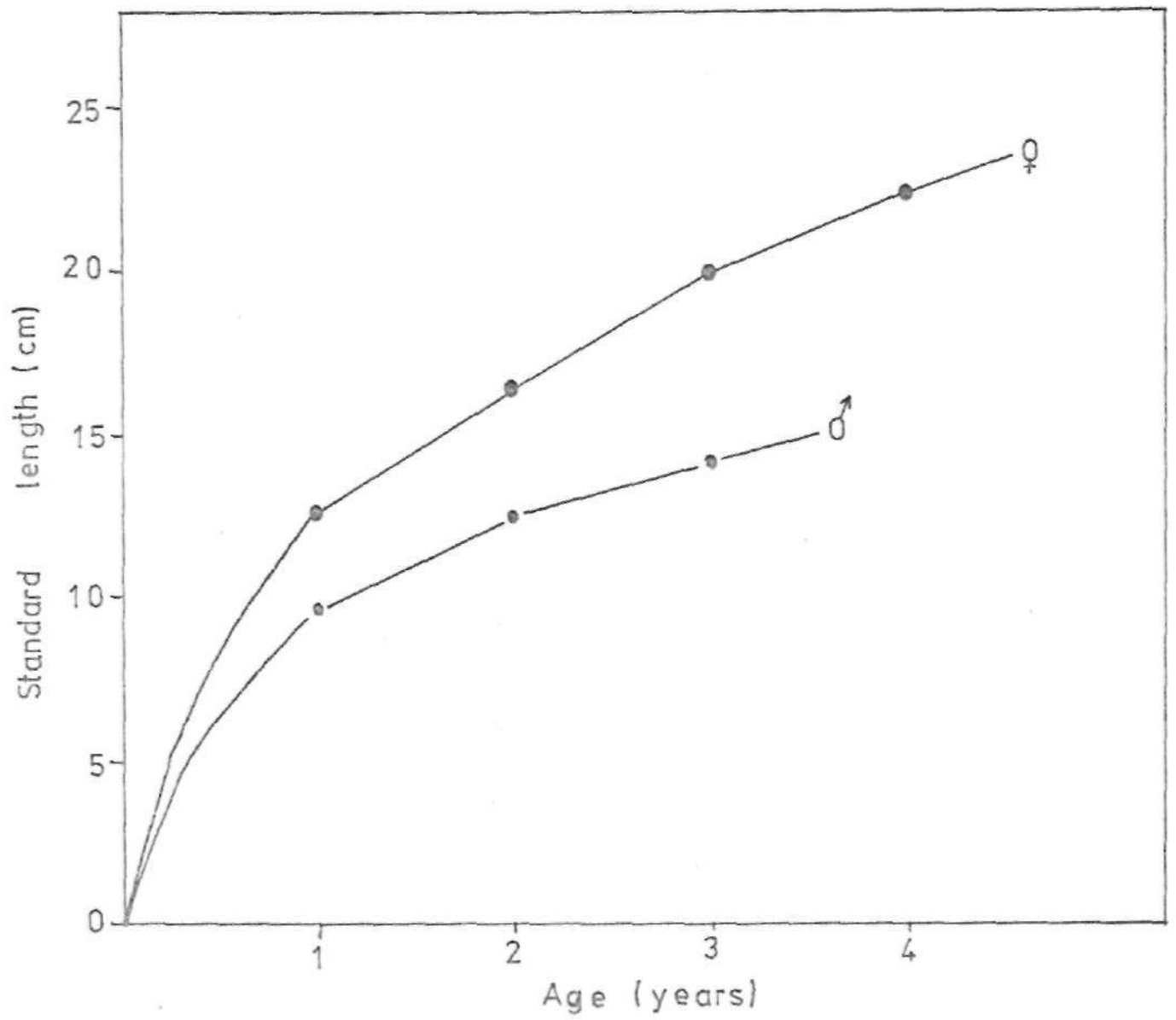
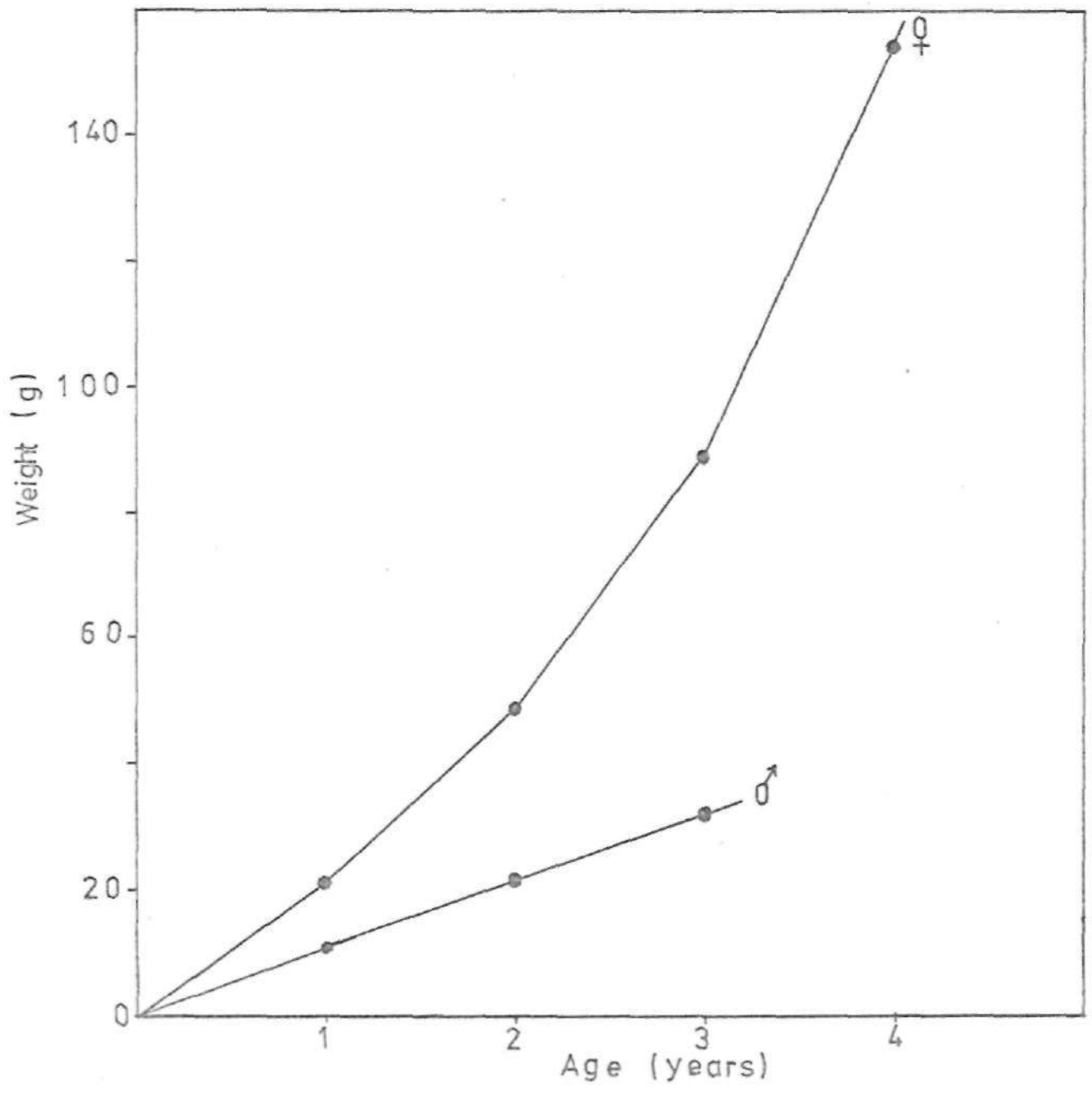

25
20
15
10
5
0
Standard length (cm)
♀
♂
1
2
3
4
Age (years)

Figure 3.8b.

(Eutropius niloticus.) Growth in weight during the life-span of females and males.


♀
♂
140
100
60
20
0
Weight (g)
1
2
3
4
Age (years)

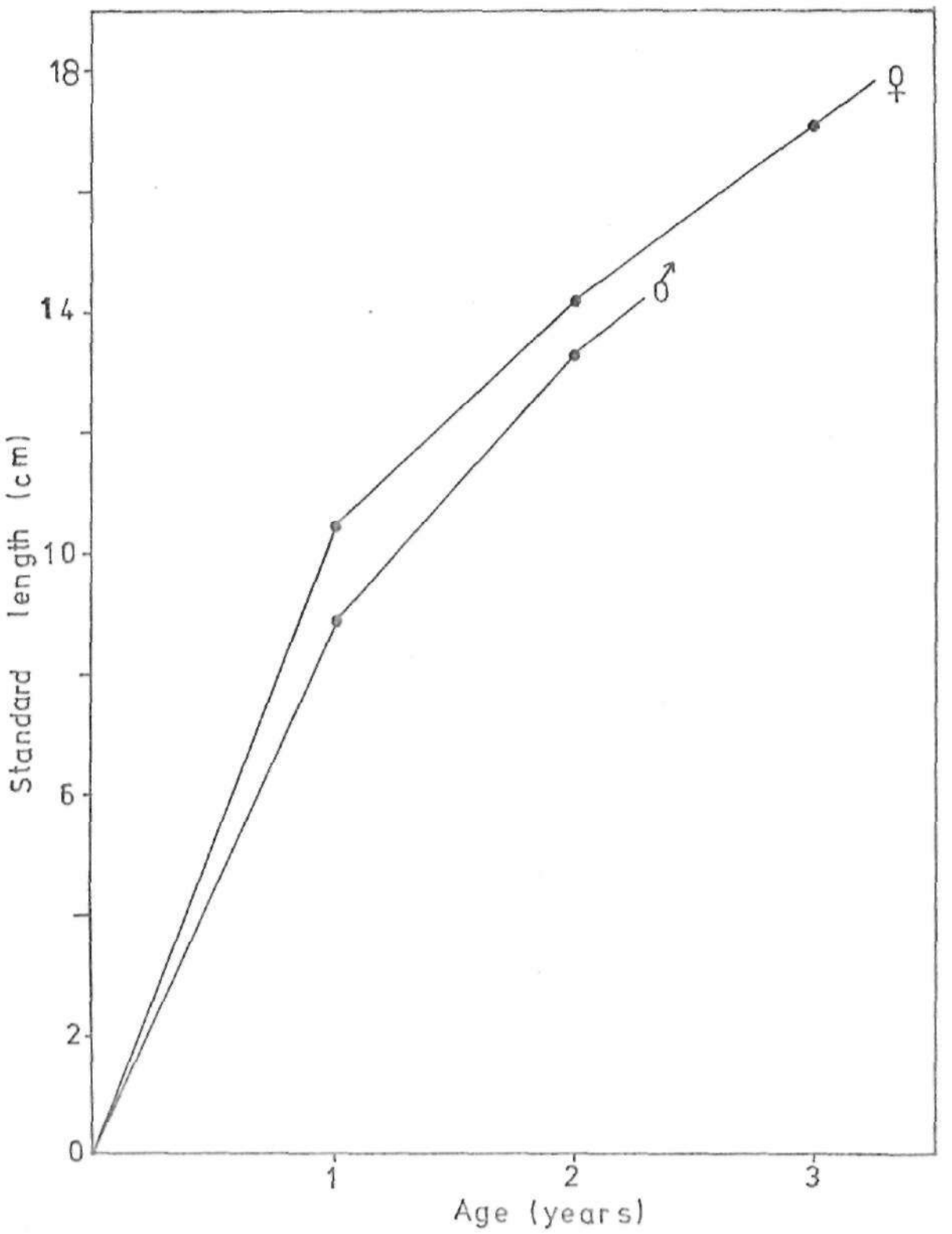


Fig. 3.9a. (Schilbe mystus.) Back-calculated mean growth in length during the life-span of males and females.

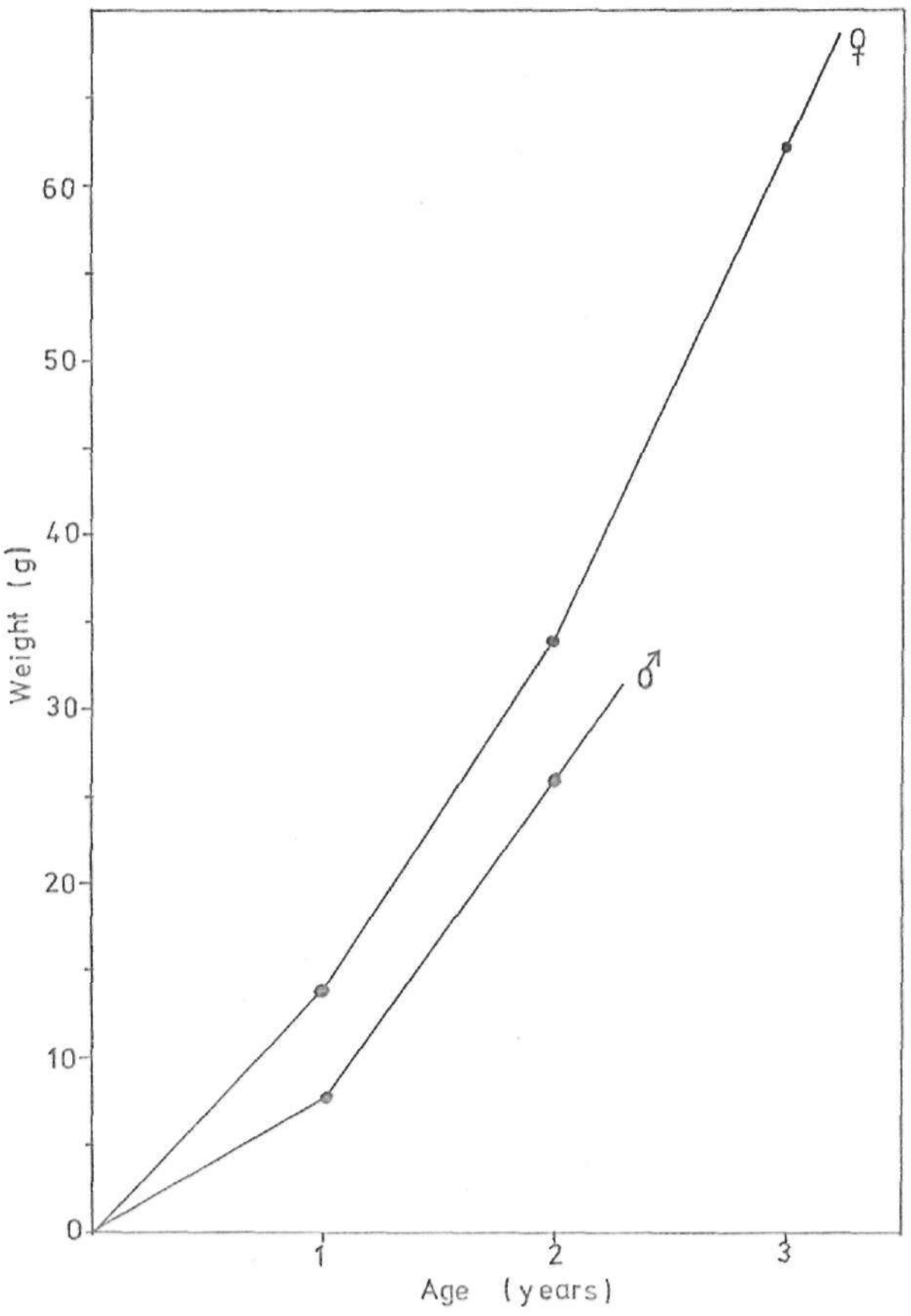


Fig. 3.9b. (Schilbe mystus.) Growth in weight during the life-span of females and males.

Table 3.3. Calculated mean yearly increment in length and weight of male and female Eutropius niloticus and Schilbe mystus in Lake Kainji.

Species	Sex	Growth in length (cm) during year of life				Number examined
		0 - 1	1 - 2	2 - 3	3 - 4	
E. niloticus	Female	12.5	3.9	3.5	2.5	474
	Male	9.7	2.7	1.8	-	109
S. mystus	Female	10.5	3.7	2.9	-	111
	Male	8.9	4.4	-	-	26

Species	Sex	Growth in weight (g) during year of life				Number examined
		0 - 1	1 - 2	2 - 3	3 - 4	
E. niloticus	Female	21.4	25.4	40.8	65.5	474
	Male	10.5	10.9	9.5	-	109
S. mystus	Female	13.8	22.3	26.3	-	111
	Male	7.6	18.6	-	-	26

S. mystus about 61% and 67% of the total mean growth in length were accomplished in the first year by females and males respectively. The general pattern of yearly increment in weight shows that the older the fish the higher the weight increase.

(e) Length - weight relationship.

The length-weight relationship were calculated using the formula described by Le Cren (1951) :-

$$W = aL^b \qquad (3)$$

Equation (3) can be represented as

$$\text{Log } W = \log a + b \log L \qquad (4)$$

where W = weight of fish (g)

L = standard length of fish (cm)

a = constant

and b = an exponent

The results of the regression are as seen in Tables 3.4 and 3.5. The correlation between the lengths and weights were found to be highly significant (P = 0.01 - 0.001). The overall regression co-efficients for males and females of each species showed that growth is isometric i. e. the weight did not increase faster than the cube of the length. Back-calculations of growth in weight were made as described earlier using the co-efficients in Tables 3.4 and 3.5. The length-weight relationship are shown in Figures 3.10 & 3.11.

3. PHYSAILIA PELLUCIDA

No structure was found suitable for ageing P. pellucida. Length-frequency histograms (Figure 3.12) showed two distinct modal lengths. If these are taken to represent age groups, then it can be said that P. pellucida life span is short when compared with other schilbeids. This assumption is supported by the following observations: (1) They reproduce at very short standard

Table 3. 4. Length-weight regression analysis of females and males of Eutropius niloticus in Lake Kainji.

Age groups	No of fish	log a	b	Standard error of 'b'	Correlation coefficient
Females					
0+	38	- 1.88	2.94	0.11	0.97
1+	211	- 1.93	2.96	0.05	0.98
2+	187	- 2.08	3.10	0.07	0.95
3+	35	- 2.79	3.65	0.35	0.87
4+	3	- 1.78	2.94	0.11	0.99
All females	474	- 2.04	3.07	0.02	0.99
Males					
0+	7	- 1.37	2.42	0.42	0.93
1+	52	- 1.61	2.56	0.12	0.95
2+	41	- 2.06	3.11	0.20	0.93
3+	9	- 2.35	3.34	0.32	0.97
All males	109	- 1.99	3.02	0.06	0.98

Table 3.5. Length-weight regression analysis of females and males of Schilbe mystus in Lake Kainji.

Age groups	No of fish	log a	b	Standard error of 'b'	Correlation coefficient
Females					
0	38	-2.25	3.29	0.14	0.97
1	24	-1.77	2.85	0.28	0.91
2	47	-2.38	3.39	0.26	0.89
3	2	-	-	-	-
All females	111	-2.20	3.24	0.06	0.98
Males					
0	11	-1.70	2.80	0.75	0.78
1	8	-2.20	3.24	0.12	1.00
2	7	-2.81	3.76	0.47	0.96
All males	26	-1.83	2.93	0.09	0.99

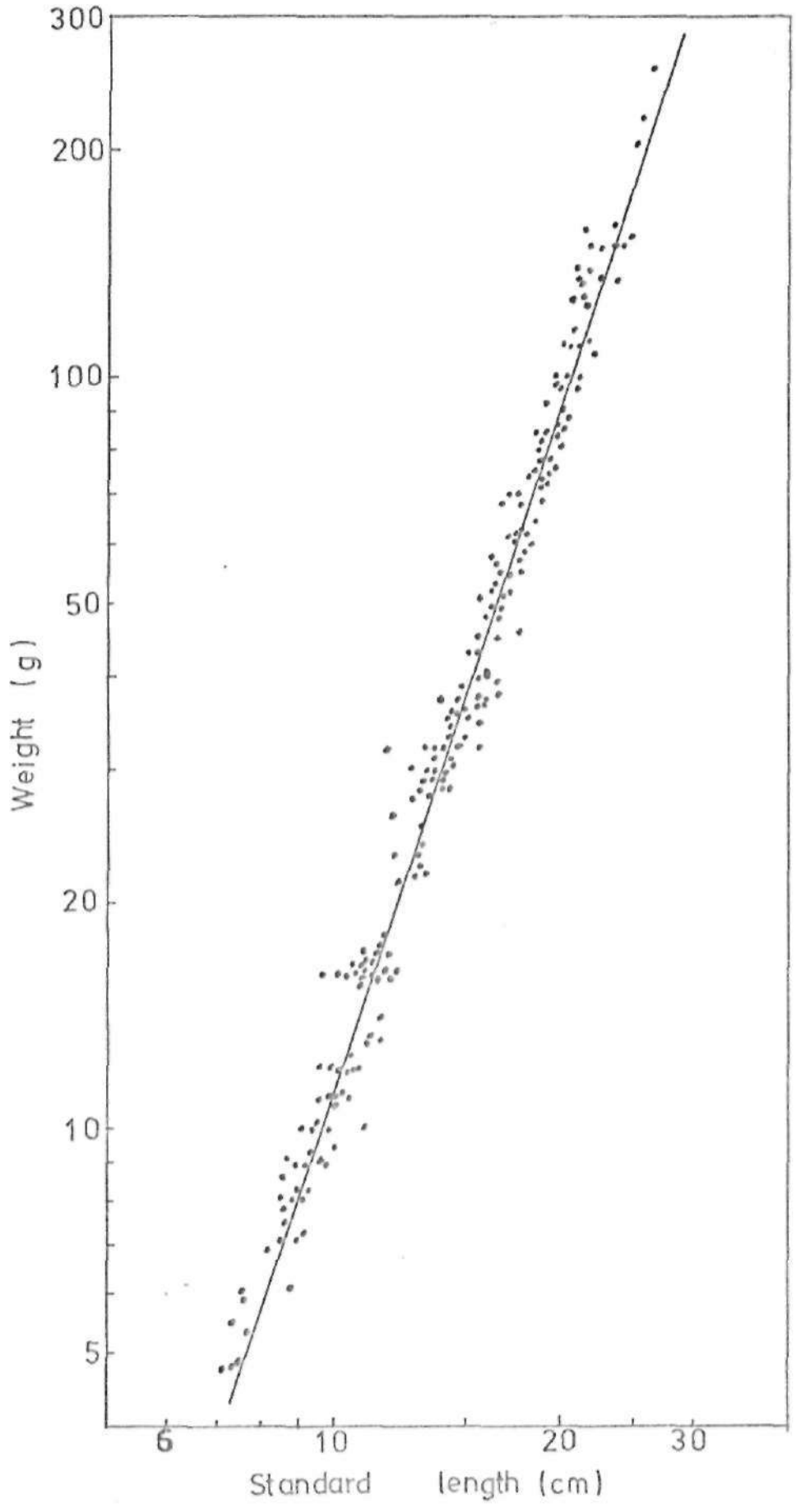


Fig. 3.10a. Length/weight relationship (log-log) of Eutropius niloticus.

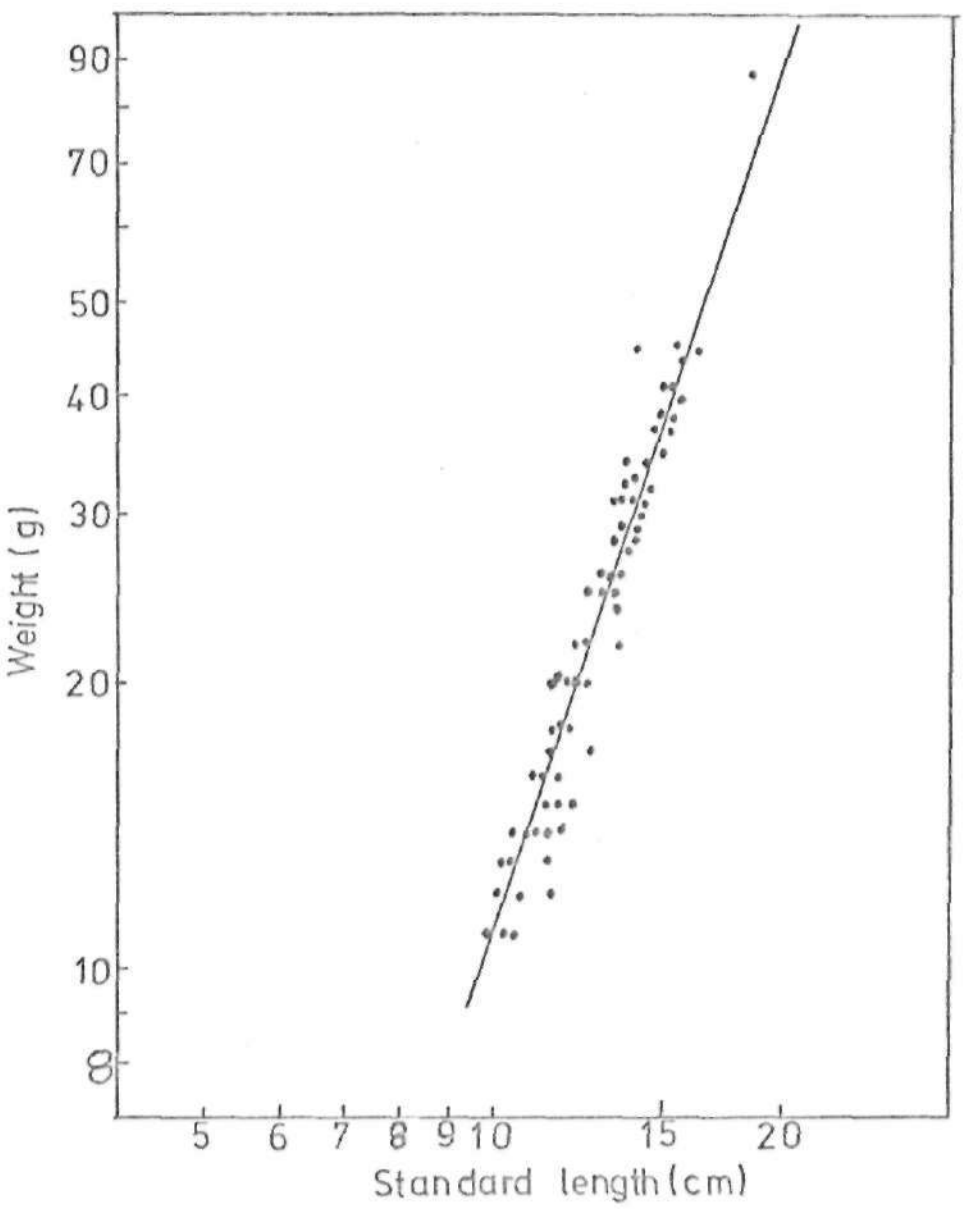


Fig. 3.10b. Length/weight relationship (log-log) of male Eutropius niloticus.

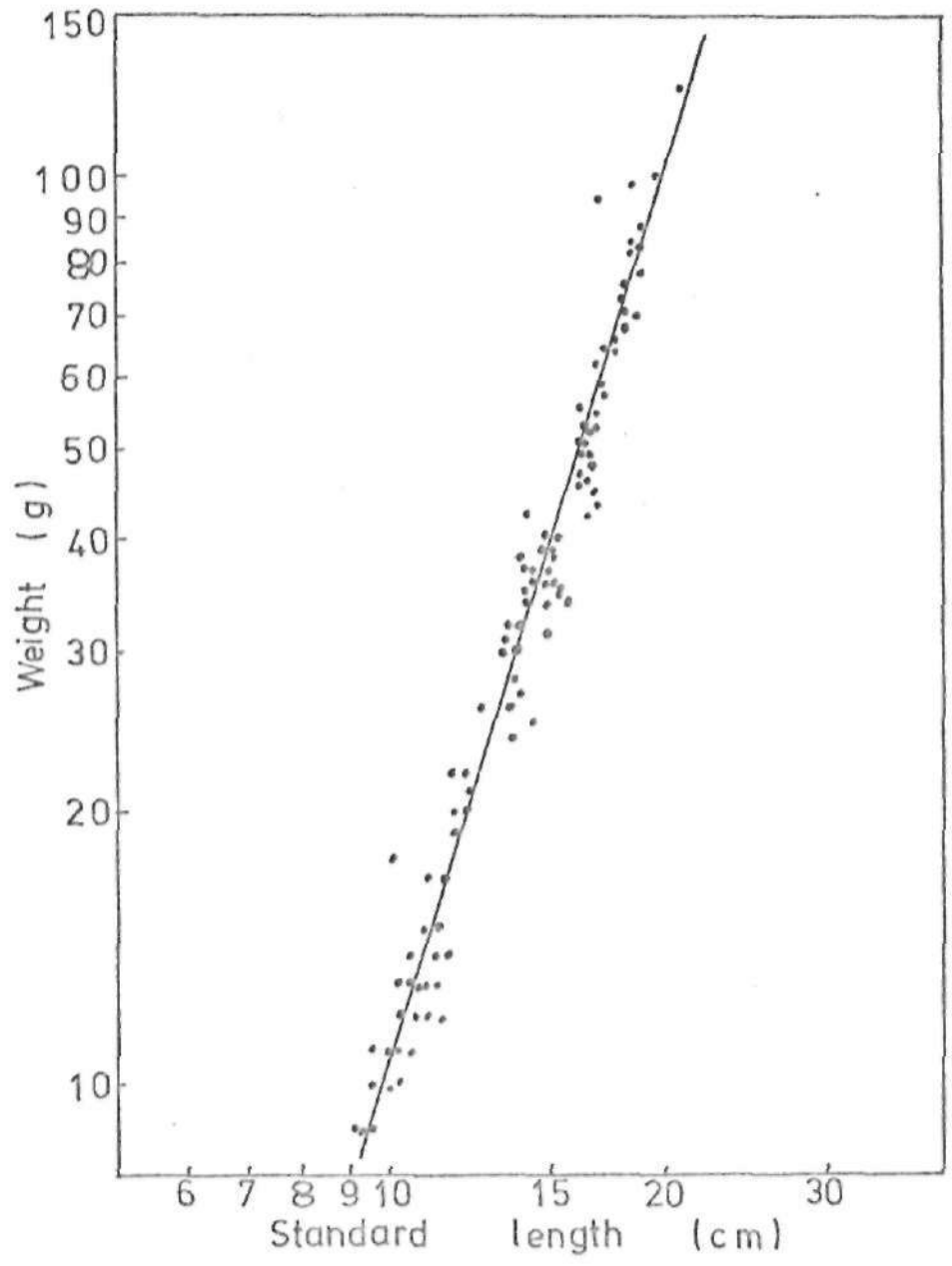


Fig. 3.11a. Length/weight relationship (log-log) of female Schilbe mystus.

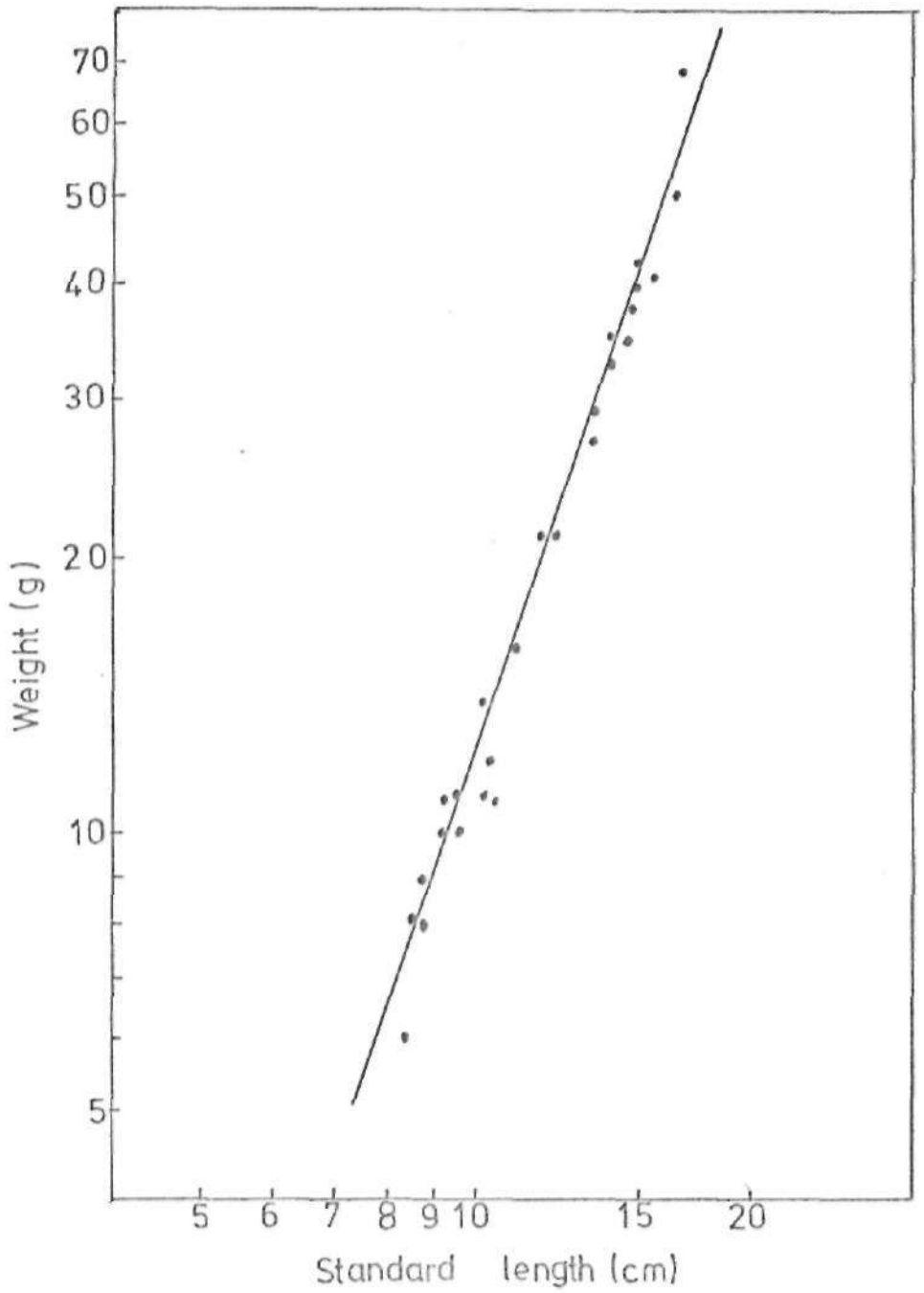
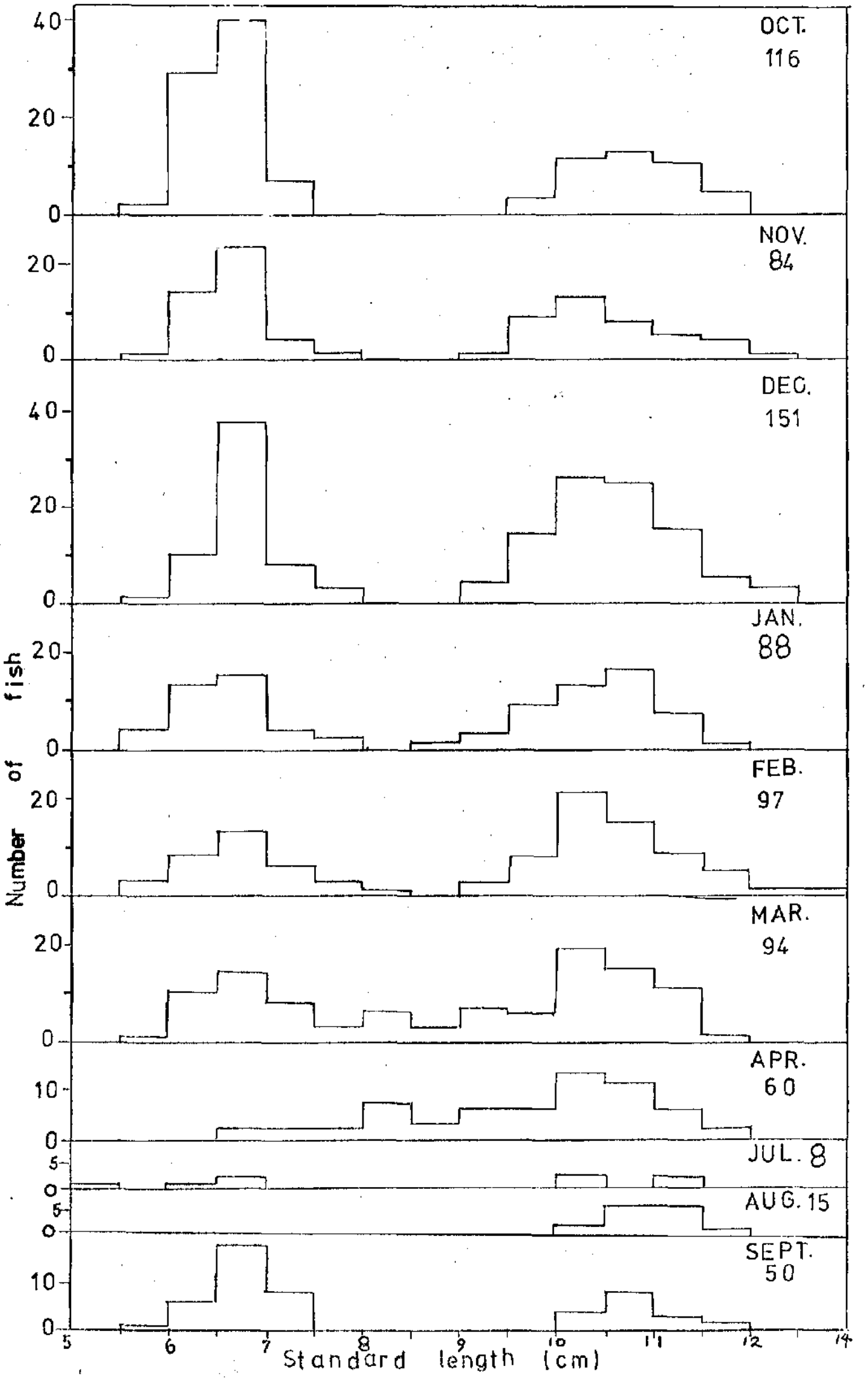
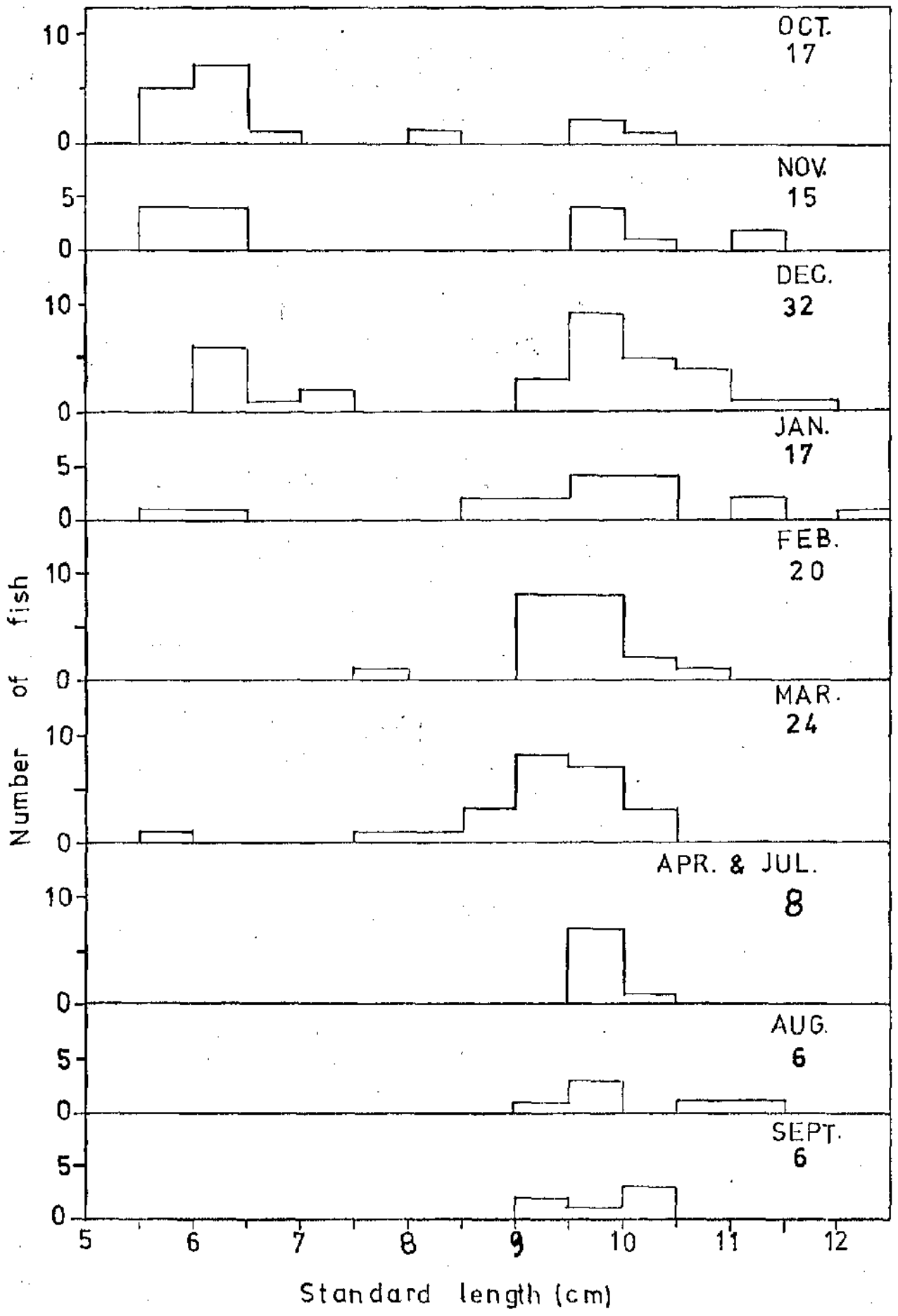


Fig. 3.11b. Length/weight relationship (log-log) of male Schilbe mystus.


OCT.
116
NOV.
84
DEC.
151
JAN.
88
FEB.
97
MAR.
94
APR.
60
JUL. 8
AUG. 15
SEPT.
50
Number of fish
Standard length (cm)


OCT.
17
NOV.
15
DEC.
32
JAN.
17
FEB.
20
MAR.
24
APR. & JUL.
8
AUG.
6
SEPT.
6
10
0
5
Number of fish
5
6
7
8
9
10
11
12
Standard length (cm)

length indicating that they mature probably before they are one year old. (2) The maximum standard length observed in the lake for females was 13.0cm and 12.0cm for males. If they attained a length of 8.0cm in the first year, they would only need 5 or 4cm to grow more in order to reach the maximum size. Assumming that growth declines with age, the remaining length can be added within one or two years. If it takes longer, it then means that the growth rate after first year's growth is exceptionally slow. It is also possible that P. pellucida after reproducing several times within a year may die, thus living only for one year. There is no evidence however to show that they die after spawning.

Another feature which emerges from the length-frequency histograms is that the females have higher modal lengths than the males. This indicates that the females grow faster than males, as with other schilbeids. Length-weight relationships are represented by the regressions log W = -2.30 + 3.27 log L for females and Log W = -1.63 + 2.58 log L for males. Standard error of 'b' and the correlation co-efficient are 0.17 and 0.81 respectively (females); 0.11 and 0.89 respectively (males). The regression for both sexes combined gives Log W = -1.97 + 2.94 log L (S.E of 'b' = 0.11, r = 0.83). Scatter diagrams were plotted for length-weight (Figure 3.13). These show the usual curve indicating that weight increases with increase in length.

4. CONDITION FACTOR

Fish condition will be described in relation to sexual maturity in Chapter Five. In this chapter the variations in the condition factor throughout a complete year were analysed for each species, combining both sexes as males and females were found not to differ (see Chapter Five). The formula shown next page was used :-

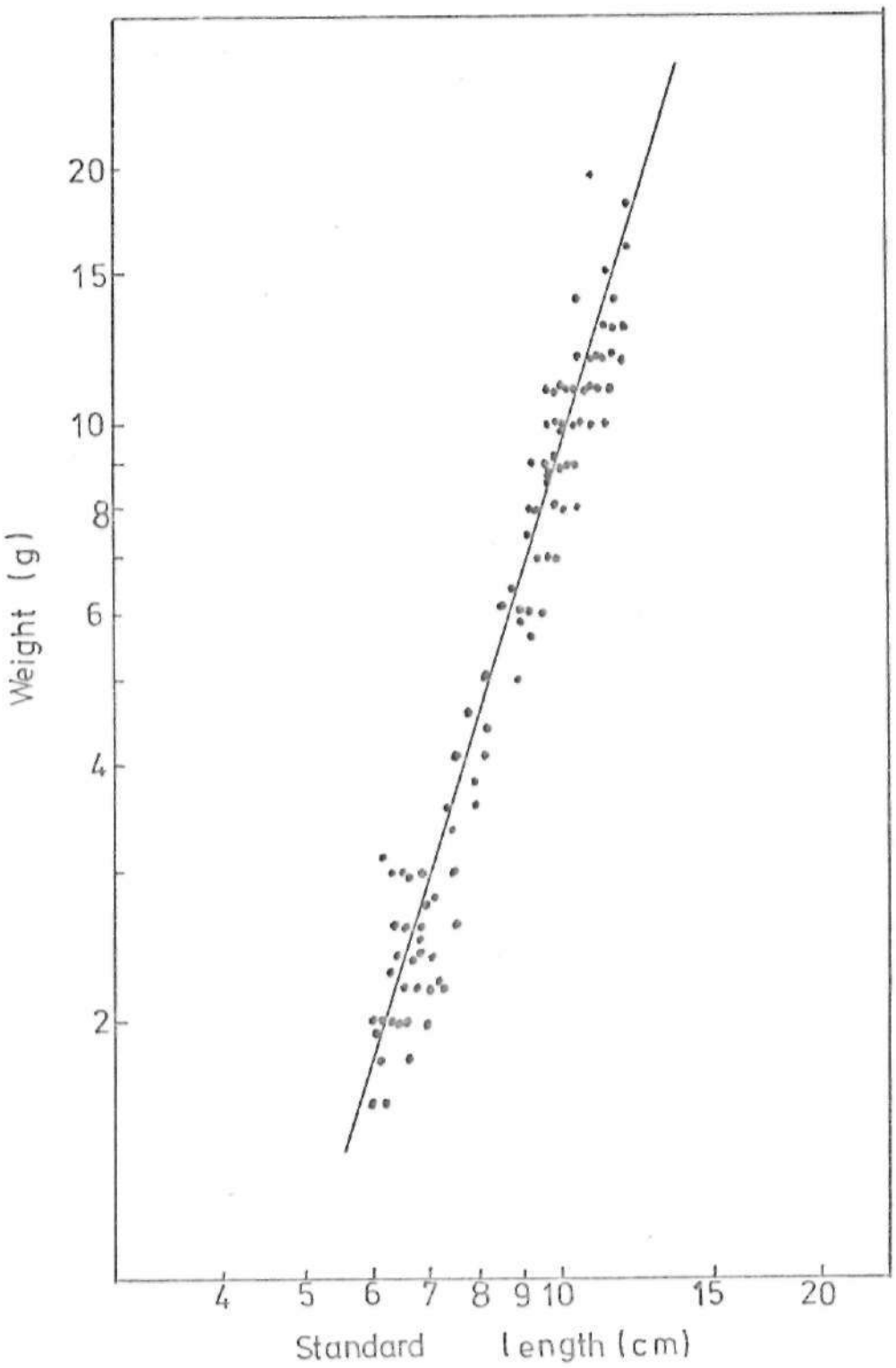


Fig. 3.13a. Length/weight relationship (log-log) of female Physailia pellucida.

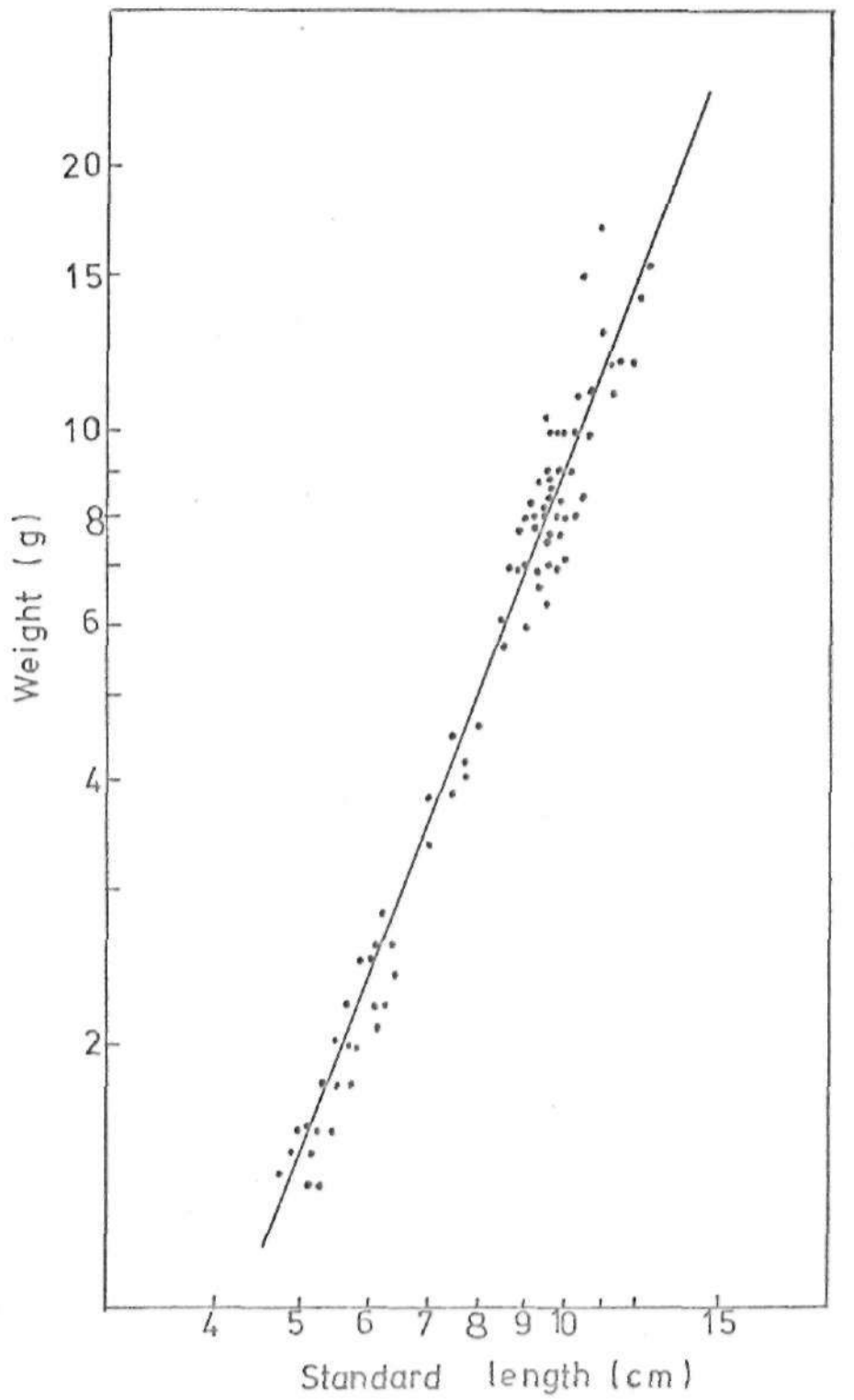


Fig. 3.13b. Length/weight relationship (log-log) of male Physailia pellucida.

$$K = \frac{W \times 100}{L^3} \qquad (5)$$

where K = condition factor

W = weight of the fish (g)

L = standard length of the fish (cm)

Figure 3.14 shows the variations in the 'K' values within a calendar year. Periods which fall below the mean annual values were regarded as low condition periods. In E. niloticus the low periods occurred from February to May and in S. mystus from November to January, and also in April/May. In P. pellucida the low periods were the months of October to January. Appendices 20 - 22 show the range, mean and standard deviation of 'K' in each month for the three species.

3.0.4. D I S C U S S I O N

Pectoral spines were found to be satisfactory structures for age and growth determinations in Eutropius niloticus and Schilbe mystus and only about 0.9% of spines had to be discarded due to unreadability. False rings rarely occurred and these were less than 2% in the samples. Only one annulus was formed in each year; thus pectoral spines are valid indicators of age in these two species.

In recent years the pectoral spine had been found to be satisfactory for age and growth studies and it has been used successfully for ageing several scaled and scaleless fishes by Cuerrier (1951), Sneed (1951), Scidmore & Glass (1953), Marzolf (1955), Perry (1967), Bilton & Jenkinson (1969), Donnelly & Caulton (1969), Gaigher (1969), Deelder & Willemse (1973) and Van der Waal & Schoonbee (1975).

The pectoral spines are presumably formed by successive deposits of calcareous materials . The deposit as expected would

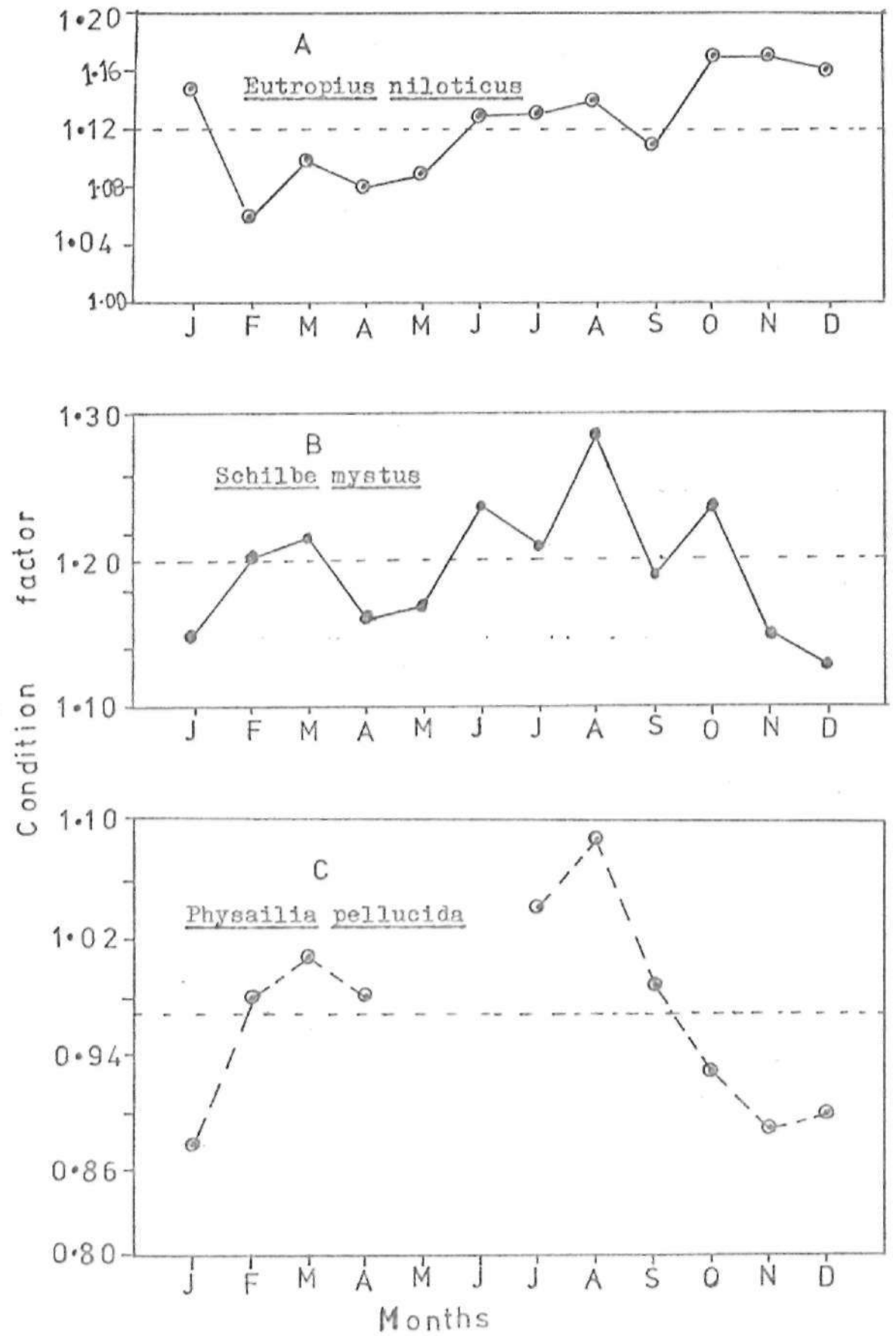


Fig. 3.14. Mean monthly condition factor.

vary according to the metabolism of the fish. According to Cuerrier (1951), the formation and development of the bony rays are assumed to be similar in nature to those of the membrane bones of the skull, where the osseous tissue is derived from connective tissue. The translucent zone is therefore due to an abundant formation of connective tissue during the period of rapid growth, converted later into bone tissue. The opaque zone would correspond to the period of metabolic inactivity during the period of slow or no growth when only a small amount of connective tissue and subsequent bone tissue is formed.

Concerning the factors involved in the process of ring formation, there is a great deal of confusion (De Bont, 1967). Thomson (1904) concluded that the formation of annual zones was due to seasonal variations in the food supply. Cutler (1918) and Jensen (1957) thought it was due to variations in temperature. Bhatia (1931a, b, 1932) concluded from his experiments that food rather than temperature seemed to affect ring formation. Chevey (1930, 1936) explained the presence of annuli on the scales of some Indo-Chinese fish species as a result of variations in the amount of water in the rivers. Brown (1946a, b) thought there is an internal cycle. Fagade (1974) studied Tilapia melanotheron (Ruppell) and found that the rings in the opercular bones were due to spawning activities. Bishai & Gideiri (1965) associated ring formation with spawning and reduced food consumption in Synodontis spp. Willoughby (1974) also arrived at the same conclusions with regards to the Synodontis species in Lake Kainji. Garrod (1959) in his observation of Tilapia esculenta (Graham) also concluded that rings on the scales were caused by spawning activities. Poinsard & Troadec (1966) related the formation of the annual rings in the otoliths of Scianidae from West Africa to the

cold season. Daget (1952), Johnels (1952) and Lowe-McConnell (1964) associated annual rings with the dry season.

The possible causes of annual rings in E. niloticus and S. mystus in Lake Kainji were investigated. Figures 3.15 & 3.16 show the seasonal variation of some of these factors within an annual cycle. The condition factor (K) was found to be high throughout the year and particularly between June and October when the rings are formed. Feeding intensity was fairly high (>50%) between June and October in both species. Fat deposition was high except for a fall in S. mystus during August. It was therefore concluded that variation in feeding was not the cause of annulus formation in the two species. Among the other factors, temperature was eliminated because the annual fluctuations is very low (<6°C) and Garrod (1959) considered this to be insufficient to cause ring formation. Secchi disc readings showed that the lake water was generally becoming turbid during this period which coincides with the annual drawdown and rainfall. The formation of the ring can be correlated with fall in water level and increasing turbidity of water. It is not known how water level can interact with the fish to cause the slowdown in growth which eventually results in the formation of the annulus. In case of transparency, this can be explained as follows. Growth of fish is under the control of the pituitary gland which secretes growth hormone. Changes in light and other factors often induce marked activity of this gland (Hoar, 1957). It is therefore possible that when the amount of light penetrating the water is reduced, the activity of the gland will be reduced thus slowing down growth or bringing growth to a standstill even if the feeding intensity of the fish is not reduced. Thus the predominant cause of annulus formation is increasing turbidity of water amplified probably by breeding in the older fish.

Figure 3.15.

(Eutropius niloticus.) Time of annulus formation and factors which may be causes of annulus formation.

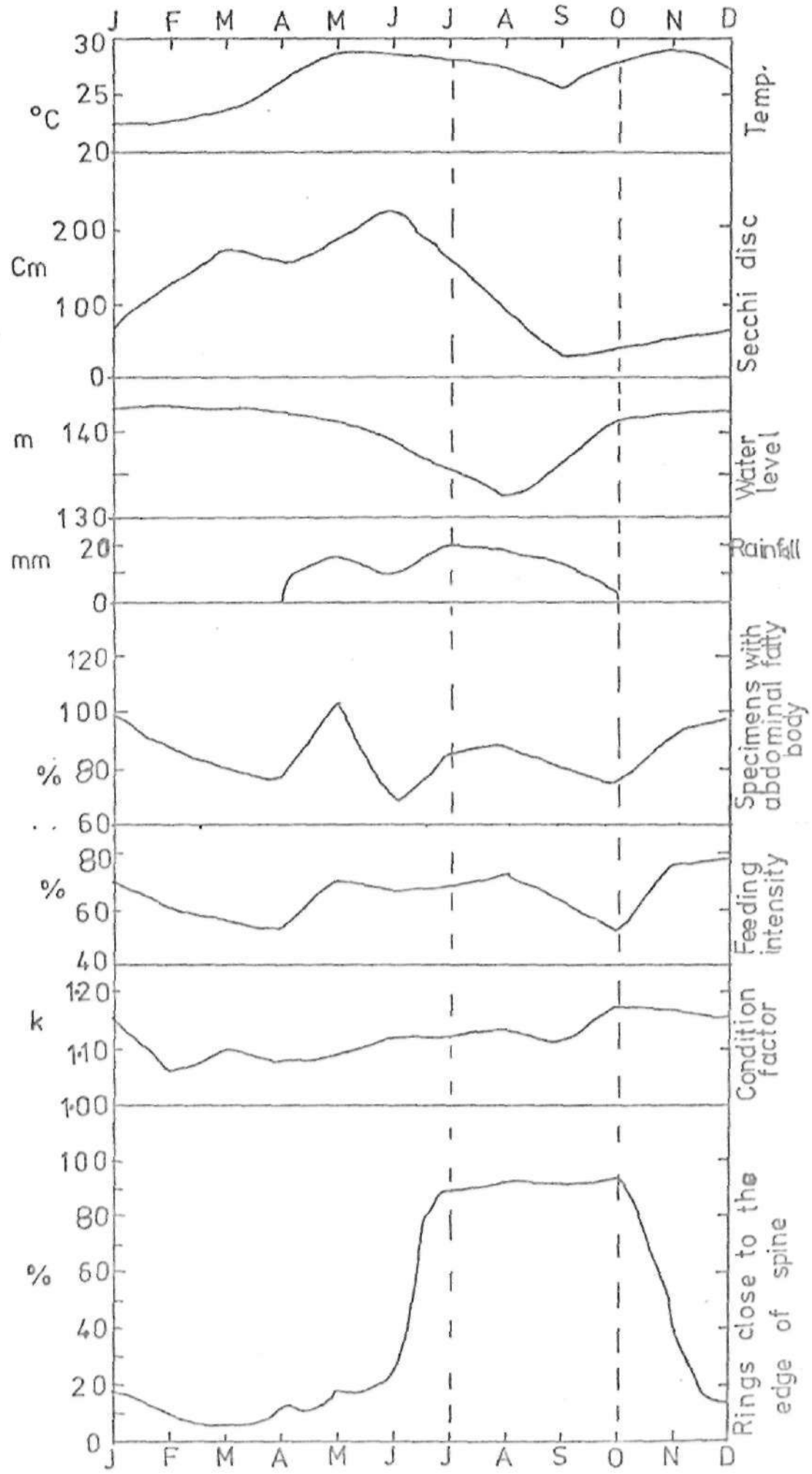
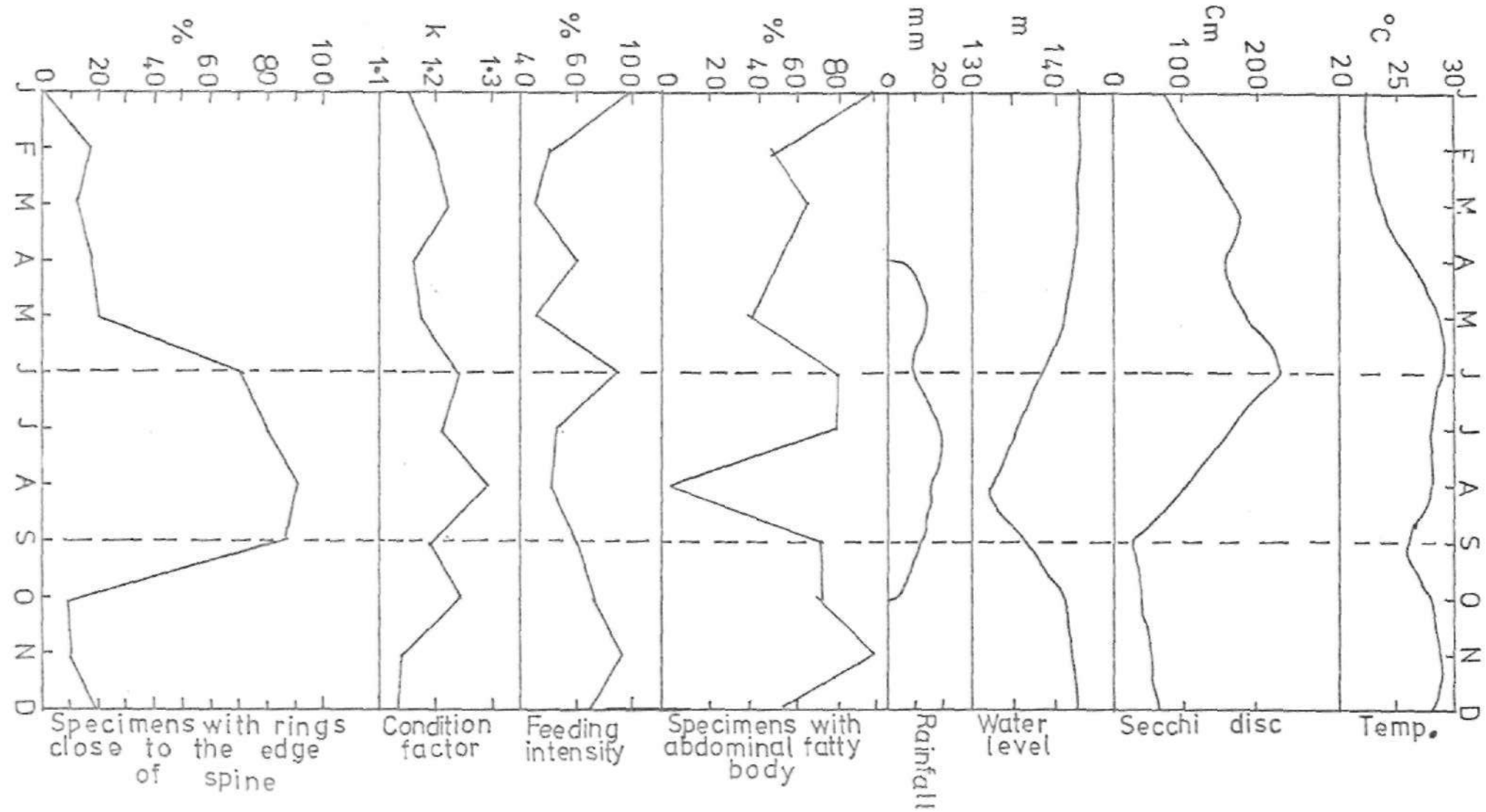

J F M A M J J A S O N D
30
25
°C
20
Temp.
200
Cm
100
0
Secchi disc
m 140
130
Water level
mm 20
0
Rainfall
120
100
%
80
60
Specimens with abdominal fatty body
80
%
60
40
Feeding intensity
1·20
k
1·10
1·00
Condition factor
100
80
%
60
40
20
0
Rings close to the edge of spine
J F M A M J J A S O N D

Figure 3.16.

(Schilbe mystus.) Time of annulus formation and factors which may be causes of annulus formation.


J F M A M J J A S O N D
°C 30 25 20
Cm 200 100 0
m 140 130
mm 20 0
% 80 60 40 20 0
% 100 60 40 20 0
k 1·1 1·2 1·3
% 0 20 40 60 80 100
Specimens with rings close to the edge of spine
Condition factor
Feeding intensity
Specimens with abdominal fatty body
Rainfall
Water level
Secchi disc
Temp.

It is interesting to note that the period when some fish in West Africa lay down annual rings falls within June to October. Fagade (1974) found that Tilapia melanotheron in Lagos Lagoon lay annual rings during June to October. Willoughby (1974) who studied the Synodontis of Kainji Lake also noted that nearly all the eighteen species lay rings around June to October. Johnels (1952) also observed that most of Gambian fish species formed their annual rings during June to October. Poinsard and Troadec (1966) also found that the opaque bands in Scianidae otoliths from West Africa were formed from June to September. The period June to October falls within the rainy season when most of the West African fish species breed.

Growth was faster in females than in males of the same age. Generally in both sexes, the rate of growth decreased with age. Groenewald (1964) and Gaigher (1969) found that the females of Eutropius depressirostris in South Africa grow larger than the males. Comparison of growth of S. mystus in Lakes Kainji and Kariba (Table 3.6) shows that Kainji specimens grow faster than samples from Kariba. No similar data are available for E. niloticus but comparison of the growth of E. niloticus in Lake Kainji with a related species, E. depressirostris revealed the same conclusions.

Changes do occur in the length-weight relationship throughout the life of the two species. The general trend is one of increasing weight per unit length.

Table 3.6. Comparison of growth of Kainji schilbeids with species from Lake Kariba.

Lake		Kainji				Kariba		Kainji				Kariba	
Species		E. niloticus				E. depressirostris+		S. mystus				S. mystus+	
		Length (cm)		Weight (g)		Length (cm)	Weight (g)	Length (cm)		Weight (g)		Length (cm)	Weight (g)
Age	1	9.7	♂	10.5				8.9	♂	7.6			
		12.5	♀	21.4		6.4	3.7	10.5	♀	13.8		5.2	2.1
"	2	12.4	♂	21.4				13.3	♂	26.2			
		16.4	♀	46.8		9.5	11.9	14.2	♀	36.1		7.7	6.5
"	3	14.2	♂	30.9				-	♂	-			
		19.9	♀	87.6		11.9	22.0	17.1	♀	62.4		10.2	15.0
"	4	-	♂	-				-		-			
		22.4	♀	153.1		14.1	37.0	-		-		12.3	26.0
"	5	-		-				-		-			
		-		-		16.8	62.0	-		-		14.1	37.0
"	6	-		-				-		-			
		-		-		18.9	85.0	-		-		16.4	53.0
Reference		This study				Cerny (1974)		This study				Frank (1974)	

\+ Females and males were not separated.

C H A P T E R F O U R

S e c t i o n 1

Food and Feeding habits

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4.1.1. I N T R O D U C T I O N

In this section, the food habits of the five schilbeid species are described. Where sufficient samples were obtained, the variation of the diets with fish lengths, seasons of the year and time of the day were also assessed. There are several reasons why it is desirable that information on the food of the schilbeids should be known. Apart from the contribution it will make to understanding the biology of the family, it will also help in understanding the complex trophic relationships existing in Lake Kainji. Such information may also be useful to fishery management planners who may need the vital information for the formulation of management policies.

Although detailed studies on the diets of some of the major fish families in Lake Kainji have been done, none has been attempted on the Family Schilbeidae. Studies on the diets of other families in the Lake are by Ajayi (1972) for the Family Bagridae; Arawomo (1972, 1976) for Citharinidae; Willoughby (1974) for the Mochokidae; Akintunde (1976) for the Cichlidae and Lewis (1974a) for Hydrocynus sp. Before the impoundment of the River Niger, Imevbore and Bakare (1970) examined the stomachs of a few specimens of E. niloticus and S. mystus and reached some conclusions about their diets. Remarks, usually unsupported by data, on the diets of the schilbeids can also be found in Banks et al (1965) and Lewis (1973b).

In other parts of Africa, very few detailed investigations have been attempted and most of the work done has been part of general survey programmes and of necessity on a small scale. However, some information can be obtained from the general studies by Pekkola (1919), Sandon & El-Tayib (1953), Verbeke (1959), Groenewald (1964), Petr (1967), Reynolds (1967, 1970), Corbet (1961) and Whitehead (1969).

4.1.2. M A T E R I A L S A N D M E T H O D S

There are a variety of methods open to the fishery biologists to assess the stomach contents of fish. Hynes (1950) gave a review of these and has pointed out their merits and limitations. He concluded, however, that each method presents essentially the same summary of the diets. Thus whatever the method employed the overall picture of the main food items of the fish will still be portrayed. A method suitable for assessing the diets of a piscivorous fish however may not be suitable for a fish feeding mainly on phyto- or zooplankton. The final choice of methods used will be guided by the purpose of the proposed study, it will also depend on its suitability of application to the fish being studied. It is advisable to use various methods so that the advantages of one may counteract defects in another.

Stomach contents were examined using the following ways of scoring :-

(a) Points method.

(b) Numerical method.

(c) Frequency of occurrence method.

Not all assessments were suitable for the analysis of the diets of the five schilbeid species. Methods (a) and (c) were used for Eutropius niloticus, Schilbe mystus and Schilbe uranoscopus while methods (b) and (c) were used for Siluranodon auritus and Physailia pellucida. Fish samples were obtained as described in Chapter Two. Initially, the stomachs were preserved in 5% Formalin and stored for later examination, but when this was found to be unsatisfactory, the stomach contents were examined fresh. Thus about 90% of the stomachs were examined fresh because the stomach contents still retained their colour, original size and features which made identification of the food organisms easier.

1. The Points / Stomach fullness Method.

Stomachs for examination were removed from the fish and the volume of food therein was estimated by the stomach's fullness as expressed in Table 4.1. Points falling in-between those on Table 4.1. were also awarded where appropriate. After grading, the stomachs were opened lengthwise and the contents were washed into Petri dishes containing 10ml of water. The food items were separated in the first instance into major groups e.g. fish, Insecta, Crustacea, Mollusca, etc. and later into Families, Orders, genera and where possible into species. Points were then awarded to the food items according to the volume they were judged by eye to have occupied in relation to the total volume of food in the stomach. Thus the sum of the points awarded to individual dietary items was equal to the point awarded for the stomach size. The points awarded for the individual food items in each fish were summed and the percentage contribution made by each determined for each month. The monthly pools were again summed and mean values calculated for the whole period of study. The final figures gave the relative volume of the food items found in the stomachs and were expressed in percentage.

This method shows the importance of each item in the diet of the fish. The major criticism of this method is that it is subjective, though Hynes (1950) states that this effect can be eliminated if large samples are analysed over a long period by a single observer.

2. The Numerical Method

This method was used for the smaller schilbeids. These fish possess very small stomachs and it was difficult to know whether a stomach was empty or full. The food organisms were also very small and could not be separated with the naked eye so that a

Table 4.1. Classification of stomach fullness.

Stomach size	Description	Points
Full stomach	The stomach bulges considerably with food. Stomach wall very thin and transparent.	100
¾ Full stomach	The stomach is almost full but does not bulge.	75
½ Full stomach	Food occupies about 50% of the stomach volume.	50
¼ Full stomach	Stomach wall very flabby, sometimes looked as if emptied.	25
Empty stomach	No visible food in the stomach when dissected and examined under the microscope.	0

stereo or compound microscope had to be used.

The stomachs were removed from the fish and the contents scraped into watch glasses. Food items were separated into genera or species where possible and counted under the stereo microscope. In some instances where many food organisms had been consumed it was impossible to count the individual food items. It was therefore necessary to take sub-samples. Sub-samples were taken as described below :-

(1) 5ml of water was added to the stomach contents and mixed thoroughly.

(2) 0.5ml of this was pippetted on a slide and examined under a low power (x 40) of a compound microscope or high power (x 40) of a stereo microscope.

(3) Procedure (2) above was repeated two more times and on each occasion the sample was mixed thoroughly before pippetting 0.5ml.

(4) The food items were identified and counted. An average of the counts was taken in order to arrive at the mean estimated number.

(5) The mean estimated number was then multiplied by 10 to obtain the final number.

The total numbers of each food item was computed for each specimen for each month of study. The percentage contributed by each item was then calculated for any desired period. With this method the composition and relative importance of various items of the diets were assessed but it was very laborious and small organisms which occurred in large numbers in the stomach masked the importance of big organisms which occurred in small numbers. This problem could be eliminated if the weights or volume of the food organisms are determined but this was not undertaken because of the small size of the food organisms.

3. Diurnal feeding pattern.

Information on the diurnal feeding pattern was collected by sampling throughout 24 hours in the last days of November and December 1974. To obtain samples, small gill nets were set near the Shagunu Field Station at station J. All the fish caught by the gill nets were removed at three-hour intervals round the clock. The fish species were counted and the numbers recorded. Later, the schilbeids were removed and the rest of the non-schilbeid fish were discarded. The lengths, weights and gonad condition of the schilbeids were recorded and the stomachs removed and analysed as described above.

4. Feeding and Fat deposition

Fat deposition either in the tissue or the abdominal cavities is often linked with feeding success (Okedi, 1971). To see whether this holds for the schilbeids in Lake Kainji, fat deposition in the abdominal cavity was followed throughout the year. The abdominal fat bodies were removed from the fish and weighed.

5. Feeding Experiments.

Aquarium tank observations were made only on the feeding behaviour of E. niloticus, for other species did not survive in the tanks for more than 48 hours.

The two specimens used in the experiments were kept in aquarium glass tanks measuring 60 x 30 x 30cms at a water temperature of $22.5^{\circ} \pm 1^{\circ}C$. The fish were starved for 33 days and were then offered a variety of items in sequence as listed in the results (Table 4.4). The behaviour of the fish was also observed.

4.1.3. R E S U L T S

A. The composition of the stomach contents

The list below itemizes the categories into which food items were grouped and specifies the species or wider groups identified within the categories. Where necessary brief notes are added for clarification.

(a) ALGAE

Blue-green :- Anabaena sp., Nostoc sp.

Green :- Protococcus sp., Endorina sp., Volvox sp, Scenedesmus sp, and Pediastrum sp.

Diatoms :- Melosira sp. and Navicula sp.

Desmids :- Closterium sp.

Dinoflagellate :- Glenodinum sp.

Rotifers :- Keratella cochlearis and Trichocercia sp.

(b) PLANT REMAINS

These were made up of leaves, seeds and fragments of wood. There was no sign that they were bitten off from plants. They were probably scavenged from the areas near the shores or at the surface of the lake.

(c) CRUSTACEA

Planktonic forms :- Bosmina longirostris MULLER, Diaphanosoma excisum SARS and Mesocyclops sp.

Non-planktonic forms :- Usually found among the reeds at the littoral areas of the lake.

Cyclestheria hislopi BAIRD, Caridina sp.

Ostracods, no attempt was made to distinguish between creeping and free-swimming forms.

Macrobranchium sp.

(d) INSECTA

This included all the insects both terrestial and aquatic

either in adult or larval forms.

Insect remains :- these were mainly made up of various insect parts which were partially digested. These could not be identified further.

Orthoptera :- mainly terrestial adult grasshoppers but stick insects and praying mantids occurred occasionally in the stomachs.

Hymenoptera :- ants only, they were not common in the stomachs.

Trichoptera.

Coleoptera :- adult insects included terrestial and aquatic forms.

Diptera :- immature stages of Chironomids and Chaoborus sp.

Ephemeroptera :- mainly Povilla adusta NAVAS. Nymphs of this burrowing mayfly line their burrows with a silk-like substance. They remain in them by day but swim actively after dark. Mature nymphs both males and females emerged periodically around 7.00 and 8.00 p.m. (local time) and they were often attracted to light. The females were mostly gravid.

Hemiptera :- both terrestial and aquatic adult forms were found in the stomachs.

(e) MOLLUSCA

Empty gastropod shells were found in only two stomachs.

(f) FISH

Fish remains :- These were made up of recognizable fish parts, for example, skulls, vertebrae, spines, which were partially digested. Partially digested whole fish were also included here.

Whole fish :- These were still intact from head to tail and could still be classified into genera or species.

Fish eggs :- these belong to other fish.

Fish scales :- they were presumed to have been scavenged from dead fish at the bottom or surface of the lake.

(g) BIRD REMAINS

Included feathers and other parts of the body picked up from dead birds. Found in two stomachs.

(h) BOTTOM DEPOSITS

Inorganic :- Mud, fine sand and gravel of very small size which were probably picked up accidentally with the food.

Organic :- Detritus, includes fine materials usually of dead vegetable and animal origin, all finely mixed up. Probably scavenged from near the shore.

(i) OTHERS

All well digested un-identifiable food contents were grouped here.

B. THE FOOD AND FEEDING HABITS OF EUTROPIUS NILOTICUS

B.1. The food items selected

Table 4.2 lists the food items found in the stomachs of E. niloticus. The relative contributions of the food items are expressed as percentage occurrence and points. Insects formed the main food while fish were of secondary importance. The rest of the possible food items were of minor importance; e.g. the crustaceans, bottom deposits and plant remains. Closer examination of the individual food items shows that Povilla adusta nymphs and imagos and grasshoppers were the most important insects in the food. They occurred more regularly in the stomachs and constituted a fairly large proportion of the food taken. Coleoptera and Hemipterans can also be considered to be taken by a fair proportion of the fish although the volume contributed to the total

Table 4.2. Relative importance and Frequency of Occurrence of dietary items in the food of Eutropius niloticus.

No. of stomachs with food = 909
No. of stomachs without food = 508
Total numbers of stomachs examined = 1417

Dietary Items		% Frequency of Occurrence	% of Total points awarded
Insect remains		41.36	14.55
Adult Insects			
Coleptera		6.82	2.58
Hemiptera		3.52	2.17
Hymenoptera		0.88	0.08
Ephemeroptera		0.33	0.01
Trichoptera		0.11	0.01
Orthoptera (mainly grasshoppers)		10.89	11.39
Immature Insects			
Povilla adusta	Nymph & Imagos	54.14	31.37
Dragonfly	Nymph	1.65	0.92
Chironomid	Larvae	1.65	0.82
Chironomid	Pupae	1.76	0.33
Chaoborus sp.	Larvae	0.22	0.01
Trichoptera	Nymph	0.88	0.21
TOTAL INSECTA			64.45
Fish remains (including whole fish)		16.17	12.94
Fish scales		19.47	9.39
Fish eggs		0.77	0.53
TOTAL FISH			22.86

Table 4.2. (cont'd.)

Bosmina longirostris	0.33	0.15
Cyclestheria hislopi	0.99	0.81
Caridina sp.	0.66	0.13
Macrobranchium sp.	0.11	0.03
Ostracods	0.11	0.01
TOTAL CRUSTACEA		1.13
Detritus	4.95	3.20
Mud, sand, pebbles etc.	4.18	2.02
TOTAL BOTTOM DEPOSITS		5.22
Plant remains	7.48	3.69
Gastropods	0.22	0.02
Bird remains	0.22	0.32
Others	5.72	2.31
TOTAL (Plant remains, Gastropods etc.)		6.34

stomach contents was very low. The other insects on the table were not important in the diets.

Fish scales were often encountered in the stomachs. The frequency of occurrence and the volume show that fish scales were utilized with some regularity by E. niloticus. Sand and small pebbles which were found in the stomachs were not considered to be part of the food. They were probably sucked up accidentally while picking other food items from the lake bottom. This assumption was confirmed by the fact that sand or pebbles were not found alone in any stomach but were always in association with detritus materials. Some fish (e.g. Citharinus sp) are known to ingest sand particles because of the algae attached to them (Arawomo, 1976).

The food items suggest that E. niloticus is omnivorous although insects predominate in its diet than any other food items. Fish were of some importance and the prey-fish which were recognised from the stomach contents are listed in Table 4.3. The most important were the clupeids, and Chrysichthys auratus (Geoff.). They were found in about 77.8% and 19.5% of the stomachs which contained identifiable fish respectively. The clupeids formed about 96% of the fish prey organisms while C. auratus formed about 1.6%.

The prey-predator length relationship (Fig. 4.1) shows that when the predator measured up to 16.0cm the prey length never exceeded 4cm, with a mean length between 2 and 3cm. Above 16.0cm, the prey length was between 38 - 40% of the predators' length. This relationship reflects clearly the type of fish prey selected by the predator at different length groups. The clupeids are the only fish sufficiently small to be taken by the smaller E. niloticus (S.L<16.0cm), while the bigger Eutropius have a wider variety of fish upon which they can prey, e.g. Alestes sp. and Chrysichthys

Table 4.3. Occurrence of fish prey in the stomachs of Eutropius niloticus.

Prey species	No. of stomachs in which prey were found	No of prey in the stomachs examined	Max no of prey per stomach	Min no of prey per stomach	Mean no per stomach
Clupeids	24	368	23	1	15
Alestes leusciscus	2	2	1	1	1
Physailia pellucida	2	2	1	1	1
Schilbe mystus	2	2	1	1	1
Chrysichthys auratus	6	6	1	1	1

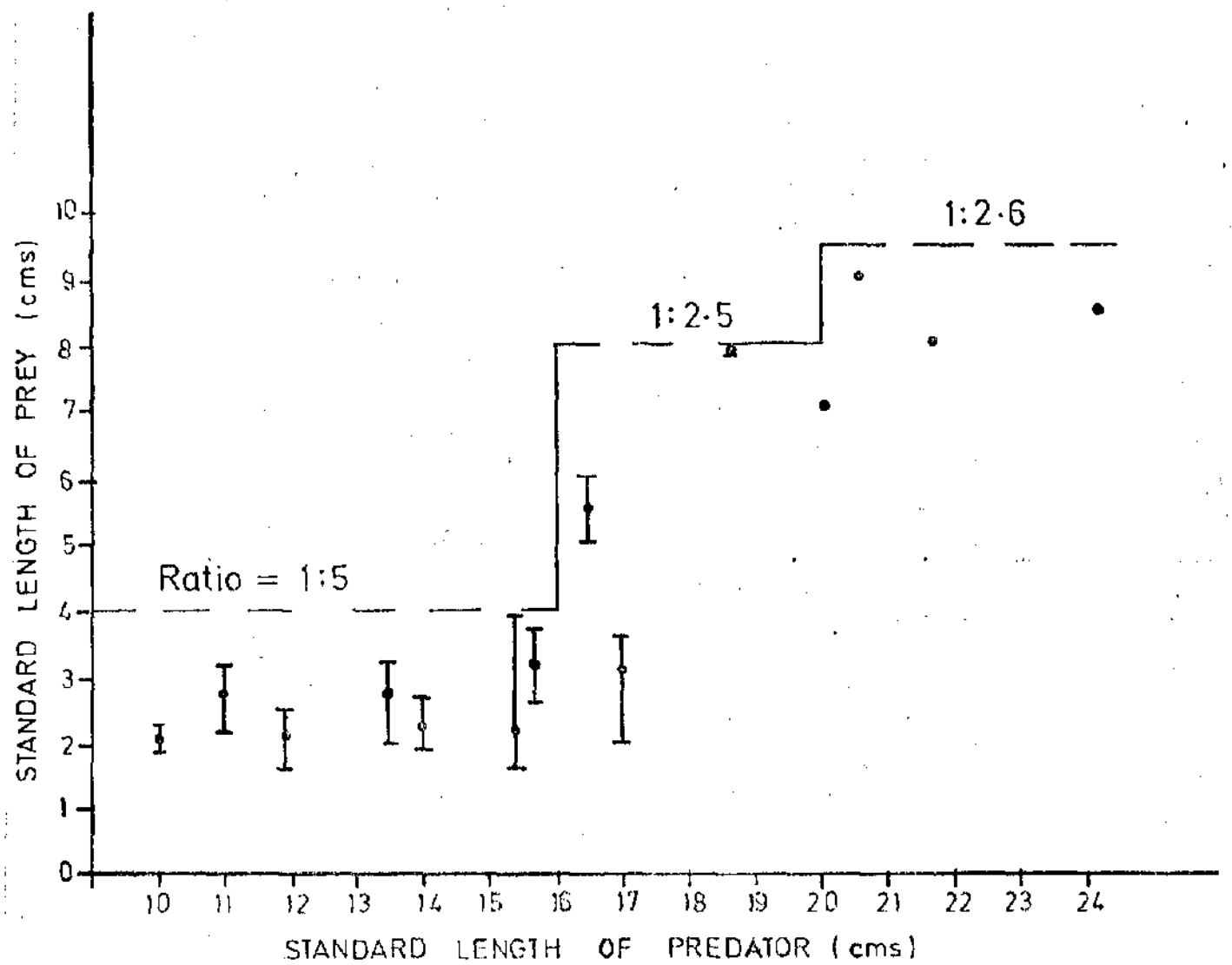


Fig. 4.1. (Eutropius niloticus.) Prey-predator length relationship.

and the size selected is a function of the size of the predator.

B.2. Seasonal feeding Intensity

The number of fish with food and those with empty stomachs were recorded for each month throughout the period of investigation. The mean monthly volume of food as estimated by the points method was also calculated for the feeding fish and the total fish examined. The two methods were used to indicate the feeding intensity of E. niloticus during the period of study. Fig. 4.2 suggests a constantly high rate of feeding activity (>55%) throughout the year. If the intensity of feeding is assessed from the bulk of food within the stomach there is a seasonal trend, with the highest intensity in November and December and again in May.

B.3. Seasonal variations in the food items selected.

The food items selected were found to vary seasonally. Figure 4.3 depicts the trend throughout the year. The food items selected at any time of the year seems to depend on their abundance and availability to the predators. Povilla adusta nymphs, although occuring in the stomachs regularly, were found to be utilized by about 55% of the fish and constituted about 50% of the stomach contents during the draw-down period (April to August). This finding confirms Bidwell (1976) who found that P. adusta were very abundant during the draw-down period. Grasshoppers were very important in the months, October to February. This period coincided with the period when P. adusta were less abundant in the lake and when the water level was rising and inundating terrestial habitats. Thus the major gap left by P. adusta was filled by the grasshoppers, hemipterans and the coleopterans. This appeared to

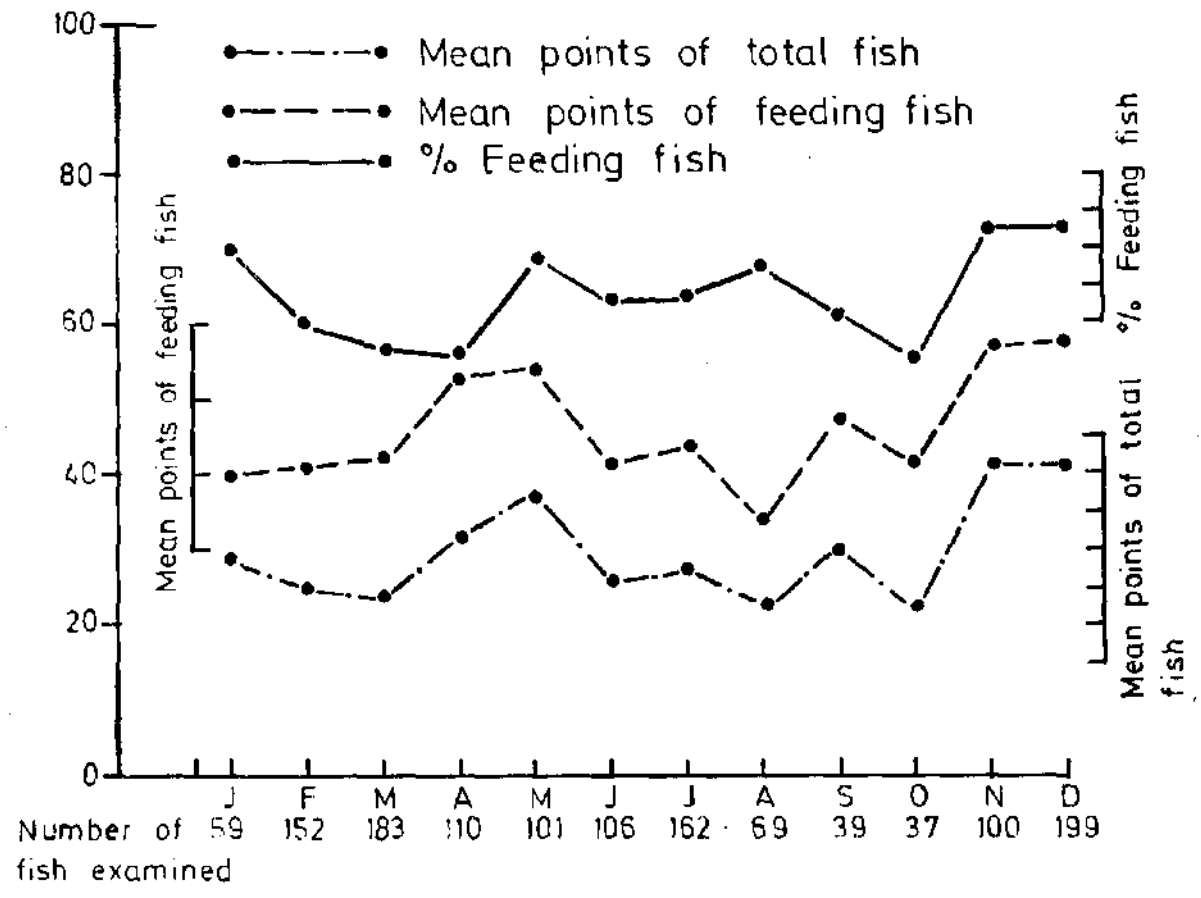


Fig. 4.2. (*Eutropius niloticus*.) Seasonal feeding intensity pattern.

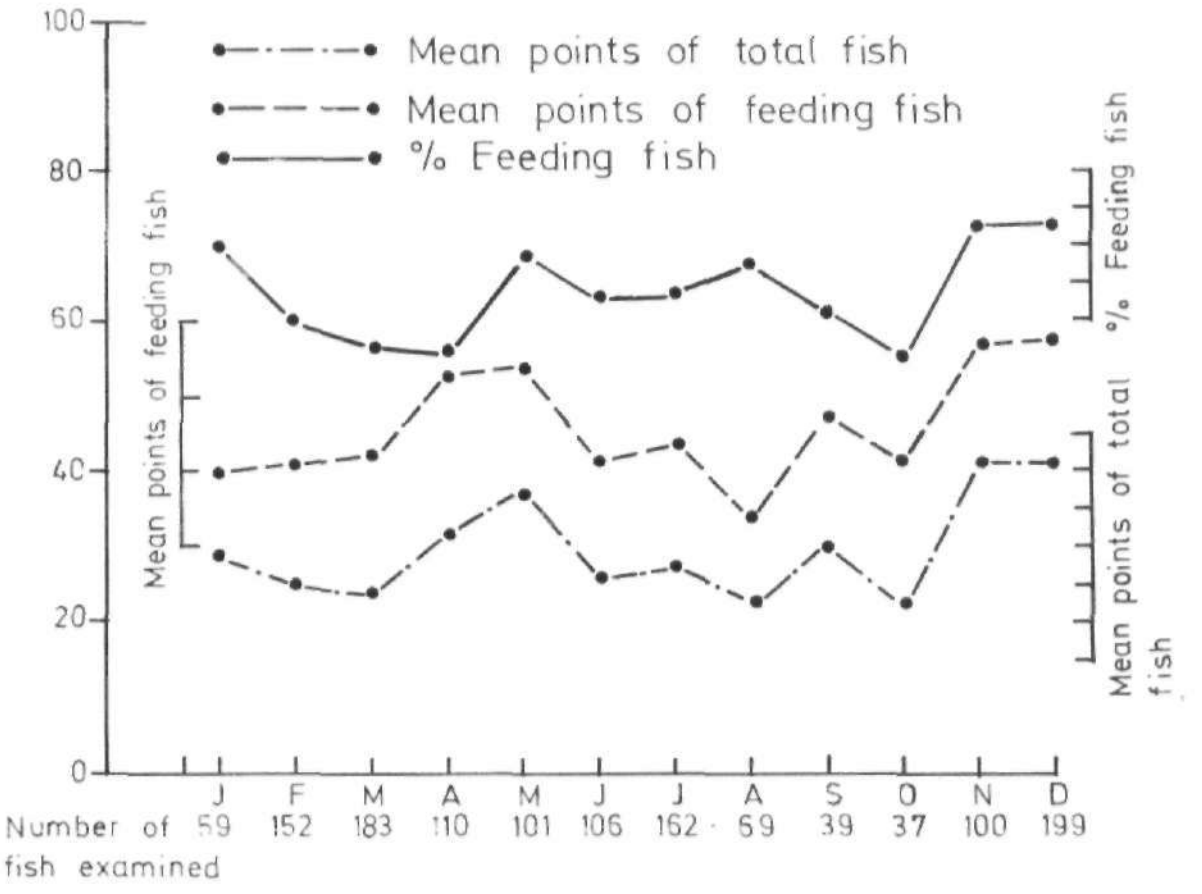


Fig. 4.2. (Eutropius niloticus.) Seasonal feeding intensity pattern.

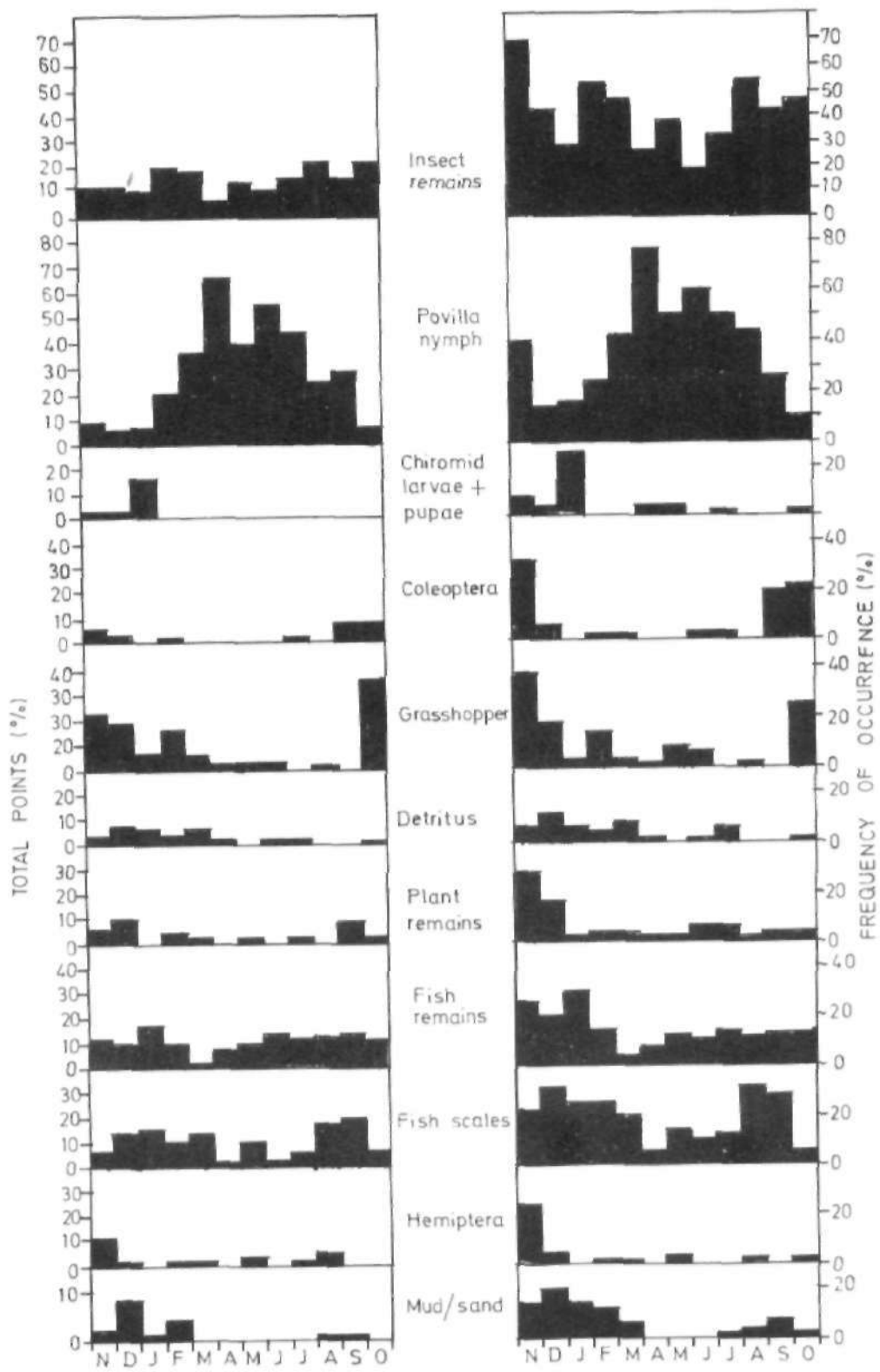


Fig. 4.3. (Eutropius niloticus.) Seasonal variation in composition of diet.

be advantageous to E. niloticus because of the continuity of insect supply throughout the year. Grasshoppers were very common around the Field Stations in the above mentioned months. Those found in the stomachs of E. niloticus were likely to be those which were drowned in the lake. The stomachs of the fish were often distended with grasshopper meals and because of their large size only one grasshopper was found per stomach in most cases. This would reduce the time spent for foraging, possibly advantageous to the fish. Unidentified insect remains formed over 10% but not above 20% of food contents found in the stomachs in most of the months. Food items from fish sources (excluding fish scales) were consumed with fairly equal degree of intensity throughout the year except for the months of November to January. Fish scales were also consumed in most of the months except in April to July during the draw-down when P. adusta was available in large quantity. Feeding on bottom food was reduced from April to October. The other food items did not show any marked seasonal variations in their occurrence in the stomachs.

B.4. Variations in the food items selected by different age groups.

E. niloticus was grouped for analysis into age groups as observed from the pectoral fin sections (see Chapter Three).

Not all the food items listed in Table 4.2 were found to be important to the different age groups of E. niloticus. Different age groups consumed more of one food item than the others. Figure 4.4 depicts the range of principal food items selected and the frequency of selection by the different age groups. There was an overall correlation between increasing amounts of larger food items and increasing age and size of the fish (see also Fig. 4.1).

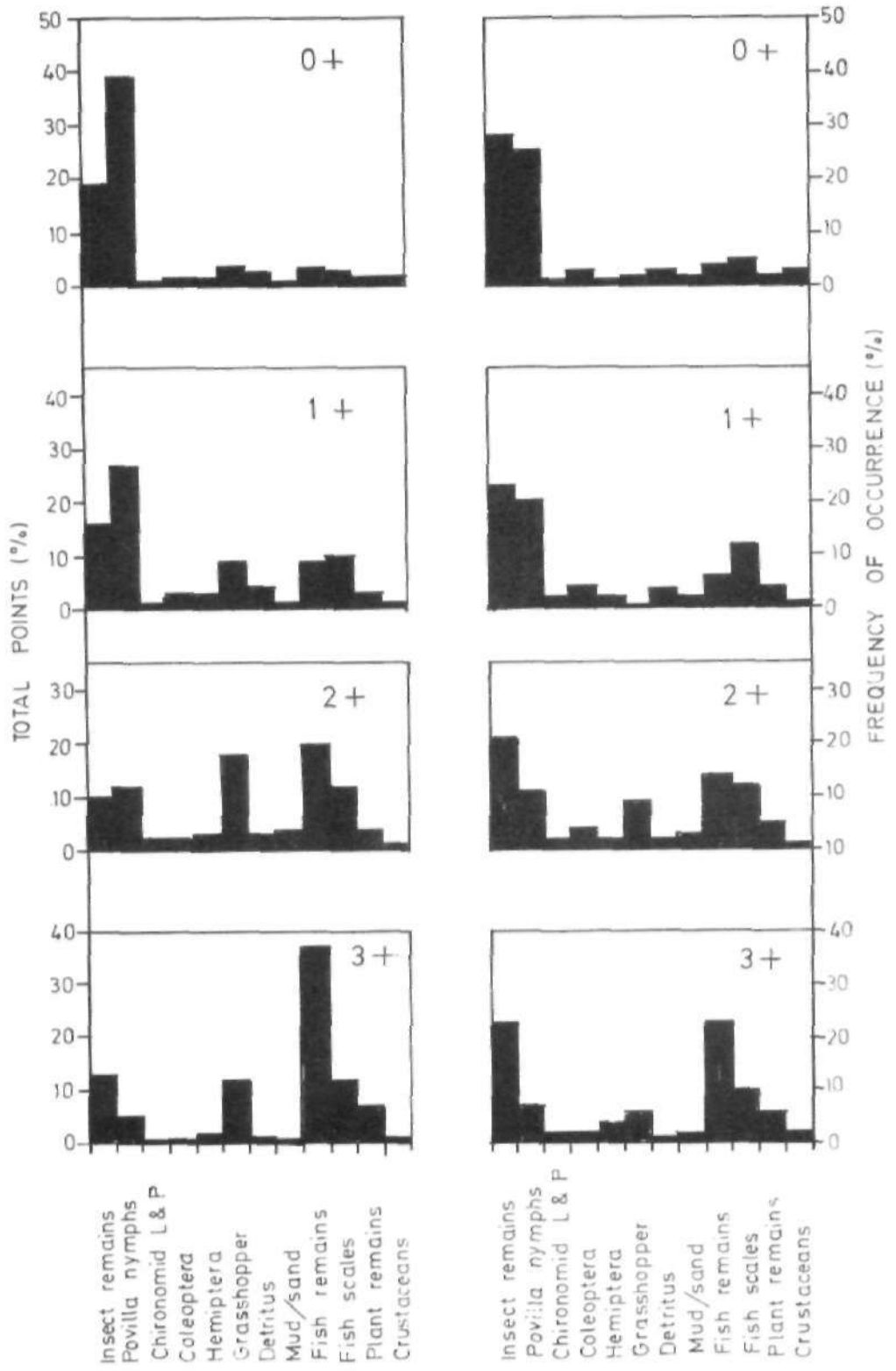


Fig. 4.4. (Eutropius niloticus.) Variation in the dietary items selected by different age groups.

In the first year of life (0+), Povilla adusta formed about 40% of the food taken while insect remains formed about 20%. No other single food items formed up to 5% of the total food consumed. Although P. adusta was still selected by the majority of the population other food items were also becoming important in the second year of life (1+). Grasshoppers, fish remains and fish scales were also important in the second year. In the third year grasshoppers, fish remains and fish scales were the dominant food items. Grasshoppers formed about 18% by points and 10% by frequency of occurrence whereas fish remains and fish scales formed about 20% and 12% by points respectively and 14% and 12% by frequency of occurrence respectively. Although Povilla adusta was still consumed by the fish, it was not an important part of the diet. Fish remains predominate in the diets during the fourth year of life. They were found in the stomach of about 25% of the fish and formed about 37% of the total food consumed. Insect remains, grasshoppers, fish scales and plant remains also constituted a significant portion of the food in the fourth year of life.

It can then be summarized that, unidentified insect remains and Povilla adusta decreased in the diets with increase in fish length while grasshoppers, fish remains, fish scales and plant remains occurred more often in the stomachs as length increased. Other food items seemed not to show any significant changes in relation to length of E. niloticus.

B.5. Feeding experiments

The feeding experiments which were conducted with fish of Standard Length 20.5cm and 18.3cm show that E. niloticus was very discriminatory in food selection. The results (Table 4.4) also indicated that complete digestion or emptying of the stomach often took place on average once every 48 hours, although this probably

Table 4.4. Feeding pattern of Eutropius niloticus.

Date	Items offered	Results		Time when fed	
		Fish I	Fish II	Fish I	Fish II
2.5.76	Dried Povilla imago (given after starving for 33 days)	-	-	11a.m.	10p.m.
3.5.76	Cotton wool	-	-	11a.m.	10p.m.
3.5.76	Fresh leaves of Parkia sp	-	-	11a.m.	10p.m.
4.5.76	Live coleoptera	+	+	11a.m.	10p.m.
5.5.76	Live grasshopper	-	-	11a.m.	10p.m.
6.5.76	Live stick insect	+	+	11a.m.	10p.m.
7.5.76	Live grasshopper	-	-	11a.m.	10p.m.
8.5.76	Live grasshopper	+	+	11a.m.	10p.m.
9.5.76	Dead (but fresh)fish	-	-	11a.m.	10p.m.
10.5.76	Dead (but fresh) fish	+	+	11a.m.	10p.m.

\- Item was rejected

\+ Item was consumed

depended on the rate of digestion of the various food items consumed. It is presumed that feeding did not take place until the previous food taken had been emptied from the stomach. This observation was also confirmed from the examination of the stomach contents of the fish captured by the gill nets. The contents in the stomach were often found in a similar state of digestion. This means that there is a regular diet pattern in feeding.

Hungry fish were always very restless and darted here and there picking up any materials floating on the surface of the water. Some of the materials picked up were immediately rejected while the favoured ones were consumed (see Table 4.4). A well-fed fish swam gently, ignoring all the food materials in or on the water. Feeding took place in the tank at any time of the day, which confirmed the field observations made during the 24 hours sampling programme. In the field the peak period of foraging however, was found to be between 18.00 and 23.00 hours (see section G of this chapter).

The methods by which E. niloticus locates its prey organism are not studied. However, Tafeda (1961) noted that the catfish, Ameiurus melas uses the barbels in locating its food materials.

C. THE FOOD AND FEEDING HABITS OF SCHILBE MYSTUS.

C.1. The food items selected.

Insects and fish were two major groups in the diet of Schilbe mystus (Table 4.5). Fish materials were the most important food item for they formed 63% by points of the total stomach content. The prey fish selected by the predator were small and although a wide variety of fish prey was found in the stomachs, the clupeids were consumed more than others. Others included Alestes leusciscus, Chrysichthys auratus, Eutropius

Table 4.5. Composition, Relative importance and Selection of dietary items by Schilbe mystus in Lake Kainji.

No. of stomachs with food = 91
No. of stomachs without food = 85
Total number of stomachs examined = 176

Dietary Items	% Frequency of Occurrence	% of Total Points awarded
Insect remains	23.08	11.58
Adult Insects		
Coleoptera	2.20	2.83
Hemiptera	3.30	0.81
Orthoptera (mainly Grasshoppers)	5.49	5.30
Immature Insects		
Povilla adusta Nymphs	18.68	11.98
Dragonfly Nymphs	3.30	2.81
Chironomid Larvae	5.49	0.37
Chironomid Pupae	3.30	0.27
TOTAL INSECTA		35.95
Fish remains	49.45	45.98
" scales	2.20	0.82
" whole	9.89	16.24
TOTAL FISH		63.04
Caridina sp	2.20	0.27
Others	3.30	0.74
TOTAL OTHERS		1.01

niloticus and the young of Tilapia sp. Insufficient stomachs were found with whole fish in them for measurement to determine predator / prey length relationships but evidence from the few stomachs with whole prey suggested that the size of the prey selected was greatly influenced by the size of the prey and the mouth gape of the predator. Insects formed about 36% of the total food and unidentified remains formed the major bulk. However, adult Coleoptera and grasshoppers, Povilla adusta and dragonfly nymphs were the important insects found in the stomachs. The only crustacean, Caridina sp. in the diet was an unimportant component of the food.

C.2. Seasonal variation in the food items selected.

Fish materials occurred in the stomachs regularly for most of the months during the year except in December, March and June. Povilla adusta nymphs were important in the diets during the draw-down period and at the begining of the "white flood" from March to August. Grasshoppers were only taken in those months when P. adusta were not available, thus the months of October to December and May were the most important months for grasshoppers. Insect remains occurred regularly in stomachs except in the months of May to September which were dominated by fish materials and P. adusta (Figure 4.5).

C.3. Variation of food with fish sizes.

Figure 4.6 shows the variations in the food items selected by the different age groups. In the first year of life (0+) the fish were found to feed on the full range of food items but with the insects as the main diet. Older fish (1+ and 2+) seemed to feed almost exclusively on fish. Larger insects like grasshoppers and Povilla adusta nymphs played a minor role in the diet.

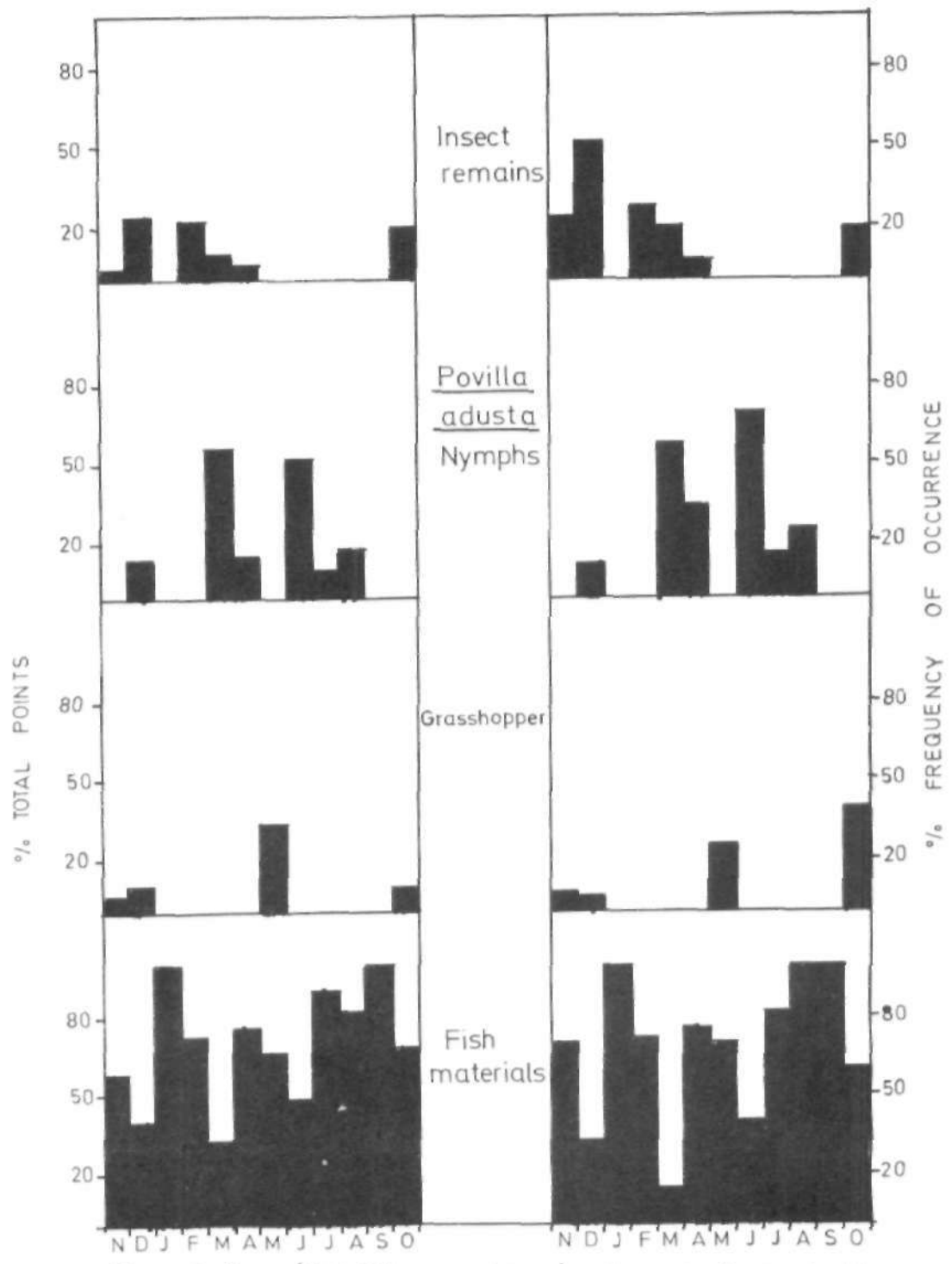


Fig. 4.5. (Schilbe mystus.) Seasonal variation in composition of diet.

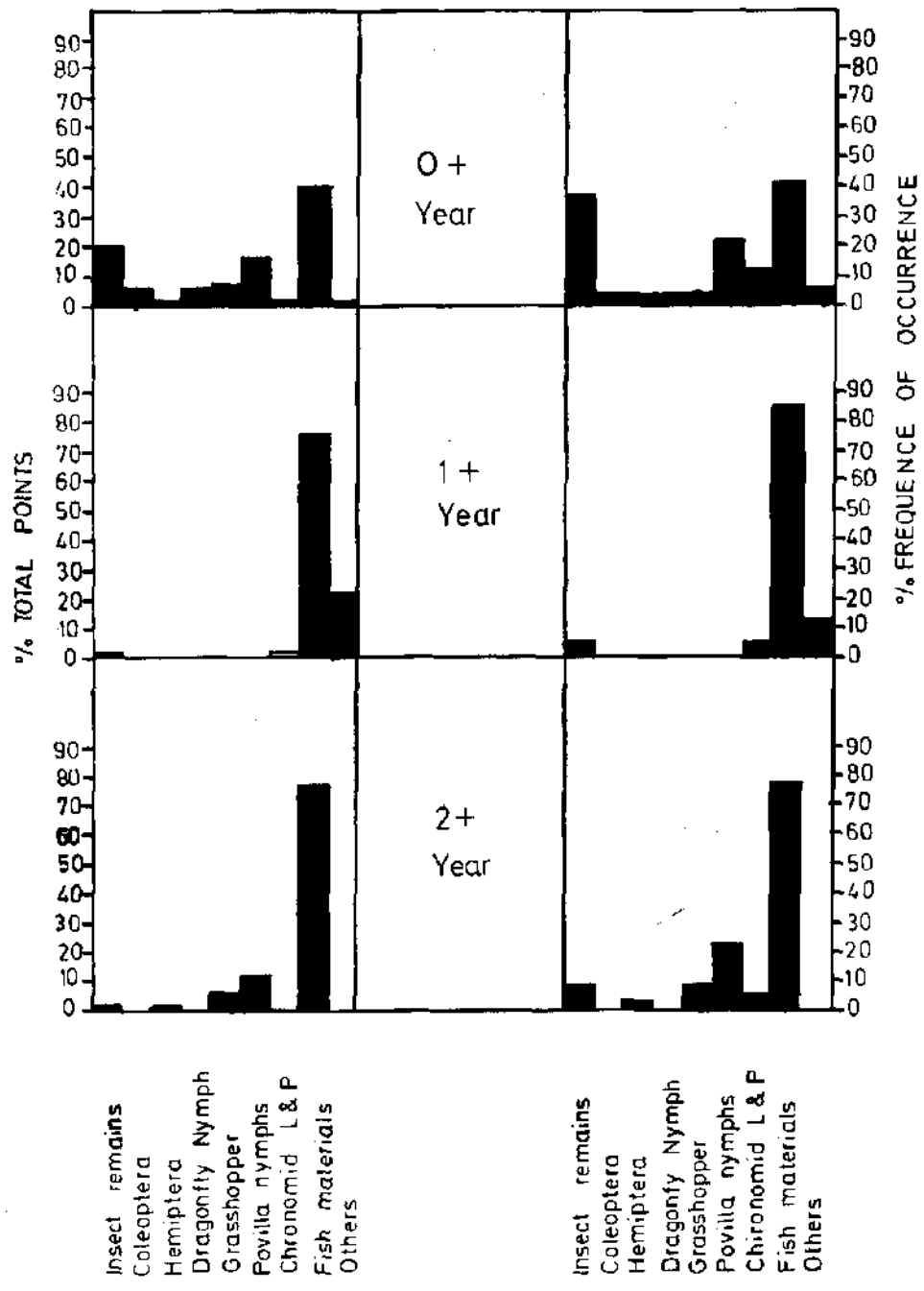


Fig. 4.6. (Schilbe mystus.) Variation in the dietary items selected by different age groups.

C.4. Seasonal Feeding intensity.

The seasonal feeding intensity pattern (Figure 4.7) shows that feeding was generally low during February to May but from July feeding gradually rose to a peak in November. The low feeding intensity in February to May is rather surprising in view of the fact that no shortage of food supply was found to occur at those months. The clupeids which formed their main diets are abundant throughout the year (Otobo, 1974), similarly Povilla adusta nymphs which constitute an important part of the diet are abundant at that period (Bidwell, 1976).

D. THE FOOD AND FEEDING HABITS OF PHYSAILIA PELLUCIDA.

D.1. The food items selected.

The composition and relative importance of the dietary items found in the stomachs of Physailia pellucida are as seen in Table 4.6 which shows that P. pellucida fed almost exclusively on small crustaceans and immature insects. The small crustaceans formed about 86.9% of the food while the insects, formed 13.1%. The most important crustacean was Bosmina longirostris. Other crustaceans of less importance are as seen in the table. The insects were mainly the immature stages of dipterans and Povilla adusta. Povilla adusta nymphs, chironomid larvae & pupae and Chaoborus sp. larvae occurred frequently in stomachs. The importance of Bosmina longirostris and Chaoborus sp. seem to be over-emphasized if the total numbers of organisms is considered alone. These two organisms are small and many would be needed to fill a stomach; whereas one Povilla larva or pupa would do so. Although the contribution of Povilla nymphs and Chironomid larvae and pupae seemed to be low when numbers alone were considered, it is worth emphasizing that they were equally as important as Bosmina or

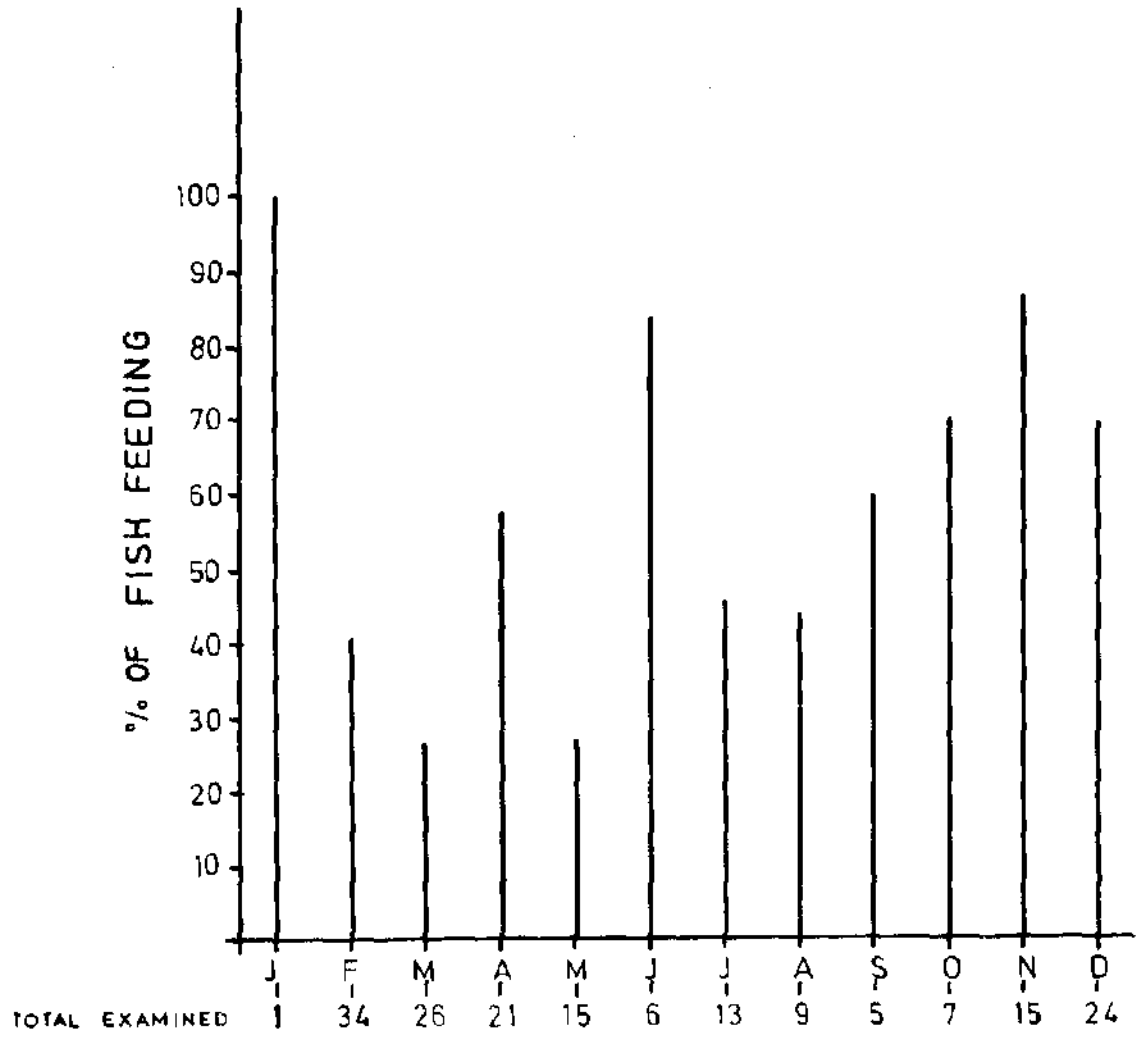


Fig. 4.7. (Schilbe mystus.) Seasonal feeding intensity pattern.

Chaoborus if the total volume or weight contributed by each dietary item was taken into consideration.

D. 2. Seasonal variation in the food items selected.

Figure 4.8 shows the seasonal variation in occurrence of food organisms in the stomachs of P. pellucida. No stomach was examined in the months of January and November. Povilla adusta nymphs were utilized by over 40% of the population throughout the year although they did not constitute as much as 5% of the total number of organisms found in the stomachs in any month. Chaoborus sp. larvae formed over 60% of the stomach contents in the months of May to July, the draw-down period. In those months when feeding on Chaoborus sp. larvae were reduced, Bosmina longirostris seemed to become important. B. longirostris formed the main stomach contents from December to April and from August to October. The seasonal fluctuations in consumption of Bosmina longirostris corresponds to the variation in abundance of the organisms in the lake (Clarke, per. comm.). Chironomid larvae and pupae were found in about 30% of the stomachs examined from July to December.

D.3. Seasonal feeding intensity.

The seasonal feeding intensity pattern was observed by noting the percentage of feeding fish in all months as shown in Fig. 4.9. That about over 45% of the fish were feeding at anytime of the year suggests that the fish fed well throughout. In the months of May to August however, the number of fish examined was low and the figure obtained were not therefore, likely to depict true trends. The period May to August falls within the draw-down regime when the numbers of P. pellucida in small nets were very low.

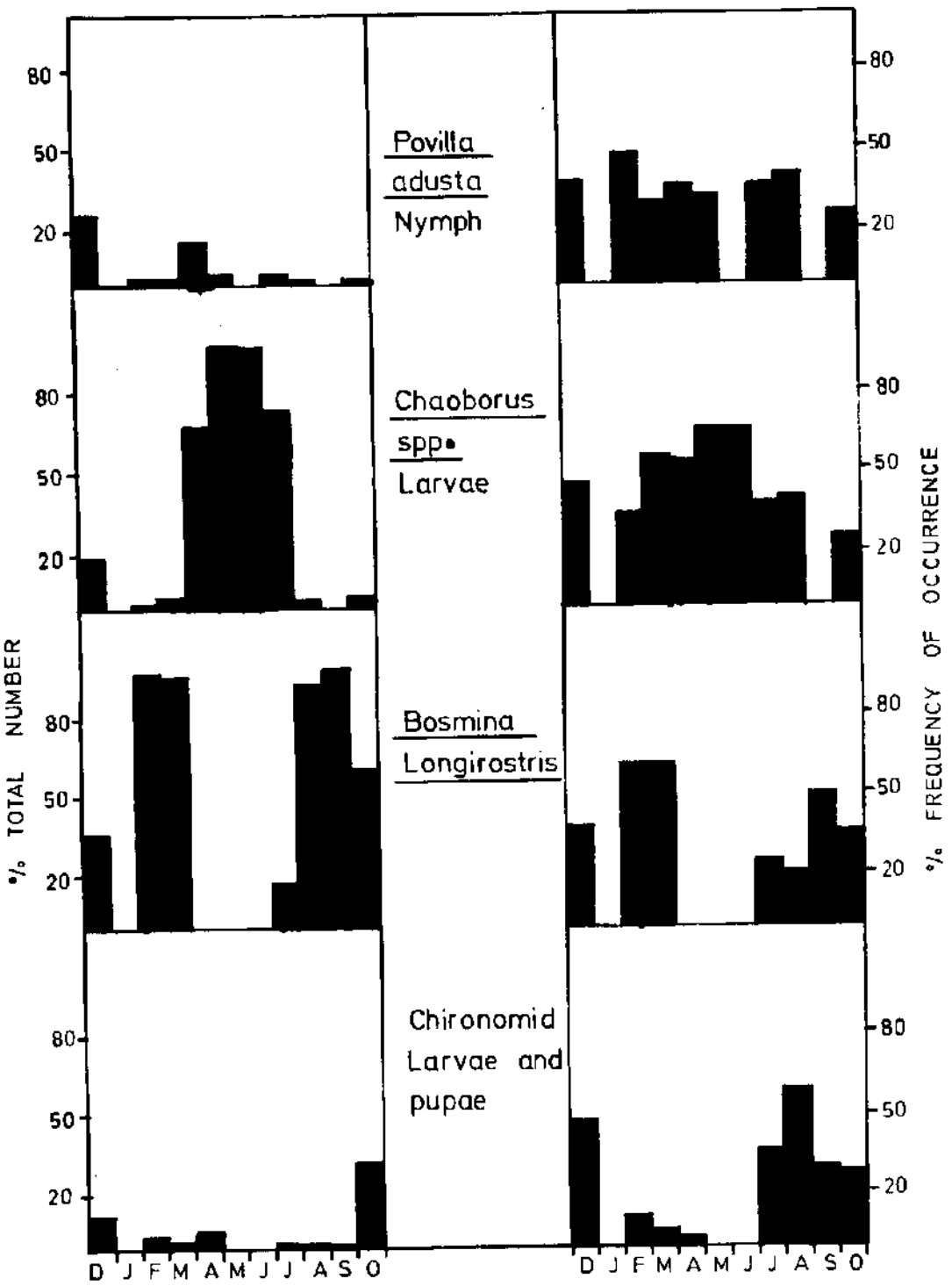


Fig. 4.8. (*Physailia pellucida*.) Seasonal variation in composition of diet.

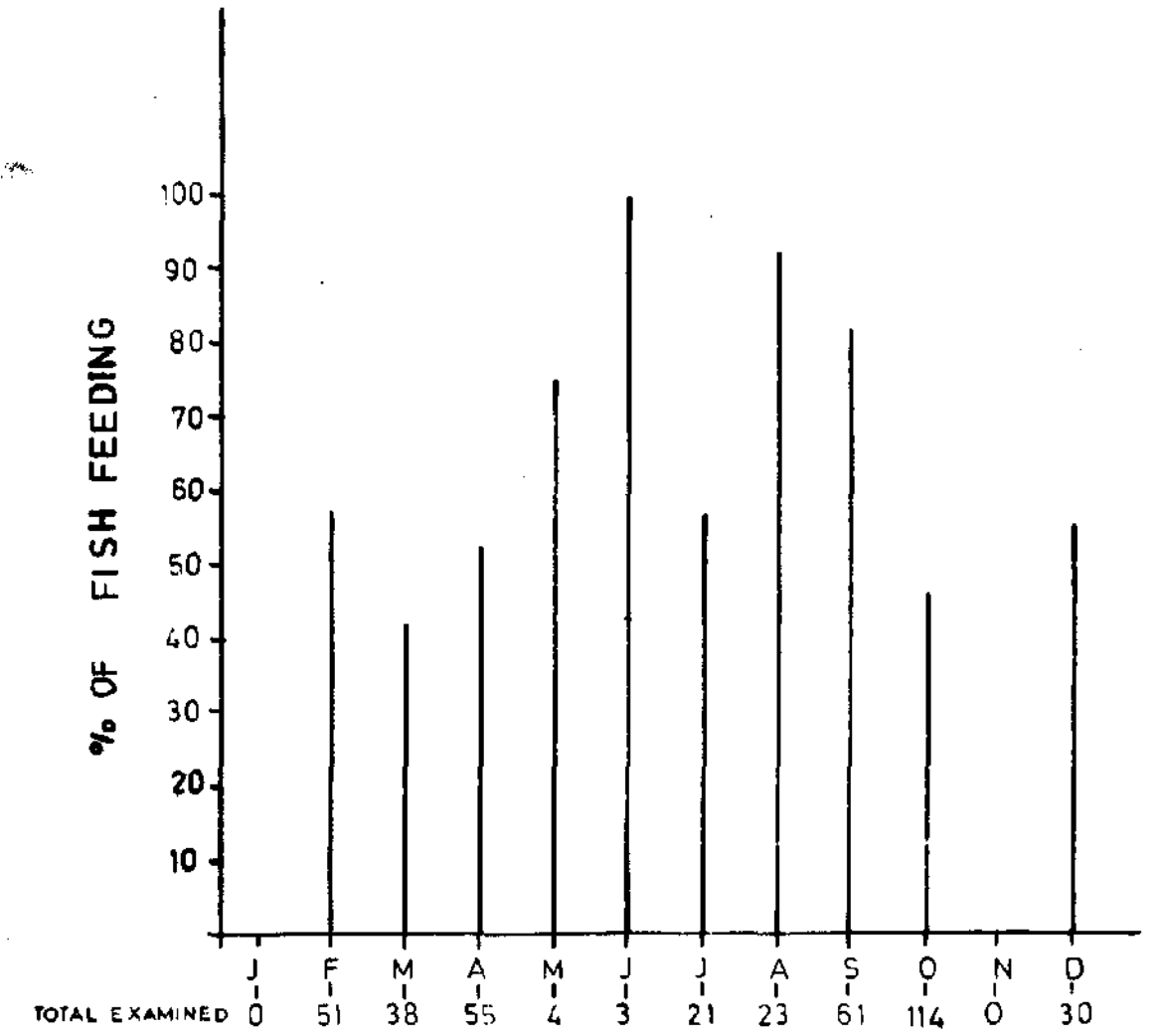


Fig. 4.9. (Physailia pellucida.) Seasonal feeding intensity pattern.

D.4. Variations in the food items selected by different length groups.

The percentage frequency of occurrence of the food items in the stomachs of the two length groups of P. pellucida are shown in Table 4.7. The table shows that in the larger group, the fish species could feed on all the items listed in the table, whereas in the first group feeding was restricted to a few items. Povilla adusta was utilized more by the second group than the first group. Chironomid larvae were important to the first group whereas the pupae were consumed more by the second group. Chaoborus larvae, Diaphanosoma sp., Caridina sp. and Conchostraca were also important to the second group while Mesocyclops sp. were consumed more by those of the first group.

E. The food of Schilbe uranoscopus.

It was reported earlier that S. uranoscopus is very rare in Lake Kainji. Only seven specimens were found in samples throughout the twenty-four months of sampling. Their stomachs were examined and it was found that they fed almost exclusively on fish, identifiable as clupeids. Other food items might be found in their stomachs if larger numbers of S. uranoscopus had been available for study.

F. The food of Siluranodon auritus.

Siluranodon auritus was not found regularly in samples and the few specimens examined (46) were mainly females collected in the creek area close to the Field Station from July to October 1975. Detailed analysis of feeding trends was not possible. Some general but tentative conclusions can be drawn from the few

Table 4.7. Variation of food items with age of *P. pellucida*.

Length ranges (cm)	5 - 7.9	8 - 12.9
	1st group	2nd group
	% Frequency of Occurrence	
Insect remains	17.14	7.14
Coleoptera	-	0.89
Povilla adusta Nymphs	28.57	45.53
Chironomid Larvae	42.86	10.71
Chironomid Pupae	5.71	8.04
Dragonfly Nymphs	-	0.89
Chaoborus sp. Larvae	20.00	47.32
Bosmina longirostris	37.14	35.71
Diaphanosoma excisum	-	5.36
Caridina sp.	-	14.29
Mesocyclops sp.	14.29	2.68
Ostracoda	2.86	0.89
Conchostraca	-	8.93
Fish remains	-	0.89
Pebbles	-	0.89
Others	-	2.67
No. with recognizable food contents	35	112
No. with fully digested food contents	46	55
No. with empty stomachs	63	77
Total number examined	144	244

stomachs examined. The stomach contents suggest that they eat phytoplankton although a few immature insects and crustacea were occasionally found in their stomachs. Table 4.8 shows the composition of the diets and the relative importance of various food items. The most important algae frequently selected by the fish were Volvox sp. and Melosira sp. Nostoc sp., Protococcus sp. and Eudorina sp. were also of minor importance in the diets. The only important source of animal protein in the food was Bosmina longirostris, the zooplankter which also formed a significant portion of the food of Physailia pellucida.

G. DIURNAL FEEDING PATTERN.

Observations on the diurnal feeding pattern of the three main species shows that feeding takes place at anytime of the day, but with peak feeding periods between 18.00 and 23.00 hours (7.00 - 12.00 mid-night local time), (Tables 4.9 and 4.10). This was found to coincide with the period when the main prey organisms were also very active. The following prey organisms formed a large proportion of the main diets of the three schilbeids; the clupeids, grasshoppers, Povilla adusta, Chaoborus sp. larvae, Bosmina longirostris, Chironomid larvae and pupae (Table 4.10). That these prey organisms were very active around the stated hours was confirmed from reports of other workers. Petr (1970) reported that the emergence of imagos of P. adusta occurred between 18.30 - 19.00 hours. Reynolds (1971a) observed that the clupeids migrate vertically to the surface between 17.40 - 18.45 hours in Lake Volta. Similar vertical migration was observed in Lake Kainji (Otobo, per. comm.). McGowan (1974) noted that Chaoborus sp. larvae were active at night. Personal observations of the grasshoppers showed that they were nocturnal with peak activity period between 18.00 - 22.00 hours. The synchronization of the feeding

Table 4.8. Composition, Relative importance and Selection of dietary items by Siluranodon auritus in Lake Kainji.

No. of stomachs with food = 34
No. of stomachs without food = 12
No. of stomachs examined = 46

Dietary Items	% Frequency of Occurrence	% of Total number counted
ALGAE		
Blue-green Algae		
Anabaena sp.	22.20	2.40
Nostoc sp.	22.20	13.00
Green Algae		
Protococcus sp.	33.33	5.24
Eudorina sp.	44.44	7.00
Volvox sp.	88.88	14.85
Scenedesmus sp.	11.11	0.20
Pediastrum sp.	11.11	0.20
Diatoms		
Melosira sp.	66.66	42.18
Navicula sp.	11.11	0.60
Desmids		
Closterium sp.	33.33	1.04
Dinoflagellate		
Glenodinum sp.	11.11	0.20
Rotifer		
Keratella cochlearis	55.55	3.09
Trichocercia sp.	11.11	0.40
TOTAL ALGAE & ROTIFER		90.40

Table 4.8 (cont'd)

INSECTA		
Povilla adusta nymphs	22.22	0.36
Chironomid larvae	11.11	0.04
Chaoborus sp. larvae	22.22	1.64
TOTAL INSECTA		2.04
CRUSTACEA		
Bosmina longirostris	55.55	4.96
Mesocyclops leuckarti	11.11	0.08
Ostracods	22.22	0.12
TOTAL CRUSTACEA		5.16
Unidentified Eggs	22.22	0.40
Others	22.22	2.00

Table 4.9. Diurnal activity pattern of the Schilbeids in Lake Kainji. (Numbers + of schilbeid caught at 3hrs intervals with gill nets. Mesh sizes 1.3cm - 10.2cm).

	1 noon	3 p.m.	6 p.m.	9 p.m.	12 midnight	3 a.m.	6 a.m.	9 a.m.
P. pellucida	0	1	2	177	198	159	117	4
E. niloticus	2	1	12	8	0	2	3	0
S. mystus	0	0	0	8	0	0	2	0

+ Combined numbers for November and December 1974.

Table 4.10. Diurnal feeding activity pattern of the schilbeids in Lake Kainji.

	12noon	3p.m.	6p.m.	9p.m.	12midnight	3a.m.	6a.m.	9a.m.
Physailia pellucida								
% Feeding fish ++	-	100	100	100	100	75	30	25
Food items	-	1	1	1,2,3,9+	2,3,4,9+, 10,11	2,3,6,9+, 10, 11	2+,6,10	9
Eutropius niloticus								
% Feeding fish ++	50	-	100	75	-	100	100	-
Food items	1+,4,6,11	-	1,12+,13, 14,15	1,2,4+,5, 6,7,13	-	1,4+	1,8+,13	-
Schilbe mystus								
% Feeding fish ++	-	-	-	70.5	-	-	100	-
Food items	-	-	-	1,2,4,12+	-	-	1,12+	-

\+ dominant food items.

++ for number of stomachs examined see Table 3.9.

Key to food items

1. Insect remains
2. Chironomid pupae
3. Chironomid larvae
4. *Povilla adusta* nymphs
5. Grasshoppers
6. Coleoptera
7. Dragonfly nymphs
8. Hemiptera
9. *Chaoborus* larvae
10. *Bosmina longirostris*
11. *Diaphanosoma excisum*
12. Fish remains
13. Fish scales
14. Detritus

hours of the three species with the peak period of activity of the prey organisms is an obvious advantage to the predators.

H. TROPHIC RELATIONSHIP WITH OTHER FISH.

Since it was noted that some of the Schilbeids preyed on other fish in the lake an attempt was made to investigate and determine which fish preyed on the schilbeids in Lake Kainji. It was obvious that other fish preyed on the schilbeids from the half bodies and heads of schilbeids which were often found in the gill nets. This observation suggested that the remaining portions were chopped off by the predators while the prey was being held by the nets.

The stomachs of the known predatory fish were opened and the contents were washed into a watch glass or white enamel basin depending on the size of the contents. The stomach contents were later sorted and only the fish contents were given further attention. In most cases the fish were identified to generic level. Fully or partially digested fish which could not be identified or grouped into any genus or species were treated as fish remains (see Table 4.11). About 440 stomachs were examined.

The results (Table 4.11) revealed that only H. forskali preyed on the schilbeids. The other common prey fish found in the stomachs of the predators examined were the clupeids, Alestes sp, Chrysichthys sp, Bagrus sp, and Citharinus sp. Most of the predators (77.5%) had empty stomachs which may have been due to the fact that carnivorous fish digest their food faster than the herbivores.

The number of partially consumed bodies and heads in the gill nets was analysed to see whether this sort of predation has any seasonal pattern. It was found (Table 4.12) that the draw-down

Table 4.11. Stomach contents of the main predatory fish in Lake Kainji.

Number of predators examined = 440
Number with food = 99
Number with empty stomachs = 341

	Predators					
	Hydrocynus forskali	H. brevis	Bagrus bayad	Bagrus docmac	Clarotes laticeps	Lates niloticus
Prey items	(% Frequency of occurrence)					
Eutropius niloticus	7.3	-	-	-	-	-
Other schilbeids	-	-	-	-	-	-
Clupeidae (Sierrathrissa leonensis and Pellonula afzeliusi)	58.2	-	-	-	-	50.0
Alestes sp.	9.1	-	-	-	-	-
Chrysichthys auratus	5.5	-	62.5	-	-	-
Bagrus sp.	-	-	-	-	-	10.0
Citharinus sp.	-	-	-	-	-	10.0
Fish remains	1.3	-	12.5	33.3	-	30.0
Other food items	18.6	-	25.0	66.7	-	-
Number of stomachs examined	324	13	26	6	3	68
Number with food	78	-	8	3	-	10
Number with empty stomachs	246	13	18	3	3	58

period April to August was the main season for this type of predation. An examination of the general catch data also revealed that this was the period when the predators e.g. Characidae, increased in number in the gill net catches. Thus a correlation can be seen between the number of part-eaten bodies and heads in the gill nets and the increase in the number of predators. In Lake Kainji most of the predators are known to swallow their prey whole, while a few cut off portions from their prey. Hydrocynus brevis is among those reputed to cut off portions from its prey (Lewis, 1974a). The bits of bodies and heads of the schilbeids can possibly be attributed to the feeding of Hydrocynus brevis, though this does not mean that it was the only predator of the schilbeids. Studies conducted by Lewis (1974a) on the food of Hydrocynus species in Lake Kainji revealed that the schilbeids formed an essential part of the diets of H. brevis, H. forskali and H. vittatus. Fagade & Olaniyan (1973) in their study of the food of the fishes in the Lagos Lagoon found that the juvenile schilbeids formed about 16% of the food of Caranx hippos (Linne), one of the important piscivores in the lagoon. In Lake Chad, Torbor (1972a, b) found that Lates niloticus, Bagrus bayad and Hydrocynus forskali preyed on the schilbeids.

I. Seasonal variations in feeding intensity and accumulation of abdominal fat.

Accumulation of abdominal fat has been shown to be related to feeding intensity in certain species of fish e.g. the East African Mormyrid (Okedi, 1971). The theory is that during a period of high feeding activity, more food is consumed than required for the usual metabolic functions of the body. The excess food taken by the fish is converted into fat and stored either in the body tissues or abdominal cavities.

Table 4.12. The % composition of multilated bodies in the catch (Schilbeids only).

		Total schilb-eids examined	No of Multi-lated bodies	% Multi-lated bo-dies	Main Predatory months
1974	October	198	4	2.0	
	November	250	2	0.8	
	December	199	-	-	
1975	January	150	1	0.6	
	February	160	-	-	
	March	113	-	-	
	April	53	12	22.6	+
	May	127	28	22.0	+
	June	122	25	20.5	+
	July	221	51	23.1	+
	August	32	4	12.5	+
	September	40	2	5.0	
	October	48	9	18.8	+
	November	104	2	1.9	
	December	15	2	13.3	+
1976	January	40	7	17.5	+
	February	55	-	-	
	March	37	-	-	
	April	20	4	20.0	+
	May	25	3	12.0	+
	June	59	16	27.1	+
	July	4	-	-	
	August	39	6	15.4	+
	September	34	3	8.8	

In E. niloticus the rise and fall in percentage of fish with abdominal fat body followed the rise and fall of feeding activities (Fig. 4.10). Peak periods of high feeding intensity and fat accumulation were January, May, August and December. The relationship of these periods with seasonal availability of food has been discussed while the relationship with limnological conditions of the lake will be discussed later under discussion (4.1.4).

In Schilbe mystus the trend was the same as seen in E. niloticus except that the peak periods fell on different months. January, June and November were the periods of high feeding intensity and fat accumulation (Fig. 4.11).

The situation in Physailia pellucida was different from the previous species described. Feeding activities did not seem to affect accumulation of fat. A high percentage of the fish were found to accumulate fat in their abdomens throughout the year. Peak periods of feeding activities were June and August whereas February to July were the months when almost every fish (100%) examined had fat in their abdomen (Fig. 4.12).

From this study, it can be seen that feeding and abdominal fat accumulation vary from one species to another. In some, there may be a correlation while in others there may be none. In either case fat accumulation will depend on several factors which are related to the amount of food consumed, the amount utilized and the general physiological condition of the fish examined.

4.1.4. D I S C U S S I O N

Comparison of the five species of schilbeids in Lake Kainji show that they exhibit differences in the dietary items selected (Table 4.13). Although there is some overlap among food items, there are qualitative differences in the items selected and, with

No. of fish	59	152	183	110	101	106	162	69	39	37	100	199
	J	F	M	A	M	J	J	A	S	O	N	D
Fat deposited (g)	·97	·78	·96	·97	1·0	·90	·82	·38	·13	·72	·42	·56

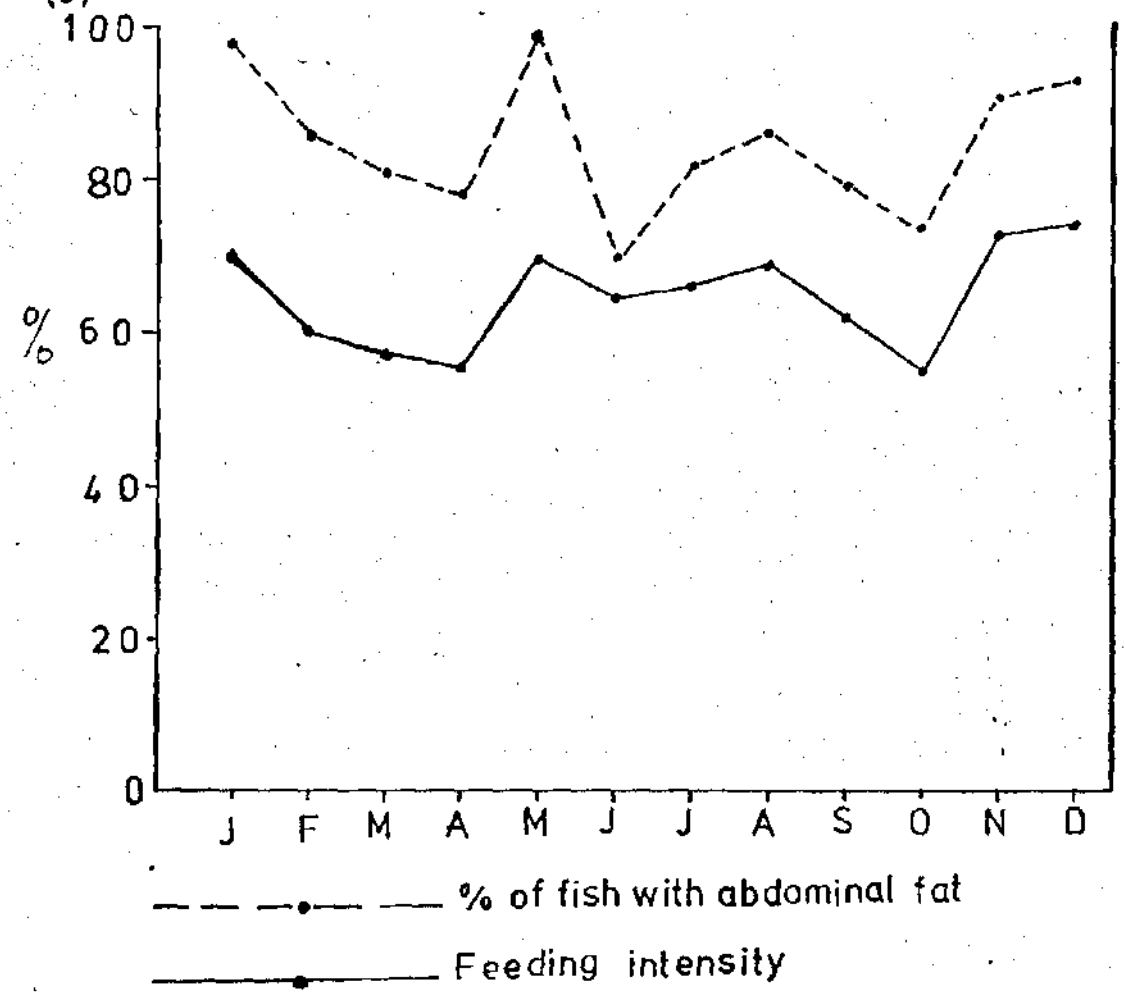


Fig. 4.10. (Eutropius niloticus.) Seasonal variation in feeding intensity and accumulation of abdominal fat body.

No of fish	1	34	26	21	15	6	13	9	5	7	15	24
	J	F	M	A	M	J	J	A	S	O	N	D
Fat deposited (g)	·09	·28	·29	·48	·25	·36	·61	·03	·10	·55	·40	·40

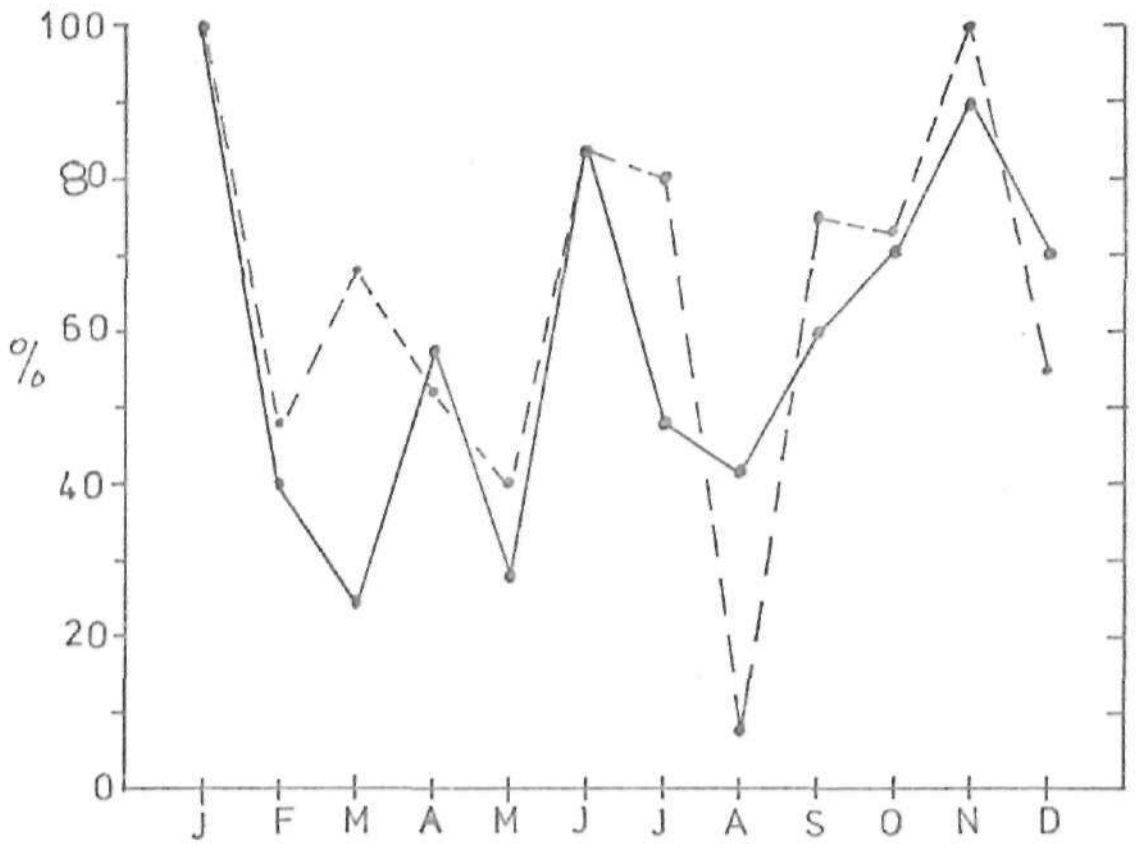


Fig. 4.11. (Schilbe mystus.) Seasonal variation in feeding intensity and accumulation of abdominal fat body.

No of fish	0	51	38	55	4	3	21	23	61	114	0	30
	J	F	M	A	M	J	J	A	S	O	N	D
Fat deposited (g)	0	1·4	1·5	1·9	1·5	0·4	1·9	0·8	0·6	0	0	0·6

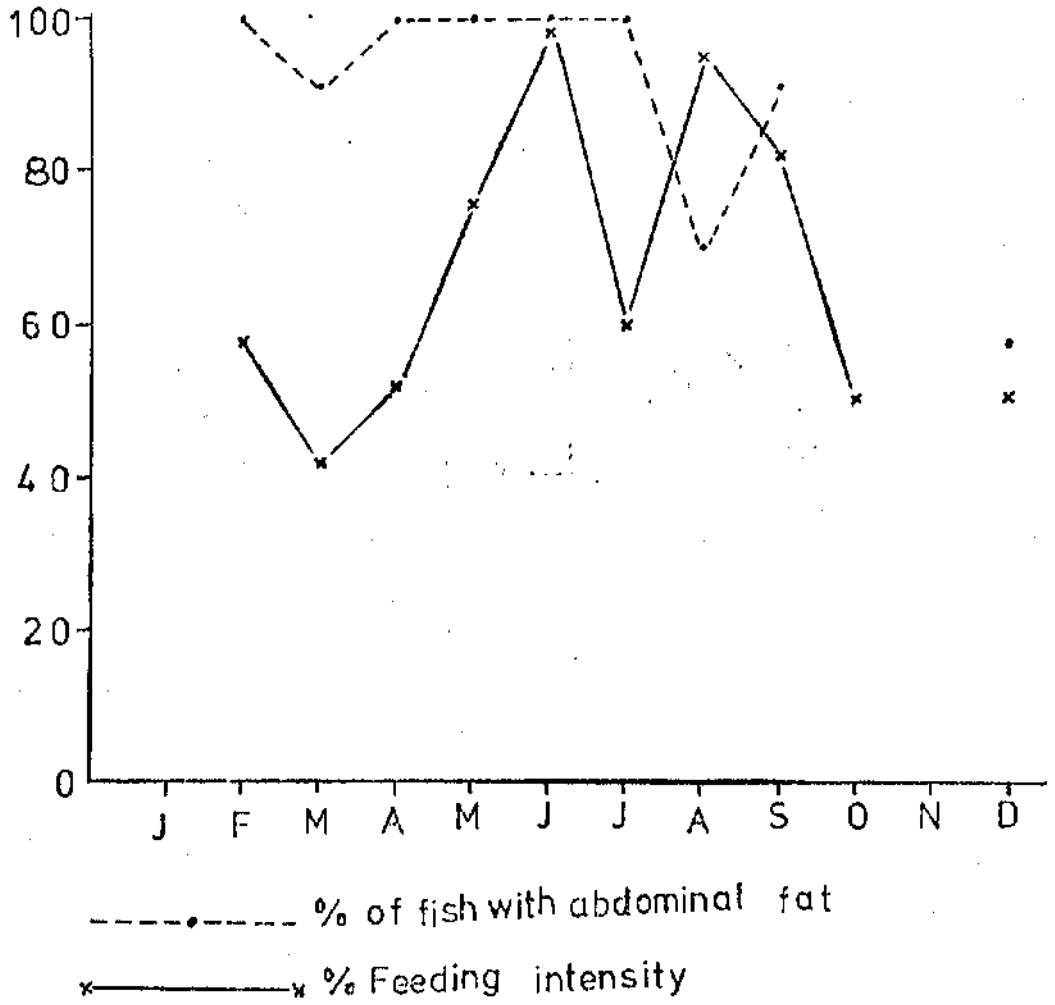


Fig. 4.12. (Physailia pellucida.) Seasonal variation in feeding intensity and accumulation of abdominal fat body.

Table 4.13. Selection of major food items by the Schilbeid species in Lake Kainji.

	Algae	Higher Plant	Crust-acea	Insects	Fish	Bottom deposits
Siluranodon auritus	5	0	3	1	0	0
Physailia pellucida	0	0	5	3	1	1
Eutropius niloticus	0	2	2	5	4	2
Schilbe mystus	0	0	1	4	5	0
Schilbe uranoscopus	0	0	0	0	5	0

Keys

5. Food item common, available in all seasons, formed over 60% of the total food consumed and therefore could be described as the main diet of the fish.

4. Food item common available in all seasons, formed between 21-59% of the total food consumed, could be described as the secondary diet of the species.

3. and 2. Food items taken occasionally, formed between 1-20% of the food consumed (3 = 11-20%; 2 = 1-10%).

1. Food item rarely taken, formed less than 1% of the total food consumed.

0. Food item not found in the stomachs examined.

the exception of the two species of Schilbe, the main items in the diet of individual species coincide with those foods which are of only secondary importance to another species. The large number of potential dietary items available and utilized by individuals will reduce competition.

Fish of small size e.g. P. pellucida and Siluranodon auritus depend on small invertebrates and phytoplankton respectively while the bigger schilbeids like E. niloticus, Schilbe mystus and S. uranoscopus depend on larger invertebrates and vertebrates.

A simple food web of Lake Kainji (Fig. 4.13) is included to illustrate the role of the schilbeids in the trophic relationship in the Lake. It shows that the schilbeids form important links at all the trophic levels in the lake.

Eutropius niloticus is omnivorous but feeds on insects and fish materials more than any other food item. Feeding takes place mostly at the surface and in the midwater.

The feeding patterns of the fish throughout the various seasons had a strong correlation with various limnological factors operating within the lake and availability of food. The period of high feeding intensity coincides with the black flood regime when the water is relatively clear and the visibility greatly improved. It also coincides with the beginning of the rains when allochtonous materials is brought in by the rain water and strong winds which often accompany the rains. During this period of high feeding intensity, a variety of food materials is available. The low period of feeding intensity coincides with the white flood regime when the lake water is turbid and under-water visibility greatly impared.

Clupeids form over 95% of the prey fish consumed. The selection of clupeids has many advantages. First, the size of the

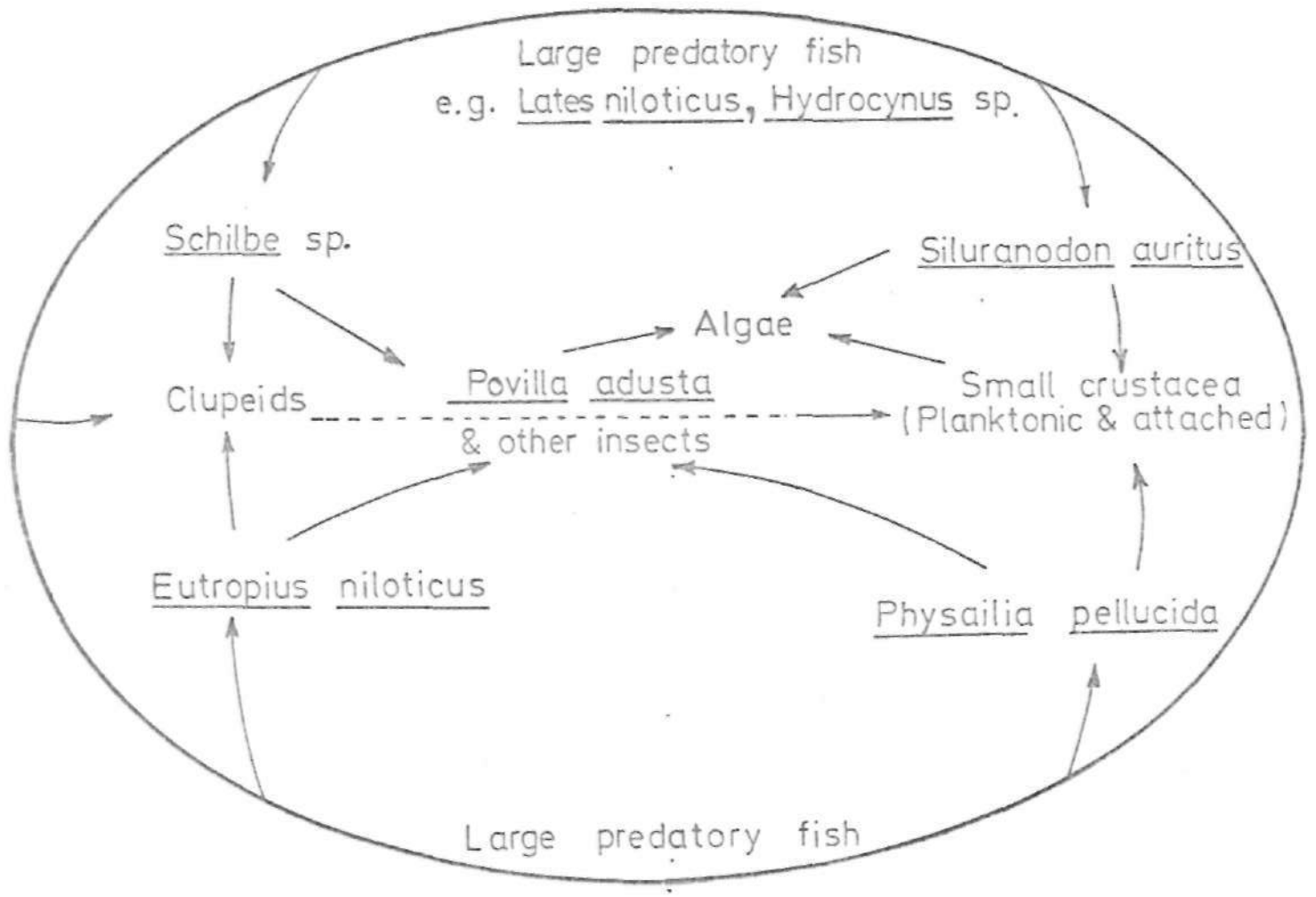


Fig. 4.13. A simplified food web of Lake Kainji involving the species of the Family Schilbeidae.

prey falls within the range that can be managed conveniently by the predator. Secondly, they are available in high numbers in all seasons throughout the lake (Otobo, 1974). Thirdly, they are found in association with E. niloticus particularly in the pelagic areas of the lake and therefore become readily available to the predator. The fourth advantage is that the clupeids are less protected unlike other fishes which possess protective structure. Synodontis species for example possess spines, and Tetradon fahaka (KENNETT) swells considerably to a size beyond that which could be managed by a smaller predator; Malapterurus electricus (GMELIN) has deterrent electrical apparatus.

E. niloticus can consume very large organisms in relation to stomach size. The stomach walls were often greatly distended with food and became very transparent to the point where injuries were sometimes caused to the stomachs by large dietary items. These seemed to heal quickly and do not appear to affect the normal feeding of the fish. Torbor (1972b) also observed this in Lake Chad species.

Various dietary items decrease or increase in importance with age. This change could be attributed to the size of the prey organism in relation to the size of the predator and to the ease of obtaining prey. At the early stages of life, the food items selected were small but as the predator increases in size a similar increase in the size of the selected prey organisms occurred. It seems that fish and grasshoppers became important part of the diet in the third year of life because of this size relationship. The grasshoppers encountered were of larger size some having a volume larger than a clupeid. A large fish would save time and energy by consuming larger food organisms rather than searching for smaller prey. Personal observation shows that

the Povilla nymphs which were consumed mostly in the first year of life were digested more rapidly than any other dietary item, which was an advantage for a fast growing fish. Since fastest growth rate for most fish occurs in the first year, a fish at this stage of growth would need a diet which could be rapidly digested and incorporated into its tissues.

Changes in the food composition and feeding habits of fish in relation to the size or age of fish and seasons are biological phenomena which are common to many species of fish in the tropics and temperate areas of the world. Hellawell (1971a, b; 1972; 1974) observed these phenomena in the grayling, Thymallus thymallus (L.); chub, Squalius cephalus (L.); roach, Rutilus rutilus (L.) and dace, Leuciscus leuciscus (L.) respectively. Mann (1976a) also noted these relationships in the chub. Bhatt (1970, 1972) studied the food of Indian catfish, Mystus seenghala (Sykes) and Mystus vittatus (Bloch) respectively. He also found that the diets changed with size of the fish and seasons. Fagade and Olaniyan (1973) noted similar occurrence in the West Africa Shad, Ethmalosa fimbriata (Bowdich) which was studied in the Lagos Lagoon.

The success of Eutropius niloticus can be attributed to its ability to colonize the variety of habitats created by the formation of the lake (see Chapter Two) and its ability to utilize a wide range of food. Previous studies on the diets of E. niloticus are summarised in Table 4.14. Before the closure of Kainji Dam, the diets of E. niloticus were investigated by Imevbore and Bakare (1970). The eight stomachs examined were found to contain ephemeropteran nymphs, adult Odonata, Coleoptera, fish scales and fish remains. Although few specimens were observed, the food item consumed in the river were very similar to those found in the stomachs of the lake specimens reported in this chapter. Banks et al (1965) in their preliminary report indicated that E. niloticus

Table 4.14. Comparative chart on the diets of *E. niloticus* from various water bodies.

Habitat	Insects[+]	Fish[++]	Fish scales	Small Crustaceans[+++]	Plant remains	Detritus	Sizes of specimens examined	References
River Niger	X	X	X				Adults	Imevbore & Bakare (1970)
Lake Kainji	X				?		Juveniles?	El-Zarka (1973)
Lake Kainji	X	X	X	X			Adults	Lewis (1973b)
Lake Kainji	X	X	X	X	X	X	Juveniles & adults	This study
Lake Volta	X	X					Adults	Petr (1967)
Lake Volta	X	X					Juveniles	Whitehead (1969)
Lake Volta	X					X	Juveniles	Reynolds (1967)
Lake Chad	X	X		X			Adults	Blache (1964)
Lake Kyoga	X	X					Adults	Worthington (1929)
River Nile	X						Adults	Pekkola (1919)
River Nile	X	X		X	X		Juveniles & adults	Sandon and El-Tayib (1953)
Transvaal Rivers	X	X				X	Adults	Groenewald (1964)[++++]

\+ Included both adult and immature forms, terrestial and aquatic. ++ Included whole fish and fish remains.
+++ Included planktonic and benthic forms.
++++ Studied *Eutropius depressirostris*.

was an omnivore but did not give details of the contents found in the stomachs. El-Zarka (1973) listed the fish as a zooplankton and insect larvae feeder. It was, however, not known whether he was reporting on the very early stages of development when zooplankton could be an important component of the diets. However, the age groups investigated here could not be described as zooplankton feeders for zooplankton formed only a minor part of their diets (1.1%). Lewis (1973b) remarked that the food consisted of insects, fish and vegetable matter. Studies on the food of E. niloticus in other tropical waters in Africa show similar diets to the Kainji species. Greenwood (1957) quoting Worthington (1929) reported that the specimens observed in Ugandan freshwaters consumed small fishes and insect larvae. The food of the juveniles observed by Whitehead (1969) in Lake Volta, Ghana consisted of mostly Povilla nymphs but adult insects also played some role in their diet though fish remains were also found in their stomachs. Povilla nymphs were the major food of this age group in Lake Kainji, therefore his results agreed with my findings. Whitehead (1969) quoting Blache (1964) reported similar diets in Lake Chad specimens. Petr (1967) in his investigation of the food preferences of the commercial fishes of Lake Volta noted that E. niloticus fed mainly on insects and fish material. The fish consumed by Volta species, were mainly Clupeids just like the Kainji lake specimens. Reynolds (1967) working on Lake Volta also found similar food items in the diets. The stomachs of the Nile specimens studied by Sandon and El-Tayib (1953) and cited by Imevbore and Bakare (1970) contained aquatic hemipterans, plant fibres, fish, crustaceans and chironomid larvae. Pekkola (1919) also noted that the Nile species were mainly insectivorous. Groenewald (1964) investigated the diets of a closely related

South African species, Eutropius depressirostris Peters. He found that it fed on detritus, fish and insects. From the various reports cited above it can be seen that insects and fish are the main diets of E. niloticus in almost all the habitats cited above.

Previous studies on the diets of P. pellucida are summarized in Table 4.15a. Reynolds (1970) found that P. pellucida fed on small crustaceans, dipteran larvae and pupae and Povilla adusta nymphs. Other items of lesser importance included terrestial insects, fish and algae. His findings compare well with the present study except that algae and fish were unimportant for the Kainji species. P. pellucida feeds primarily at night and like the Volta species feeding take place in mid-water, rather than at the surface. This was evident from the presence of Chaoborus larvae which are predominantly benthic during the day and planktonic at night. The presence of Povilla adusta nymphs and Bosmina longirostris in the same stomach suggests that the chaoborid larvae were picked up at night during their usual vertical migration to the surface. The absence of Povilla eggs (except in one stomach) showed that larger mature imagos were not usually consumed. There was no marked change in food selection with length; only a slight trend towards an increase in size of food organisms consumed with increase in size of fish. The size of the stomach and the mouth gapes of the predator were the main factors which seemed to delimit the size of the prey organism taken.

Reynolds (1970) examined a few specimens of Siluranodon auritus inhabiting Lake Volta. This species has similar abundance, food preferences and distribution in the Volta and Kainji. Reynolds (1970) found that this rare species feeds largely on algae, rotifers and small crustaceans just like those of Kainji Lake (see Table 4.15b). It is of interest to note that Siluranodon auritus is the only phytoplankton feeder among the Schilbeids in

Table 4.15. Comparative chart of the diets of P. pellucida and Siluranodon auritus from various water bodies.

A. Physailia pellucida

Habitat	Food items: Insects +	Small crustaceans ++	Rotifers	Fish	Algae	Sizes of specimens examined	References
Lake Kainji	X	X				Adults	Lewis (1973b)
Lake Kainji	X	X		X+++		Adults	This study
Lake Volta	X	X		X	X	Adults	Reynolds (1970)

B. Siluranodon auritus

Lake Kainji	X	X			Adults	Lewis (1973b)
Lake Kainji	X	X		X	Adults	This study
Lake Volta	X	X	X	X	Adults	Reynolds (1970)

\+ mainly immature insects
++ included planktonic and benthic forms
+++ found in one stomach.

Lake Kainji.

Previous studies on the diets of the Schilbe sp. are summarized in Table 4.16. In the Upper Nile, Sandon and El-Tayib (1953) reported that S. mystus is a bottom feeder relying on mud, chironomid larvae, beetles, cladocerans and rotifers. In contrast, Verbeke (1959) recorded a mixture of vegetable matter, fish and insect larvae as food of S. mystus in Lake Albert. Bakare and Imevbore (1970) observed that the ten specimens collected in the Kainji Reservoir area fed on fish. No vegetable matter, mud or rotifers were found in the stomachs of Lake Kainji species. In Ghana, the Volta Lake species were found to feed mainly on fish (clupeids) and terrestial insects, (Petr, 1967), while the Ugandan species were found to feed on fish and insect larvae (Graham, 1929; Worthington, 1929). Corbet (1961) reported that the Lake Victoria and adjacent rivers species in East Africa were primarily piscivorous but also fed on insects. Whitehead (1969) and Reynolds (1967) also found the juveniles in Lake Volta to have the same food habits as those in Lake Kainji. Mok (1974) also remarked that the diets of S. mystus and S. uranoscopus were very similar in Lake Chad, the juveniles being found to be mainly 'entomophagous' while the adults were 'ichthyophagous'. His findings coincide with the results of this work. Like the other schilbeid species in Lake Kainji, the composition of the diets of S. mystus has suggested primarily night feeding activity with feeding taking place both at the surface and mid-water. In Lake Kainji there is tendency for the adults to depend mainly on fish while the juveniles, which could not cope with the large size of the prey fish, relied heavily on insect material as a supplement to their fish diets.

Schilbe mystus and Schilbe uranoscopus are both mainly piscivorous, and in view of this competition for food might be expected

Table 4.16. Comparative chart on the diets of Schilbe mystus from various water bodies.

Habitat / Food items	Insects[+]	Small crustaceans	Rotifers	Fish remains	Plant remains	Mud	Sizes of specimens examined	References
River Niger				X			Adults	Imevbore and Bakare (1970)
Lake Kainji				X			Adults	Lewis (1973b)
Lake Kainji	X	X[++]		X			Juveniles and adults	This study
Lake Volta	X			X			Adults	Petr (1967)
Lake Volta	X			X			Juveniles	Reynolds (1967)
Lake Volta	X			X			Juveniles	Whitehead (1969)
Lake Chad	X			X			Juveniles and adults	Mok (1974)
Lake Albert	X			X			Adults?	Verbeke (1959)
Lake Kyoga	X	X		X			Juveniles/adults	Worthington (1929)
Lake Victoria	X	X		X			Juveniles/adults	Graham (1929)
Lake Victoria	X	X		X	X		Adults	Corbett (1961)
Upper Nile	X	X	X			X	Juveniles	Sandon and El-Tayib (1953)

\+ included all forms of insects.
++ found in one stomach only. Studies included S. uranoscopus.

to occur. Competition for food is not likely to occur because S. uranoscopus does not occur in large numbers in the lake nor are the two species often present in the same area at the same time (see Chapter Two). Moreover, the clupeids which formed the main fish prey for these two species are available in very large quantities throughout the lake and for most of the year Otobo, 1974).

The comparison of the diets of the schilbeids from different geographical areas shows that there is no wide differences in the diet within one species. This lack of major differences shows that selection of food item is influenced by a similar behavioural pattern irrespective of geographical location of the fish.

C H A P T E R F O U R

S e c t i o n 2

E n z y m o l o g y

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4.2.1. INTRODUCTION

The study of gastric and intestinal digestion in fish can be traced as far back as 1899 (Barrington, 1957). Since then many investigations have been accomplished (see Yung, 1899; Weinland, 1901; Sullivan, 1907; Bayliss, 1935; Norris and Elam, 1940; Baldwin, 1952; Fish, 1960; McGeachin & Debnam, 1960; Cockson and Bourne, 1972). In spite of the large volume of information which is available on the digestive enzymes of fish in temperate regions, no comparable information can be obtained for the fish in tropical Africa. Various studies on food and feeding habits of the commercial fish in Lake Kainji have been undertaken but none of these relate the feeding habits to the enzymes found in the alimentary canal.

In this section, the enzymes in the digestive tracts of the three common schilbeids in Lake Kainji are described for the first time and the enzymes present are linked to the food habits of the fish.

4.2.2. MATERIALS AND METHODS

1. Preparation of fish.

Adult specimens of Physailia pellucida, Eutropius niloticus and Schilbe mystus were captured alive and kept in aquarium tanks until needed. Commercial fish feeds were given to the fish while in the tank. The fish were later starved for at least 48 hours prior to gut extraction to bring all of them to similar physiological condition. The fish were killed by a cut across the head with a scapel passing through the brain. The entire gut (from oesophagus to cloaca) was removed and freed from other tissues in a petri dish already kept in a tray containing crushed ice.

2. Preparation of Enzyme Extracts.

The gut was weighed and homogenized in all glass homogenizer with 10 - 15ml of KOH neutralized deionized water. The homogenate was centrifuged for 25 minutes at 25,000g in a refrigerated Beckman J - 21 centrifuge. The clear supernatants were used as sources of the enzymes. The protein concentrations of the extracts were then determined as explained below using the method of Gornall et al (1949).

About 2ml of enzyme extract was pippetted into a test tube and water was added to bring it to 3ml. 2ml of biuret reagent was added and mixed together.

A blank was prepared with 3ml of water and 2ml of biuret reagent. The blank and the sample were allowed to stand for at least 15 minutes. The optical density (O.D) was read at 546m. To obtain the amount of protein in each sample the O.D was multiplied by 11.4 (see Appendix 23).

3. Preparation and incubation of the substrate enzyme mixtures.

The preparation and incubation of the substrate-enzyme mixtures followed that of Ogunbiyi and Okon (1976). Test tubes were prepared as explained in Appendix 24. Into each test tube 0.2ml of enzyme extracts was added to 1.8ml of buffered substrates. The controls, 0.2ml heated enzyme extracts and 1.8ml of buffered substrates were also prepared. Both the test samples and the controls were incubated in a constant temperature water bath at $37^{o}C$ for 24 hours. After incubation the mixtures were heated in a boiling water bath for about 2 to 3 minutes in order to stop further enzyme activity. The cooled samples were then analysed as follows.

4. Determination of Proteases.

For the qualitative determination of the two proteases the tests described by Balogun and Fisher (1970) and quoted by Ogunbiyi and Okon (1976) were performed.

About 1ml of 10% TCA was added to each sample in test tubes A_1 - 4 and B_1 - 4 and centrifuged in a Gallenkamp Junior bench Centrifuge for twenty minutes. The clear supernatant was used for further analysis while the precipitate was discarded. The enzyme activity was determined using the method of Lowry et al (1951) (see Appendix 25). Tyrosine was used as the standard. Absorbance was read using a Bausch and Lomb Spectronic 20 spectrophotometer.

5. Determination of Carbohydrases.

(a) Qualitative determination.

5ml of Benedict's qualitative reagent were added to the mixture in test tubes D_3, D_6; E_3 E_6; H_3, H_6. and boiled for one hour. Development of a brick-red coloured precipitate indicated a positive test.

(b) Quantitative determination

The colorimetric methods of Nelson (1944) and Somogyi (1945) quoted from Ogunbiyi and Okon (1976) were used. The test was performed using the substrate - enzyme mixtures D_1 D_4, E_1, E_4, F_1, F_3 and G_1, G_3. Glucose was used as the standard. For the procedure see Appendix 26. The enzyme activity was calculated.

6. Determination of Lipase activity.

The analysis was carried out according to Ogunbiyi and Okon (1976). About 3ml of 95% Ethanol was added to the already incubated substrate-enzyme mixture (Samples C_1, C_2 and C_3 C_4). Two

drops of phenolphthalin indicator were used. The control and the test samples were titrated to the same pink colour using 0.05m NaOH. An increase in the titre of the test sample when compared with the control was taken as an indication of the presence of lipase activity in the extract. Appendix 27 shows the list of all buffered substrates and reagents used in the experiments.

4.2.3. R E S U L T S

Table 4.17 shows the various enzymes detected in the digestive tracts of the fish species. Trypsin and pepsin were found to be present in all the three species. Of all the carbohydrases tested for only amylase was found and was present in E. niloticus and S. mystus. There was none in P. pellucida. No lipase was detected in any of the three species (Appendix 28).

The quantitative aspects of the results (Table 4.18) show interesting results (see also Appendices 29 & 30). P. pellucida and E. niloticus have high pepsin activity and low trypsin activity; while there was not much differences in those of S. mystus. Amylase activity in S. mystus was higher than that of E. niloticus. In E. niloticus pepsin had the highest activity, followed by amylase and trypsin in that order. Amylase activity in S. mystus was the highest followed by pepsin and trypsin in that order.

4.2.4. D I S C U S S I O N

The result of this study shows that E. niloticus and S. mystus have enzymes capable of digesting protein and at least one carbohydrate while P. pellucida has protein digesting enzymes. The enzymes detected in the alimentary tract of the three schilbeid species investigated would seem to be related to the food habits of the fish. In the previous section, the food and feeding habits of the five species have been analysed. The diets of E. niloticus

Table 4.17. Enzymes in the alimentary tracts of the three common Schilbeid species in Lake Kainji, Nigeria.

Fish species / Enzymes	*P. pellucida*	*E. niloticus*	*S. mystus*
PROTEASES			
Trypsin	+	+	++
Pepsin	++	++	++
CARBOHYDRASES			
Amylase	-	+	++
Invertase	-	-	-
Lactase	-	-	-
Maltase	-	-	?
Cellulase	-	-	-
LIPASE	-	-	-

\+ Low activity ++ High activity - Absent ? see discussion

Table 4.18. Activities of the enzymes in the alimentary tracts of the three common schilbeid species in Lake Kainji, Nigeria.

Fish species / Enzymes	P. pellucida	E. niloticus	S. mystus
	mg tyrosine equivalent formed / mg protein / 24 hr at 37°C		
PROTEASES			
Trypsin	0.97	0.16	3.02
Pepsin	5.48	2.44	3.21
	mg glucose equivalent formed / mg protein / 24 hr at 37°C		
CARBOHYDRASES			
Amylase	0	0.77	5.7
Invertase	0	0	0
Lactase	0	0	0
Maltase	0	0	0
Cellulase	0	0	0

consisted of insects, fish and crustaceans. Plant materials were also found in the stomachs, although in a small quantity. The relatively high pepsin and low amylase activities can be correlated with the proportion of protein and carbohydrates in the diets.

The three enzymes detected in Schilbe mystus had relatively high activities. The high trypsin and pepsin activities were not surprising in view of the large amount of fish and insect material in its diets. It will be recalled that the food of S. mystus consisted mainly of fish and insects. It is, however, surprising that a relatively high amylase activity was recorded for S. mystus despite the fact that its diets did not include plant materials. It was expected that amylase activity if any would be greatly reduced in S. mystus. It is possible that the presence of high amylase activity in the digestive tracts of S. mystus might be a device evolved by the fish for digesting starch manufactured by the algae consumed by its prey. The food of its main prey organisms, Povilla adusta nymphs and clupeids was primarily phytoplankton (Petr 1973; Reynolds 1970 respectively). Although Yonge (1937) stated that there is definite correlation between food of any animal and the nature and relative activity of its digestive enzymes, sometimes the enzymes detected in the gut may not be positively correlated with diets. Chesley (1934) found that Brevoortia sp. a marine teleost, consuming much fatty food had a concentration of lipase not higher than those of other fish which feed on less fat. Moreover a number of factors are said to affect enzyme production in fish. Fish (1960) points out that when fish are kept under artificial conditions, gastric pH may alter with a reduction in acid production. It seems likely therefore that fish kept in the laboratory and fed on synthetic diet may differ significantly in their digestive enzyme content than when in their

natural habitats.

The paper chromatographic tests (Trevelyan, et al 1950) show that maltose might be present in Schilbe mystus. This is expected in view of the high amylase activity in this fish. According to Barrington (1957) maltose is the main product of the action of digestive amylase, and it is to be expected that maltase will closely associate with it. It is also possible that maltase may be present in E. niloticus but the concentration of the amount present may not be high enough to be detected by the method used in this work. A number of workers have found maltase in the digestive tracts of fish (Ishida, 1936).

The food consumed by P. pellucida were mainly insects and crustaceans, the presence of only proteases in the gut was therefore expected in view of its diet.

Lipase activity was not detected in any of the three species investigated. This is rather surprising in view of the fact that the diets of E. niloticus and S. mystus include clupeid fish which contain plenty of fats. The enzymes found in the schilbeids have also been reported from several marine and freshwater teleosts (see references in Barrington 1957).

Although the alimentary canal was not separated into different regions in this work, personal observation of the stomach contents shows that digestion probably begins in the stomach which is usually acidic in most vertebrates (Nikolsky, 1963). The digestion probably continues in the intestine with trypsin and amylase becoming active. Examination of the contents of the rectum shows that the fish were able to digest most of the organisms consumed except the chitinous layers of insects, shells of molluscs and plant materials. This might be due to the absence of enzymes which can breakdown such materials in the alimentary canals.

In some teleosts, trypsin is said to originate from the pancreas (MacKay, 1929) as trypsinogen which may need activation by intestinal enterokinase (Babkin & Bowie, 1928). The gall bladder and the liver were also thought to be involved in secretion of trypsin (Babkin & Bowie, 1928; Chesley, 1934). Subsequent experiments by MacKay (1929) have shown that the enzyme actually originates from the pancreas. In mammals the sole source of trypsin is the pancreas (Barrington, 1957). Pepsin production is usually associated with the stomachs where an acid condition necessary for the action is found. Amylase was reported to be present in the intestine of several species of teleost (see Bayliss, 1935; Babkin & Bowie, 1928; MacKay, 1929; Al-Hussaini, 1949). Amylase was also reported to be present in the pancreas by Oya et al (1927), Vonk (1927) and Chesley (1934). Lipase activity has been detected in the intestinal mucosa of several teleosts by Babkin & Bowie (1928), Ishida (1936), MacKay (1929) and Bayliss (1935). Lactase, invertase and cellulase are not normally found in teleosts.

C H A P T E R F I V E

Sex, reproductive cycle and fecundity.

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5.0.1. I N T R O D U C T I O N

The build-up and continuous existence of the population of any organism depend on its ability to reproduce. During the reproductive process the genetic make up of the population is determined, as is also the basic pattern of its future behaviour.

In fishes as in most animals, reproduction follows a basic pattern which is common to all members of the same species. In some fishes e.g. Labidesthes sicculus, Oncorhynchus sp. and Anguilla sp. reproduction occurs once in their life time (Lagler et al, 1962). In some, reproduction follows a yearly cycle, such as seen in most temperate freshwater fish e.g. Ictalurus melas (Dennison et al, 1972), Rutilus rutilus (Mann, 1973) Esox lucius (Mann, 1976b) Squalius cephalus (Hellawell, 1971c) and in tropical freshwater species e.g. Ethmalosa fimbriata (Fagade and Olaniyan, 1972), Mormyrus kannume (Scott, 1974) and Barilus niloticus (Reynolds, 1974). Where seasonal climatic changes are pronounced, breeding and spawning usually occur within a restricted period within the annual cycle. In the tropical environment where more uniform weather conditions exist throughout the year, extended breeding periods covering at least three quarters of the year occur in some species e.g. Tilapia sp (Lowe, 1955), Pellonula afzeliusi and Physailia pellucida (Reynolds, 1974). No matter what type of reproductive behaviour is exhibited, the timing of breeding and subsequent spawning helps to ensure that the larvae are hatched at a favourable time when (a) weather conditions are not too severe (b) plenty of food is available and (c) fish larvae are moderately protected from potential predators.

Previous studies on the reproductive biology of the Family Schilbeidae have been negligible. Apart from the work of Reynolds (1974) on Physailia pellucida and Siluranodon auritus in Lake Volta,

Ghana, no other work on schilbeids is available for comparison with the present study.

Before the impoundment of the River Niger to form Lake Kainji, Imevbore (1970b) made a preliminary study on the fecundity of several species of fish trapped at the coffer dam and the fecundity of two specimens of Schilbe mystus was determined. Observations of the reproductive cycle of S. mystus and E. niloticus during the early period of formation of Lake Kainji were also made by Lelek (1972). None of the above reports however had detailed information on the reproductive biology of the schilbeids.

In this work, some aspects of the reproductive biology of the schilbeid species in Lake Kainji were investigated. The investigation covers sex determination, sex ratio, maturity of gonads, breeding and spawning periodicity and determination of fecundity. The data for the two years of sampling were pooled for analysis in view of their similarities.

5.0.2. M A T E R I A L S AND M E T H O D S

1. Method of obtaining fish samples.

The method of capture of fish samples and of obtaining routine fishery data (e.g. Total/standard lengths, weights etc.) have been described in Chapter Two and Four respectively.

2. Sex determination and classification of gonad maturity.

Sex was determined by internal examination of the fish : the abdomen of the fish was slit open lengthwise for visual examination of the gonads. The specimens were classified as male or female. In young forms, the sex was very difficult to determine and so for these a question mark (?) was placed under the column for sex. In some large individuals it is possible to determine sex externally. The male possesses a genital papilla, which is a conelike

projection of the genital aperture. The females were found not to possess an equivalent structure. After the sex had been determined, the gonads were classified according to a maturity scale modified from Nikolsky (1963) (Table 5.1).

3. Preservation of eggs and preparation of preserved eggs for fecundity studies.

Fully matured ovaries in stage 4 were removed, weighed and kept in labelled bottles containing Simpson's (1951) fluid. The ovarian wall was pierced in two places to facilitate easy penetration of Simpson's fluid into the egg masses. Apart from being a preservative, Simpson's fluid also helps to harden individual eggs and to break down ovarian tissues surrounding them. After at least three months the eggs were washed with water several times in order to free the ovarian and other unwanted tissues from the eggs. The freed eggs were returned to Simpson's fluid and kept in labelled bottles until needed for estimation of egg size and fecundity.

4. Estimation of fecundity.

The fecundity was estimated by subsampling using the dry gravimetric method modified after Simpson (1959). The eggs from both ovaries were poured from the specimen bottles into a flat petri dish. The fluid was drained off as far as practicable using a fine mouthed pipette. The eggs were spread evenly inside the petri dish and left to dry at room temperature ($23\pm2^{o}C$) overnight. They were sufficiently dried at the end of 24 hours. The dried eggs were weighed on a precision balance graduated in milligrams (mg). The eggs were mixed up thoroughly in the flat petri dish and a subsample was taken. The subsample was weighed, the eggs

Table 5.1. Gonad maturity stages in Family Schilbeidae in Lake Kainji.

Maturity stages	Gonad Condition	Description of gonads	
		Female	Male
I	Virgin	Ovary very small. Usually colourless. Accumulation of fat in the abdomen.	Testes very small not usually easily identifiable.
II	Immature or developing. (recovered spent)	Left and right ovaries visible to the naked eye. Usually oblong and transculent. Developing eggs cannot be seen with naked eye. The two ovaries form about 0.1% of the body weight.	Testes clearly visible to the naked eye but very thin with outgrowths giving the testes a lobed appearance.
III	Matured or developed.	Eggs visible to the naked eye. Ovarian colour ranges from cream to yellow. Ovaries form about 3% of the body weight. The two ovaries occupied about 30 - 50% of the abdominal cavity.	Testes white and swollen. Fingerlike outgrowths become very conspicuous.

Table 5.1. cont'd.

IV	Fully matured or Fully developed.	Abdominal fat bodies disappear. Ovaries very large occupying about 50 - 70% of the abdominal cavity. Ovaries form about 10% of the body weight. Eggs not shed even with slight pressure on the abdomen.	Testes white and swollen. Milt not running with slight pressure on the abdomen.
V	Running or spawning.	Same as in stage 4 above but eggs are shed with slight pressure on the abdomen. Genital opening swollen.	Same as in 4 but milt was running with slight pressure on abdomen. Genital opening swollen.
VI	Spent and recovering (Spawned)	Eggs have been shed. Ovaries flaccid, look like empty sacs, blood-shot colour. Few ova still present in the ovaries. Eventually all the remaining eggs are absorbed and ovary condition returns to stage 2.	Spent testes not found in samples. Testes condition would return to stage 2.

counted and the number of eggs in the entire sample calculated. Five subsamples were taken. The fecundity of each specimen was estimated by multiplying the mean of the estimates from the subsamples. The standard deviation of the estimates was also calculated.

5. Other studies.

The diameter of 50 - 200 eggs selected randomly from a suspension of preserved eggs was measured for each specimen. A binocular microscope fitted with an eyepiece micrometer was used for the measurements. Only eggs which were distorted were used in the measurements. The size frequency of the egg diameter was used to determine the spawning periodicity of the fish.

The sizes at which the mature gonads were seen in each species were noted. The reproductive cycle was followed throughout the seasons by examination of the gonad maturity. Spawning seasons were determined by noting the percentage of spent females in the sample for each month. Fish condition was calculated as in Chapter Three and the relationship of this with maturation of gonad was investigated.

5.0.3. R E S U L T S

A. REPRODUCTION IN EUTROPIUS NILOTICUS

A.1. Size and sexual dimorphism.

Females were usually bigger than the males of the same age, which suggests that the females have a faster growth rate than the males (see also Chapter Three). The standard length of the biggest female encountered was 26.5cm while the largest male was 19.5cm (Table 5.2). The males possess genital papillae which are very conspicuous particularly in larger individuals. In the

Table 5.2. Maximum standard lengths in the species of Schilbeidae in Lake Kainji.

	Female		Male		Total number of specimens examined.
	S.L (cm)	Weight (g)	S.L (cm)	Weight (g)	
Siluranodon auritus	11.2	14.0	9.4	11.0	48
Physailia pellucida	13.0	16.0	12.0	12.0	1260
Eutropius niloticus	26.5	255.0	19.5	87.0	1705
Schilbe mystus	23.5	235.0	16.8	68.0	278
Schilbe uranoscopus	16.0	52.0	-	-	7

female the papilla is absent. The papilla is a conelike projection of the genital aperture and varies from 2mm to 5mm in length. Reynolds (1971b) also noticed the presence of genital papillae in the males of schilbeids in Lake Volta. The function of the papilla is not known. It is possible that its presence may help the females in identifying the males during their spawning associations, since the males possess no other external distinguishing characters. The male gonads are attached to the roof of the abdominal lining. The external structure of the testis follows the generalized form found in most catfishes, showing fingerlike outgrowths which become more conspicuous as the fish grows.

In the females the left and right ovaries are usually oblong and transculent. In fully matured individuals the ovarian colour changes to light yellow and fully matured eggs can be seen with naked eye. The two ovaries sometimes occupied about 70% of the abdominal cavity when fully matured.

A.2. Sex ratio

The sex of 1705 specimens was determined. 1426 were females and 279 males, a ratio of 1 male to 5 females. In Table 5.3, the number of males and females in the samples and the sex ratio are shown for each month. The table shows two distinct periods of sex ratio variations; the first occurred from March to June when the number of females to male was low and fairly constant and the second period was July to February, when the number of females to male was high but also fairly constant. The period July to November is the breeding season (see section A4 of this Chapter). Table 5.3 also shows the sex ratio of different age groups.

A.3. Age and size at maturity.

Table 5.4 shows the length and age groups of **E. niloticus**

Table 5.3. Sex ratio of *Eutropius niloticus* in Lake Kainji.

Age groups	Sex	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	TOTAL	Sex ratio M:F
0+	Female	30	9	19	8	15	20	20	4	5	25	2	2	159	1:2.3
	Male	3	5	10	6	8	12	7	5	2	8	1	1	68	
1+	Female	55	71	52	75	54	38	21	33	24	31	11	12	477	1:6.4
	Male	3	10	7	7	7	13	7	10	4	4	1	1	74	
2+	Female	104	105	86	50	61	63	31	35	38	62	20	22	677	1:5.5
	Male	9	8	13	6	10	38	8	12	9	8	1	1	123	
3+	Female	17	13	30	9	10	1	6	3	4	8	6	3	110	1:7.9
	Male	-	3	-	1	-	3	1	2	2	-	1	1	14	
4+	Female	-	2	1	-	-	-	-	-	-	-	-	-	3	0:3
	Male	-	-	-	-	-	-	-	-	-	-	-	-	-	
TOTAL	Female	206	200	188	142	140	122	78	75	71	126	39	39	1426	1:5.1
	Male	15	26	30	20	25	66	23	29	17	20	4	4	279	
Sex ratio	M : F	1:13.7	1:7.7	1:6.3	1:7.1	1:5.6	1:1.8	1:3.4	1:2.6	1:4.2	1:6.3	1:9.8	1:9.8	1:5.1	

with matured gonads. In the females, the minimum size at first maturity observed was 14.7cm and in the males 13.2cm. An analysis of the numbers of mature and immature specimens in each age group in monthly samples (Appendices 31 & 32) shows that E. niloticus does not attain maturity until the second year of life. If maturity is attained in the second year, it is likely that breeding will take place twice or more during the life span of the fish.

A.4. Reproductive cycle.

The percentage of fish in various stages of maturity in each month is illustrated in Figure 5.1a & b. The number of mature and immature fish in each age group in monthly samples were also analysed (Appendices 31 & 32). Mature males and females were first seen in samples in June. The proportion of mature fish increased in July up to September and fell off gradually until the last set of mature fish were seen in samples in November, when breeding activities came to an end. Running females (stage V) were seen only in August. No running or spent male was captured during the course of this investigation. Breeding activity comes to an end at the end of the rainy season in October. Fish with matured gonads were caught in all the stations except Station O which is on the eastern bank of the lake.

A.5. Egg sizes and spawning periodicity.

Eggs from fully matured gonads in stage IV were measured as previously described. The size frequency of the preserved eggs of five specimens are shown in Figure 5.2. The frequency of occurrence of egg sizes shows a unimodal peak for each of the specimens. This indicates that spawning occurs only once during the breeding season.

Table 5.4. Sizes at maturity of Eutropius niloticus in Lake Kainji.

Maturity stages	Length groups (cm)	13.0 - 13.4	13.5 - 13.9	14.0 - 14.4	14.5 - 14.9	15.0 - 15.4	15.5 - 15.9	16.0 - 16.4	16.5 - 16.9	17.0 - 17.4	17.5 - 17.9	18.0 - 18.4	18.5 - 18.9	19.0 - 19.4	19.5 - 19.9	20.0 - 20.4	20.5 - 20.9	21.0 - 21.4	21.5 - 21.9	22.0 - 22.4	TOTALS
Female																					
III		-	-	-	2	2	3	-	-	4	2	5	10	4	9	4	4	5	-	5	59
IV		-	-	-	-	-	-	-	-	-	3	1	-	-	1	2	2	-	-	-	9
V		-	-	-	2	-	-	-	1	-	-	-	-	-	-	-	1	-	-	-	4
VI		-	-	-	-	-	-	-	-	-	-	1	-	1	-	-	-	-	-	-	2
TOTALS		-	-	-	4	2	3	-	1	4	5	7	10	5	10	6	7	5	-	5	74
Male																					
III		2	7	5	3	3															20
IV		-	1	2	1	-															4
V		-	-	-	-	-															-
VI		-	-	-	-	-															-
TOTALS		2	8	7	4	3															24

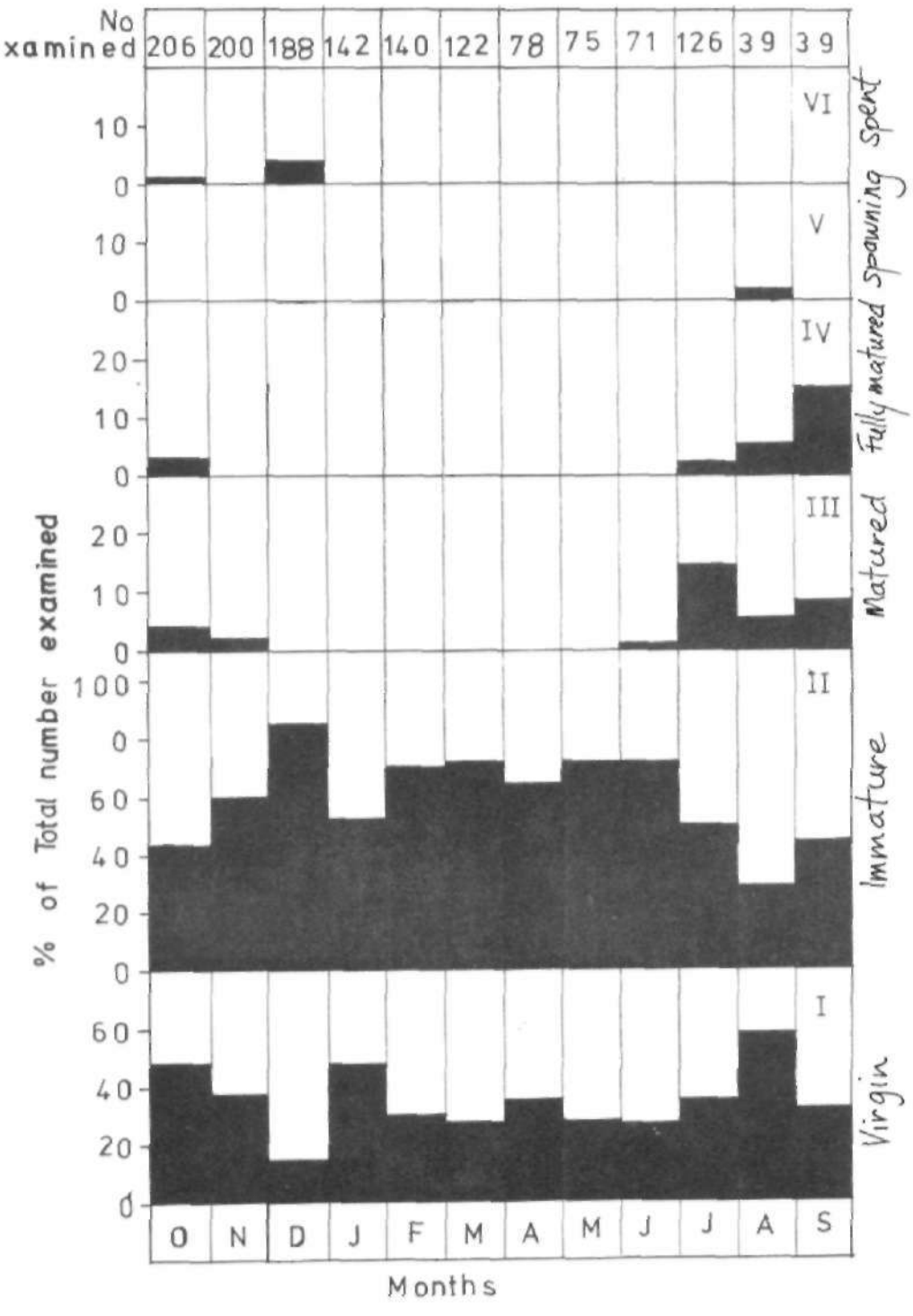


Fig.5.1a. (Eutropius niloticus.) Cycle of maturation and depletion of female gonads.

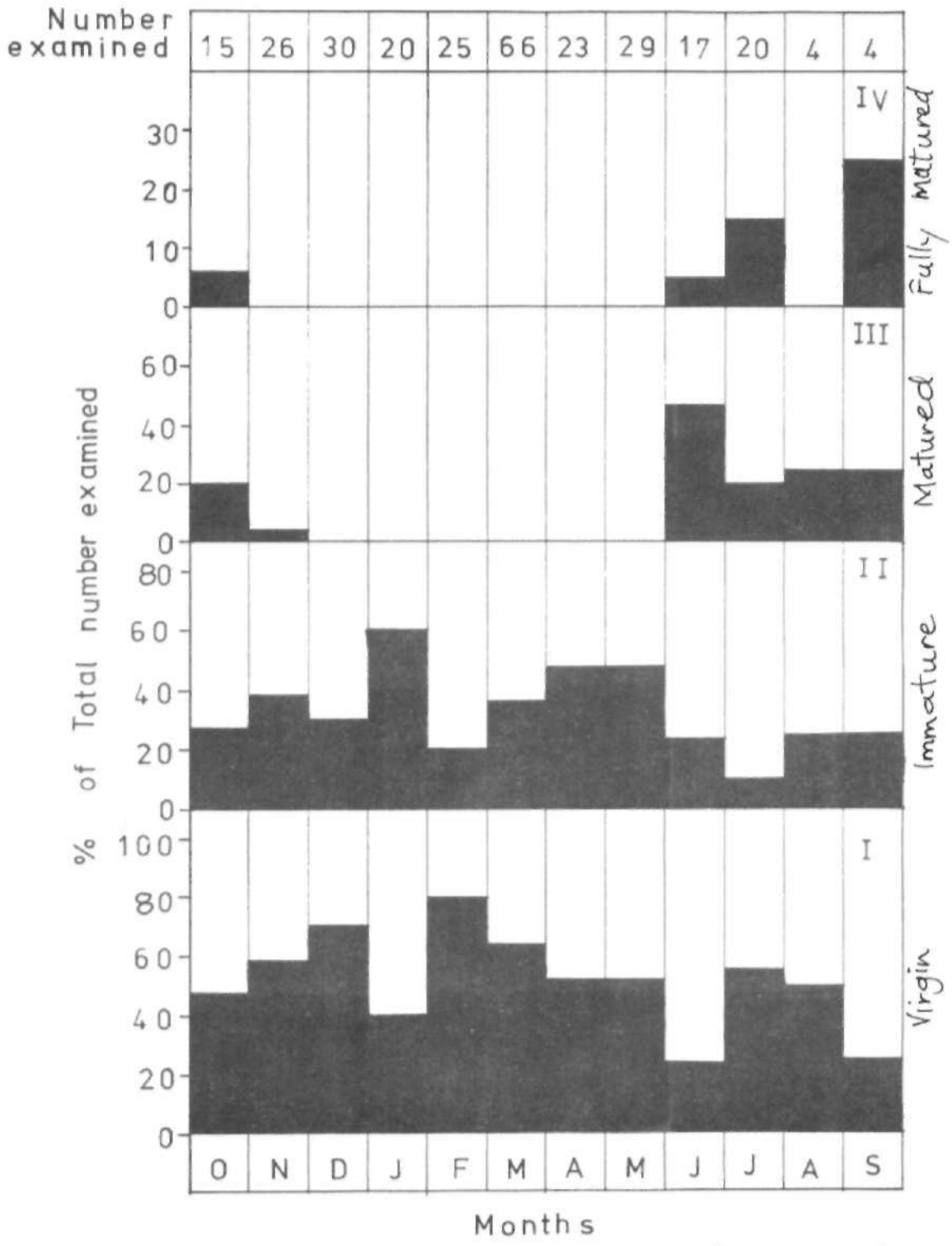


Fig. 5.1b. (Eutropius niloticus.) Cycle of maturation and depletion of male gonads.

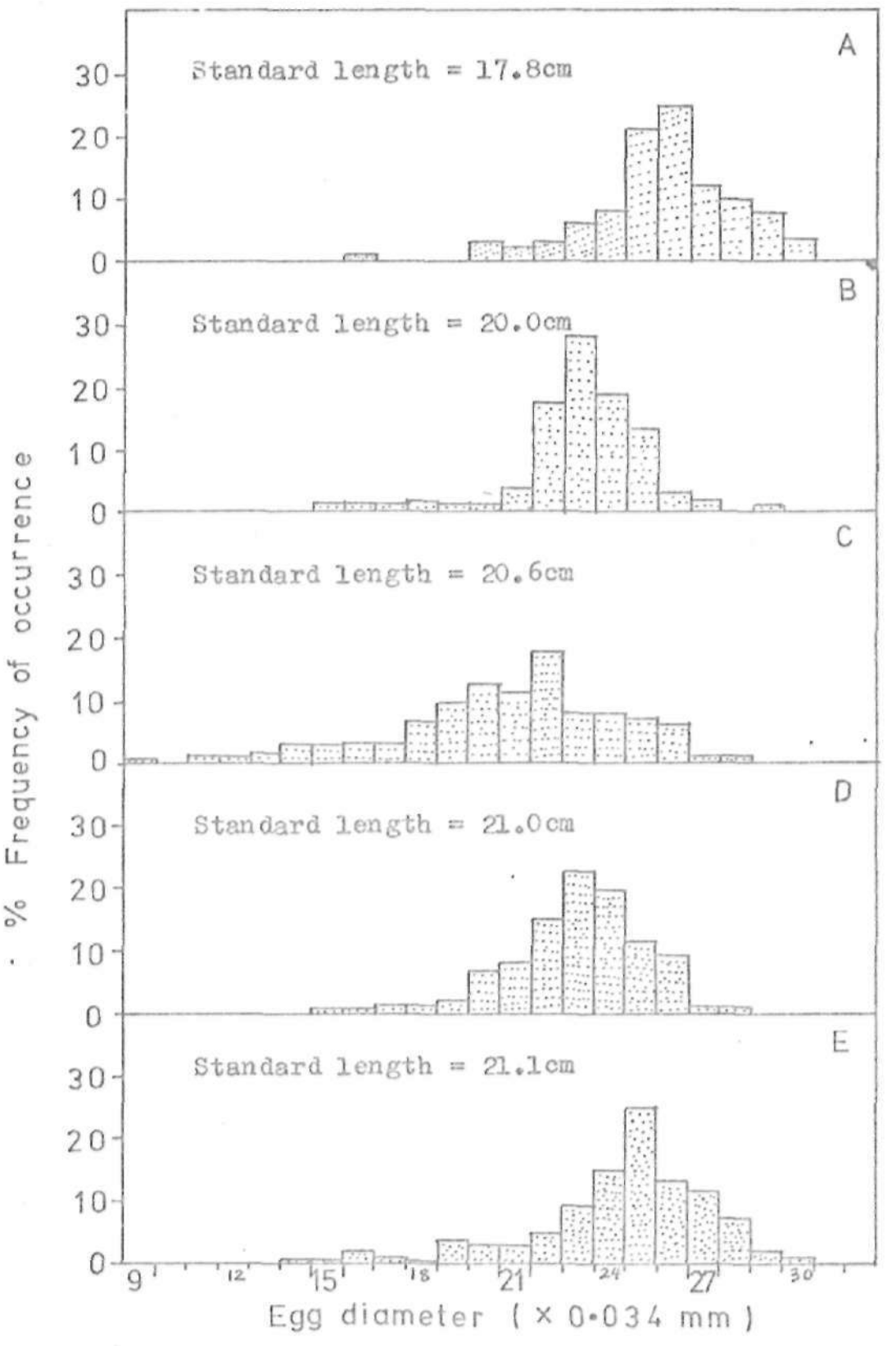


Fig. 5.2. (Eutropius niloticus) Frequency of egg sizes.

A.6. Fecundity.

The term fecundity used in this report follows that of Bagenal (1968). The number of females with fully mature gonads (stage IV) were very few. However, the few examined showed that the fecundity of Eutropius niloticus ranges from 13,905±166 to 25,675±799 (Table 5.5). The number of eggs per gram of wet weight of ovary (Table 5.5) shows that the fish is highly fecund. The number of eggs was plotted against the standard length and weight of fish (Figure 5.3). Although the result should be interpreted with caution in view of the limited numbers of samples, it can be observed that there is a slight increase in the number of eggs with an increase in length and weight of fish (fecundity - length relationship, r = 0.786, P = 0.01; fecundity - weight relationship, r = 0.889, P = 0.001).

A.7. Fish condition and maturation of gonads.

Fish condition is known to vary with the stage of fish maturation. The trend in some fish, is a high 'K' value for immature fish and a low one for mature fish, particularly those which have recently spawned. Thus the fish conditions have been correlated with spawning activities in fish (Mann, 1973). The correlation of 'K' values with spawning activities should, however, be taken with caution in view of the fact that other factors (e.g. feeding) other than spawning activities are known to affect fish conditions and in most cases it is hard to separate the effect of one from the other (Le Cren, 1951).

The 'K' values of both males and females were calculated from the conventional formula :-

$$K = \frac{W \times 100}{L^3}$$

where K = Condition factor

Table 5.5. The fecundity of Eutropius niloticus in Lake Kainji.

Standard length (cm)	Weight of fish (g)	Gonad weight (g)	Fecundity (mean estimate of five determinations)	Standard deviation	Number of eggs per gram wet wt. of ovary.
17.0	60	6.8	13,905	166	2,044
17.8	61	6.34	13,918	707	2,195
18.0	66	7.07	16,146	229	2,283
19.0	75	5.50	14,907	252	2,710
19.5	83	10.24	15,496	833	1,513
20.0	110	8.43	21,920	696	2,600
20.6	120	8.00	16,758	762	2,095
21.0	145	12.00	25,675	799	2,140
21.1	135	9.45	21,841	1,344	2,311

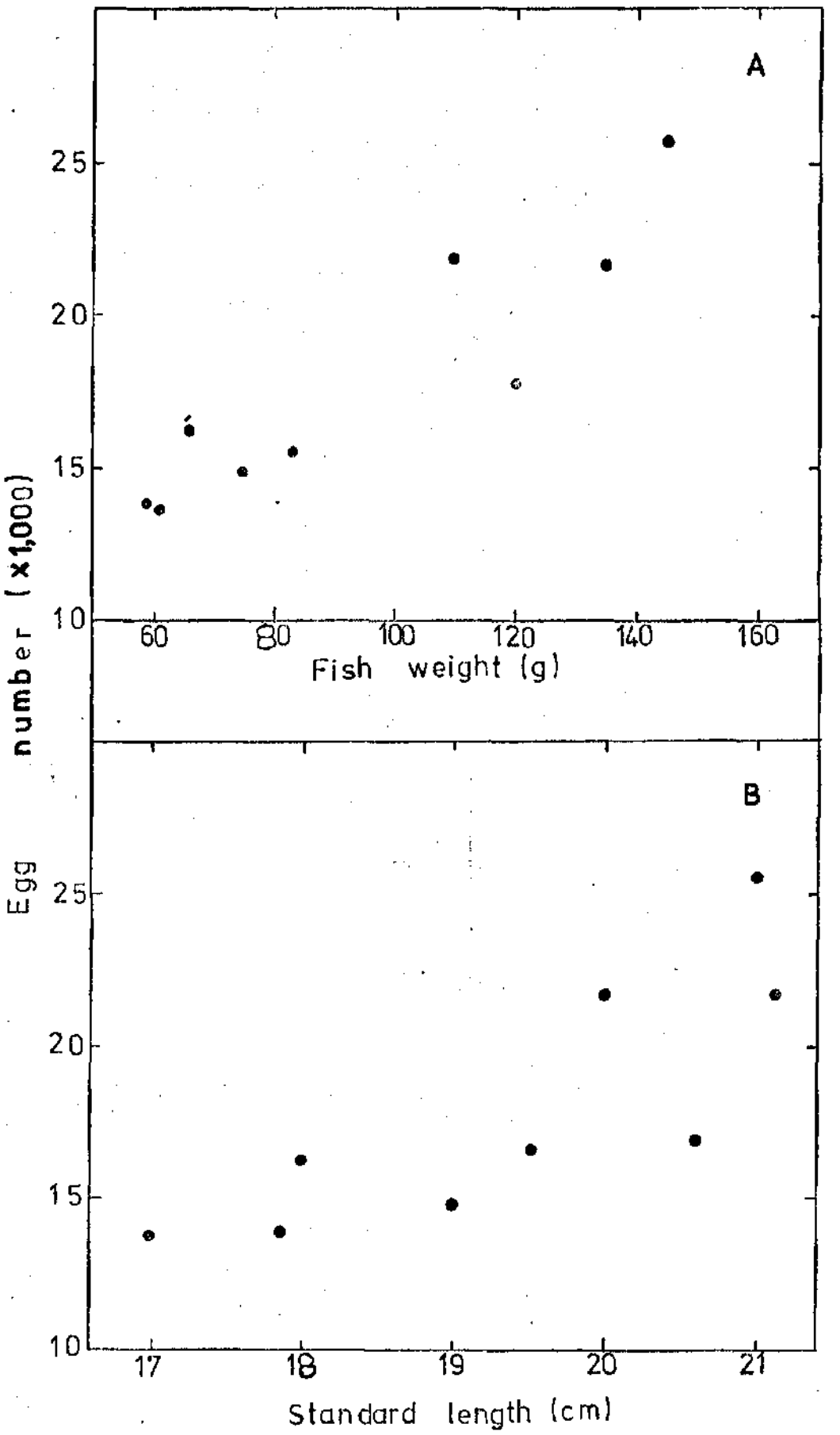


Fig. 5. 3. (Eutropius niloticus.) Relationship of egg numbers to weight and length of fish.

W = Weight of the fish (g).

L. = Standard length of the fish (cm).

The weights of the fish did not include the gonad weights. Specimens of E. niloticus used were those captured during the breeding season when all stages of gonad maturity were available in samples. Table 5.6 and Appendix 35 show that there are no differences in the mean 'K' values for the males and females at different stages of gonad maturity. No difference was noticed either in the mean 'K' values between sexes. This shows that the fish remained in good condition both when in breeding and non-breeding condition.

B. REPRODUCTION IN SCHILBE MYSTUS

B.1. Size and sexual dimorphism.

The females were larger than the males of the same age. The largest female encountered was 23.5cm while the largest male was 16.8cm (Table 5.2). The male possesses a genital papilla which is very conspicuous in the second year of life and also during the breeding season. The size differences show that the females have faster growth rates than the males - a phenomenon which is common to all schilbeids in Lake Kainji.

B.2. Sex ratio

As in E. niloticus, fewer males were present in the population than the females. Of about 278 specimens examined 36 were males (ratio = 1:6.7) (Table 5.7). The sex ratio was found to vary from season to season. The number of females to male was high in November to January and in May. In subsequent months the number of females to a male in any month was less than seven. No males were found in August, September and October. The sex ratio

Table 5.6. Condition factor in relation to gonad stages of Eutropius niloticus.

Gonad stage	CONDITION FACTOR Range	mean	S.D	Total number examined
Female				
1	0.7 - 1.3	1.1	0.1	50
11	0.6 - 2.3	1.1	0.3	50
111	1.0 - 1.3	1.1	0.1	21
1V	1.0 - 1.4	1.2	0.2	8
V	1.1 - 1.3	1.2	0.1	4
V1	1.3 - 1.5	1.4	0.1	2
Male				
1	1.0 - 1.2	1.1	0.1	6
11	1.0 - 1.3	1.1	0.1	18
111	0.9 - 1.6	1.1	0.2	14
1V	1.0 - 1.3	1.1	0.1	6
V	-	-	-	-
V1	-	-	-	-

Table 5.7. Sex ratio of Schilbe mystus in Lake Kainji.

Age groups	Sex	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	TOTAL	Sex ratio M:F
0+	Female	6	21	22	13	21	11	13	6	-	1	5	1	120	1:10.9
	Male	-	-	-	1	3	5	1	-	-	1	-	-	11	
1+	Female	1	12	7	3	7	6	6	3	1	2	3	1	52	1:3.3
	Male	-	1	1	1	3	4	4	-	1	1	-	-	16	
2+	Female	2	7	4	4	5	4	3	6	1	5	5	2	48	1:6
	Male	-	-	-	-	2	1	2	1	1	1	-	-	8	
3+	Female	2	2	1	4	1	3	-	4	-	3	1	1	22	1:22
	Male	-	-	-	-	-	1	-	-	-	-	-	-	1	
TOTAL	Female	11	42	34	24	34	24	22	19	2	11	14	5	242	1:6.7
	Male	-	1	1	2	8	11	7	1	2	3	-	-	36	
Sex ratio	M : F	0:11	1:42	1:34	1:12	1:4.3	1:2.2	1:3.1	1:19	1:1	1:3.7	0:14	0:5	1:6.7	

in each age group also varies. The ratio of the 3+ fish is not reliable in view of the few specimens examined.

B.3. Age and size at maturity.

Analysis of the age and size at maturity on Table 5.8 shows that the females attained maturity around a standard length of 14.9cm which corresponds to the second year of life. In the males, maturity was attained during the first year of life with a standard length of 9.3cm. It is likely that the males and females will breed more than once during their life span.

B.4. Reproductive cycle.

Very few mature males and females were found in the samples during the course of this work. The maturation and depletion of gonads were recorded monthly. Table 5.9 shows that mature females were present in the months of May to August while mature males were found in the sample from April to July. This suggest that the males attain maturity earlier than the females, but this observation should be taken with caution in view of the limited number of specimens. Analysis of age and maturity (Appendices 33 & 34) confirms that the females do not mature until at least their second year of life; whereas the males mature in their first year. The spawning period when fully matured gonads (IV) and spent/recovered females (VI) were seen in the samples were July and August, the end of the drawdown period and in the rainy season. Although the fish attains breeding condition in the lake, it seems from the available data that spawning does not actually take place in the lake. This is evident from the fact that no running male and females, or spent males were found in the samples.

Table 5.8. Size at maturity of Schilbe mystus in Lake Kainji.

Gonad maturity stages	9.0 - 9.4	14.5 - 14.9	15.0 - 15.4	15.5 - 15.9	16.0 - 16.4	16.5 - 16.9	17.0 - 17.4	17.5 - 17.9	18.0 - 18.4	18.5 - 18.9	19.0 - 19.4	19.5 - 19.9	TOTAL
Female													
111		1	2			2				1	-		6
1V		-	-			1				-	-		1
V		-	-			-				-	-		-
V1		-	-			-				1	1		2
TOTALS		1	2			3				2	1		9
Male													
111	1	1	1	1									4
1V	-	-	1	-									1
V	-	-	-	-									-
V1	-	-	-	-									-
TOTALS	1	1	2	1									5

Table 5.9. Seasonal occurrence of different stages of gonads in samples of S. mystus.

Gonad stages	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	TOTALS
Female													
1	1	27	16	22	11	6	3	5	-	1	2	-	94
11	10	15	18	2	23	18	19	13	2	8	6	5	139
111	-	-	-	-	-	-	-	1	-	1	3	-	5
1V	-	-	-	-	-	-	-	-	-	1	1	-	2
V	-	-	-	-	-	-	-	-	-	-	-	-	-
V1	-	-	-	-	-	-	-	-	-	-	2	-	2
TOTALS	11	42	34	24	34	24	22	19	2	11	14	5	242
Male													
1	-	1	1	2	6	6	4	1	1	-	-	-	22
11	-	-	-	-	2	5	1	-	-	1	-	-	9
111	-	-	-	-	-	-	2	-	1	1	-	-	4
1V	-	-	-	-	-	-	-	-	-	1	-	-	1
V	-	-	-	-	-	-	-	-	-	-	-	-	-
V1	-	-	-	-	-	-	-	-	-	-	-	-	-
TOTALS	-	1	1	2	8	11	7	1	2	3	-	-	36

B.5. Egg sizes and spawning periodicity.

The size frequency of occurrence of eggs from gonads of two matured fish plotted on Figure 5.4 shows two peaks for each fish. The major peak represents fully mature eggs which were to be shed during the spawning period that year and the minor peak represents small, immature eggs which presumably will not be shed but will be re-absorbed.

B.6. Fecundity.

Only two fish with fully matured gonads (stage lV) were found in the samples during the study. Fecundity estimated from these two specimens shows that for a fish with standard length 16.5cm the fecundity is $9037^{+}_{-}483$ while a fish with standard length 16.6 cm is $9088^{+}_{-}650$. Conversion of these into egg per gram of wet weight of ovary shows the following results respectively 3366/g of ovary and 3059/g of ovary.

B.7. Fish condition and maturation of gonads.

In S. mystus the weight (= weight used in calculating 'K' values) of the female fish in stages 1 & 11 and all males included the gonad weights. Table 5.10 and Appendix 36 show that there is no differences in the mean values obtained for both sexes at different stages of gonad maturity and the fish were in good condition during the breeding and non-breeding periods.

C. REPRODUCTION IN PHYSAILIA PELLUCIDA.

C.1. Size and sexual dimorphism.

The females grow to a larger size than the males. The females grow to a standard length of about 13.0cm while the maximum standard length observed in the males was 12.0cm

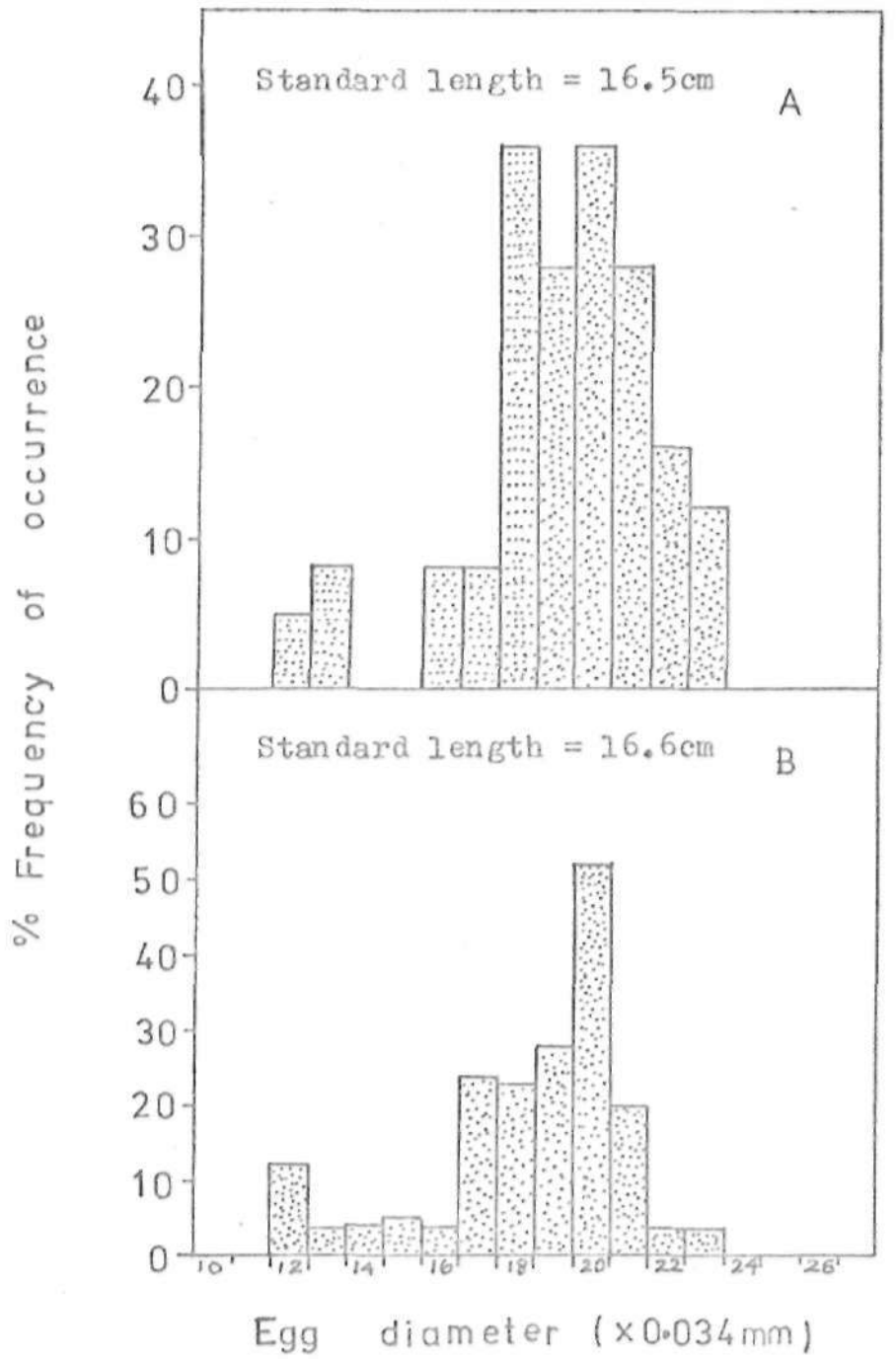


Fig. 5.4. (Schilbe mystus.) Frequency of egg sizes.

Table 5.10. Condition factor in relation to gonad stages of Schilbe mystus.

Gonad stages	CONDITION FACTOR Range	mean	S.D	Total number examined.
Female				
1	0.9 - 1.5	1.1	0.1	80
11	1.0 - 2.1	1.2	0.2	80
111	1.2 - 1.4	1.3	0.1	4
1V	-	1.2	-	1
V	-	-	-	-
V1	-	1.2	-	1
Male				
1	1.0 - 1.8	1.2	0.2	25
11	1.0 - 1.5	1.2	0.1	13
111	1.1 - 1.4	1.2	0.1	4
1V	1.2 - 1.3	1.3	0.1	2
V	-	-	-	-
V1	-	-	-	-

(Table 5.2). The males thus appeared to have a slower growth rate than the females of the same age (see also Chapter Three).

In the male a conspicuous genital papilla is often found in both matured and immature individuals. The papilla is absent in the females. In females matured ovaries occupied about 80% of the abdominal cavities.

C.2. Sex ratio.

The sex of young P. pellucida was very difficult to determine. However in about 1260 specimens whose sexes were recognised 1037 were females and 223 were males. These gave a ratio of 4.7 females to 1 male (Table 5.11). The monthly sex ratio (Table 5.11) shows that the sex ratio ranges from 1:2.4 to 1:8.9. However, apart from the months of April, September and October when the sex ratio was high (1:8.9, 1:6 and 1:7.2 respectively), there seems to be little variation in the sex ratio during the other months in the year. Table 5.12 shows changes in the sex ratio of Physailia pellucida with sizes of the fish. Below 6.0cm S.L., there were more males than females in the population. Above this length and up to 8.4cm there were more females than males. Between S.L 8.5 to 9.9 the sex ratio was even. The number of females to males increased again between S.L 10.0cm up to 12.4cm. No males were found above 12.5cm standard length.

C.3. Size at maturity

Table 5.13 shows the size groups of P. pellucida with matured gonads. From the table, it can be seen that the males and the females mature within almost the same length group. The standard length of the smallest matured female was 5.3cm while that of male was 5.2cm. Although it seems that they mature at the same length

Table 5.11. Sex ratio of Physailia pellucida in Lake Kainji.

Sex	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug+	Sept	TOTAL
Females	231	90	145	92	113	91	62	0	0	7	158	48	1037
Males	32	19	29	17	21	21	7	0	1	3	65	8	223
Totals	263	109	174	109	134	112	69	0	1	10	223	56	1260
Ratio (M:F)	1:7.2	1:4.7	1:5	1:5.4	1:5.4	1:4.3	1:8.9	0	1:0	1:2.3	1:2.4	1:6	1:4.7

+ gill net and mid-water trawling catches.

Table 5.12. Changes in sex ratios of Physailia pellucida with sizes.

Size classes (cm)	5.0 – 5.4	5.5 – 5.9	6.0 – 6.4	6.5 – 6.9	7.0 – 7.4	7.5 – 7.9	8.0 – 8.4	8.5 – 8.9	9.0 – 9.4	9.5 – 9.9	10.0 – 10.4	10.5 – 10.9	11.0 – 11.4	11.5 – 11.9	12.0 – 12.4	12.5 – 12.9	13.0 – 13.4
Females	2	35	162	206	50	15	13	7	24	52	133	123	81	26	4	3	1
Males	11	47	24	3	1	1	2	6	24	45	34	15	8	1	1	–	–
Total examined	13	82	186	209	51	16	15	13	48	97	167	138	89	27	5	3	1
Sex ratio (M : F)	1:0.2	1:0.7	1:6.8	1:68	1:50	1:15	1:6.5	1:1.1	1:1	1:1.2	1:3.9	1:8.2	1:10.1	1:26	1:4	0:3	0:1

Table 5.13. Size at maturity of Physailia pellucida in Lake Kainji.

Gonad stages	Size classes (cm) 5.0 - 5.4	5.5 - 5.9	6.0 - 6.4	6.5 - 6.9	7.0 - 7.4	7.5 - 7.9	8.0 - 8.4	8.5 - 8.9	9.0 - 9.4	9.5 - 9.9	10.0 - 10.4	10.5 - 10.9	11.0 - 11.4	11.5 - 11.9	12.0 - 12.4	12.5 - 12.9	13.0 - 13.4	TOTALS
Female																		
111	1	19	91	117	18	4	-	-	2	11	19	28	16	9	2	-	-	337
1V	-	4	39	39	10	1	-	-	1	10	24	22	15	5	-	-	1	171
V	-	-	11	15	6	-	-	-	-	-	4	1	4	2	-	-	-	43
V1	-	3	4	2	-	-	-	-	-	-	1	-	-	-	1	-	-	11
TOTALS	1	26	145	173	34	5	-	-	3	21	48	51	35	16	3	-	1	562
Male																		
111	5	27	12	1	1	-	-	-	5	9	6	2	-	-	-	-	-	68
1V	1	7	5	1	-	-	-	1	4	6	5	-	-	-	-	-	-	30
V	-	-	-	-	-	-	-	-	-	1	-	1	1	-	-	-	-	3
V1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TOTALS	6	34	17	2	1	-	-	1	9	16	11	3	1	-	-	-	-	101

groups, the majority of the males mature at a slightly lower length than the females. Only one female reached maturity at a S.L between 5.0 - 5.4 while more males matured around this length. About 40% of the males observed reach maturity below S.L 6.0cm while in the females only 4.8% reach maturity at a standard length below 6.0cm. The males and females probably reach maturity during their first year of life.

C.4. Reproductive cycle.

The percentage of fish observed with various maturity stages of gonads are as seen in Figure 5.5. This figure shows clearly that there is a prolonged breeding season. Breeding condition is attained towards the end of the rainy season in July/August but fish with running gonads (stage V) were not found in the samples until later at the beginning of the dry season in October. Spawning activities are continued throughout the dry season until the beginning of the next rainy season when it comes to an end in February/March. In the months of May and June only one immature male specimen was found in the samples. The probable reasons for the low number during this period were discussed in Chapter Two.

C.5. Egg sizes and spawning periodicity.

The size frequency histograms of the preserved eggs (Figure 5.6) show more than one peak in all the specimens examined. This also indicates that spawning occurs more than once during the prolonged breeding season.

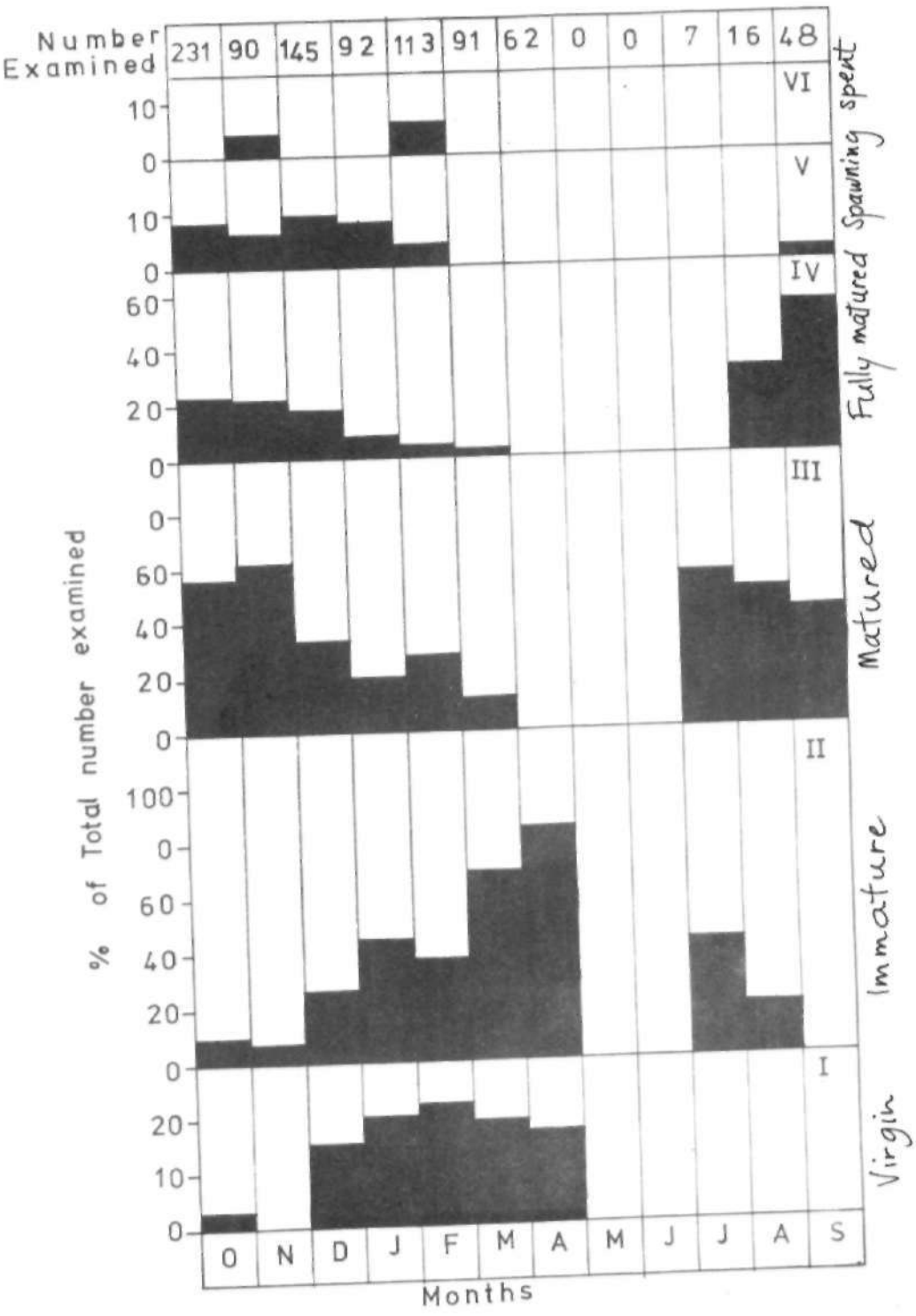


Fig. 5.5a. (Physailia pellucida.) Cycle of maturation and depletion of female gonads.

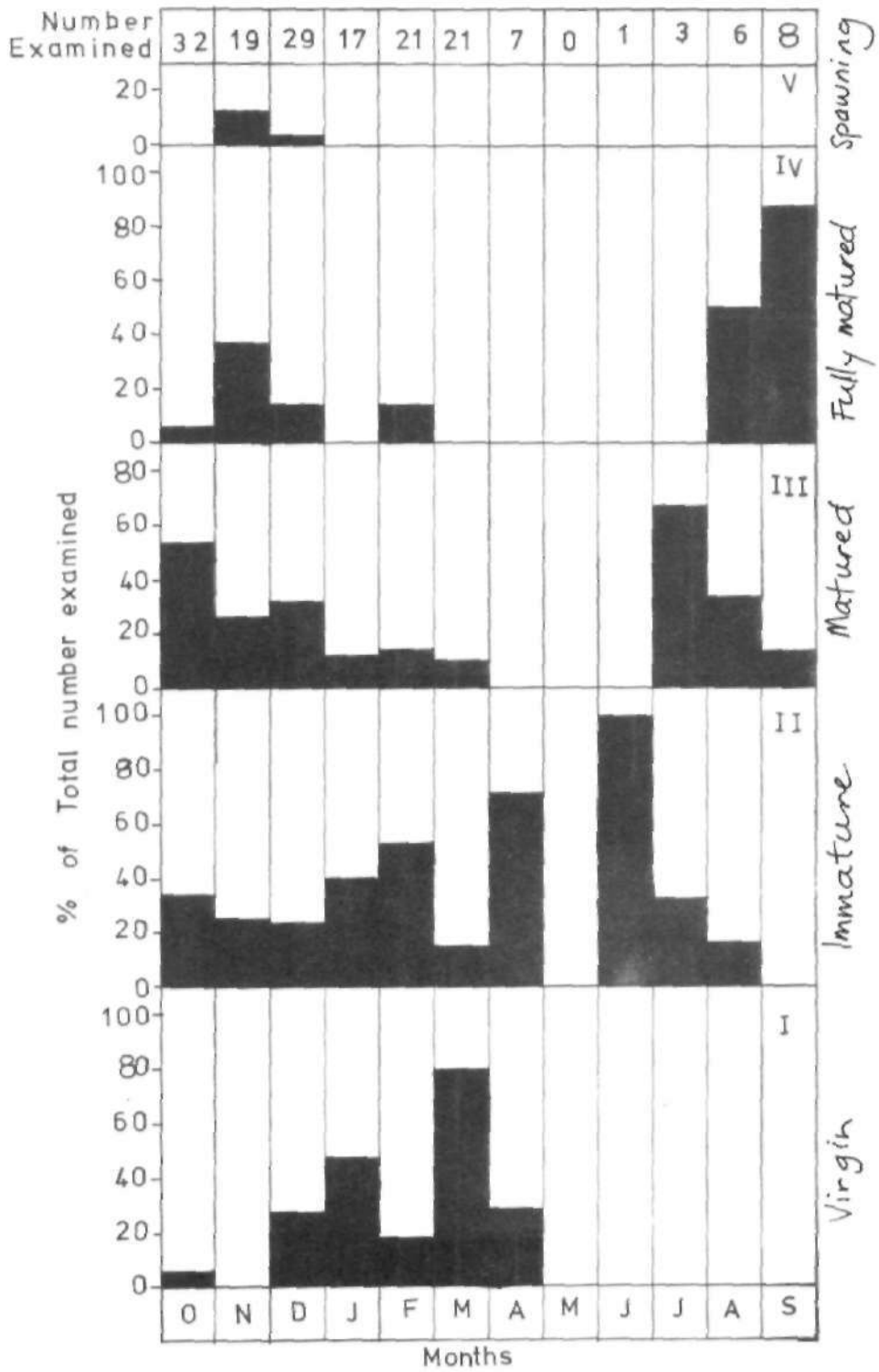


Fig. 5.5b. (Physailia pellucida.) Cycle of maturation and depletion of male gonads.

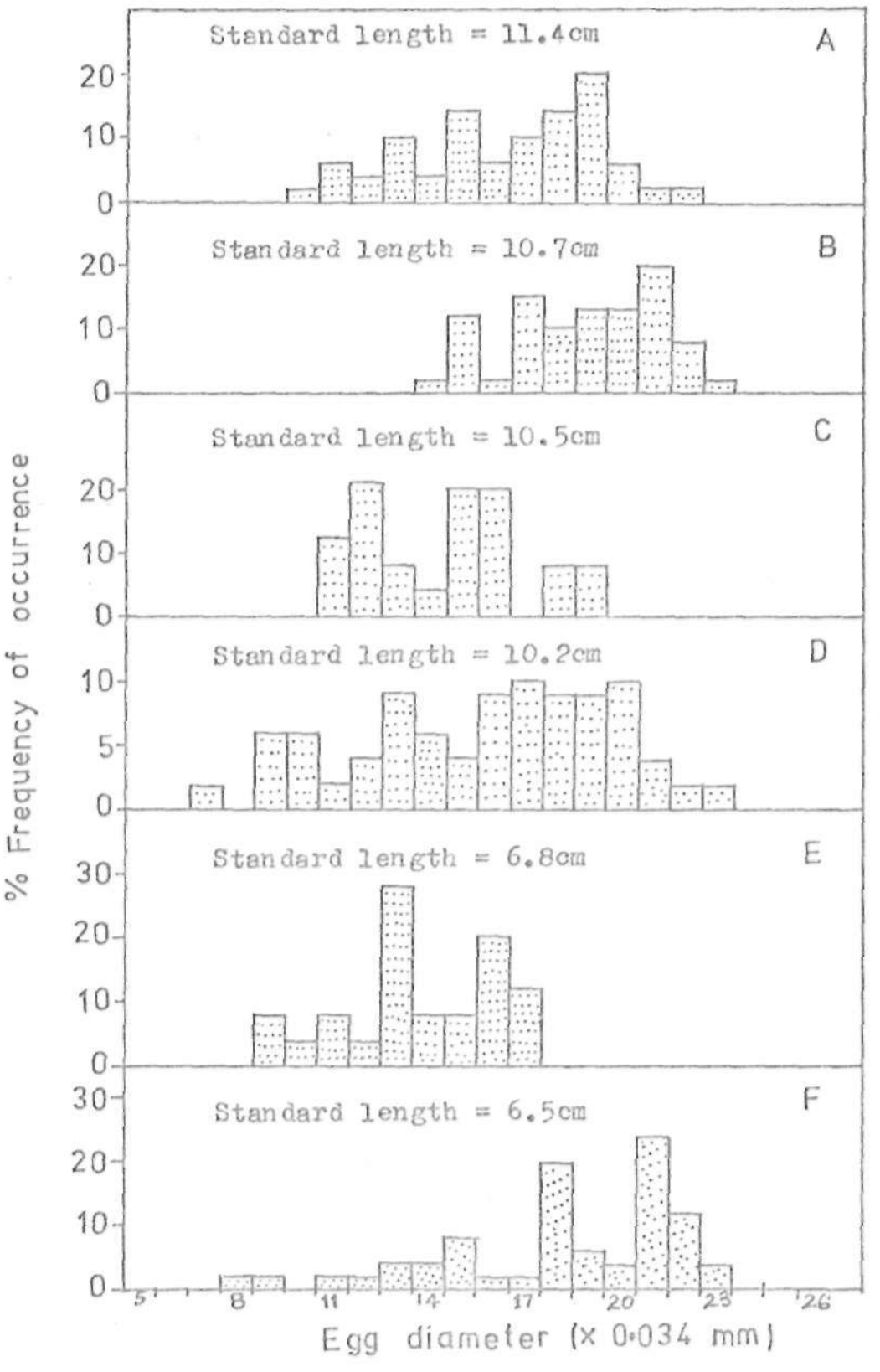


Fig. 5.6. (Physailia pellucida.) Frequency of egg sizes.

C.6. Fecundity.

The fecundity (Table 5.14) ranges from 1,145±58 to 3,923± 439. The fecundity of the smaller size class is low and less variable while those of the larger size class is high and very variable. The correlation co-efficient (r) was calculated. For fecundity-length relationship, r = 0.659, P = 0.01; for fecundity-weight relationship, r = 0.700, P = 0.01 (Fig. 5.7). Usually, it seems that little or no variations occur in fish spawning for the first time (i.e. those in lower length groups); while in those which have spawned more than once wide variations often occur. Fagade & Olaniyan (1972) also noticed a similar relationship in Ethmalosa fimbriata.

C.7. Fish condition and maturation of gonads.

In calculating the 'K' values for both males and females, the weights of the fish included the weights of the gonad. This was done in view of the fact that the weights of the gonads were too small to make any significant changes to the calculation of the 'K' values.

The results on Table 5.15 and Appendix 37 show that there were no significant differences in the condition of males and females at different stages of gonad maturity, and the fish were in good condition irrespective of their sex or maturation stage.

D. REPRODUCTION IN SILURANODON AURITUS

The females were larger than the males. The largest female in the sample was with a standard length of 11.2cm while the largest male was 9.4cm (Table 5.2). The male possesses a genital papilla.

Table 5.14. The fecundity of Physailia pellucida in Lake Kainji.

S.L. of fish (cm)	Wt. of fish (g)	Gonad wt. (g)	Total Fecundity (mean of 5 determinations)	Standard deviation
6.2	2.2	0.15	1704	101
6.8	3.0	0.18	1204	96
6.8	3.0	0.23	1755	37
6.9	3.6	0.24	1655	229
7.0	4.0	0.48	1145	58
10.0	11.0	0.99	2267	230
10.2	9.0	0.75	1689	200
10.2	11.0	1.18	3370	254
10.3	10.0	0.93	3923	439
10.6	11.0	0.59	1697	198
10.7	12.0	0.82	1763	112
11.4	13.0	1.01	2847	285
11.5	14.0	0.93	3863	490
11.3	14.0	0.90	3519	248
11.6	11.0	0.64	2420	86

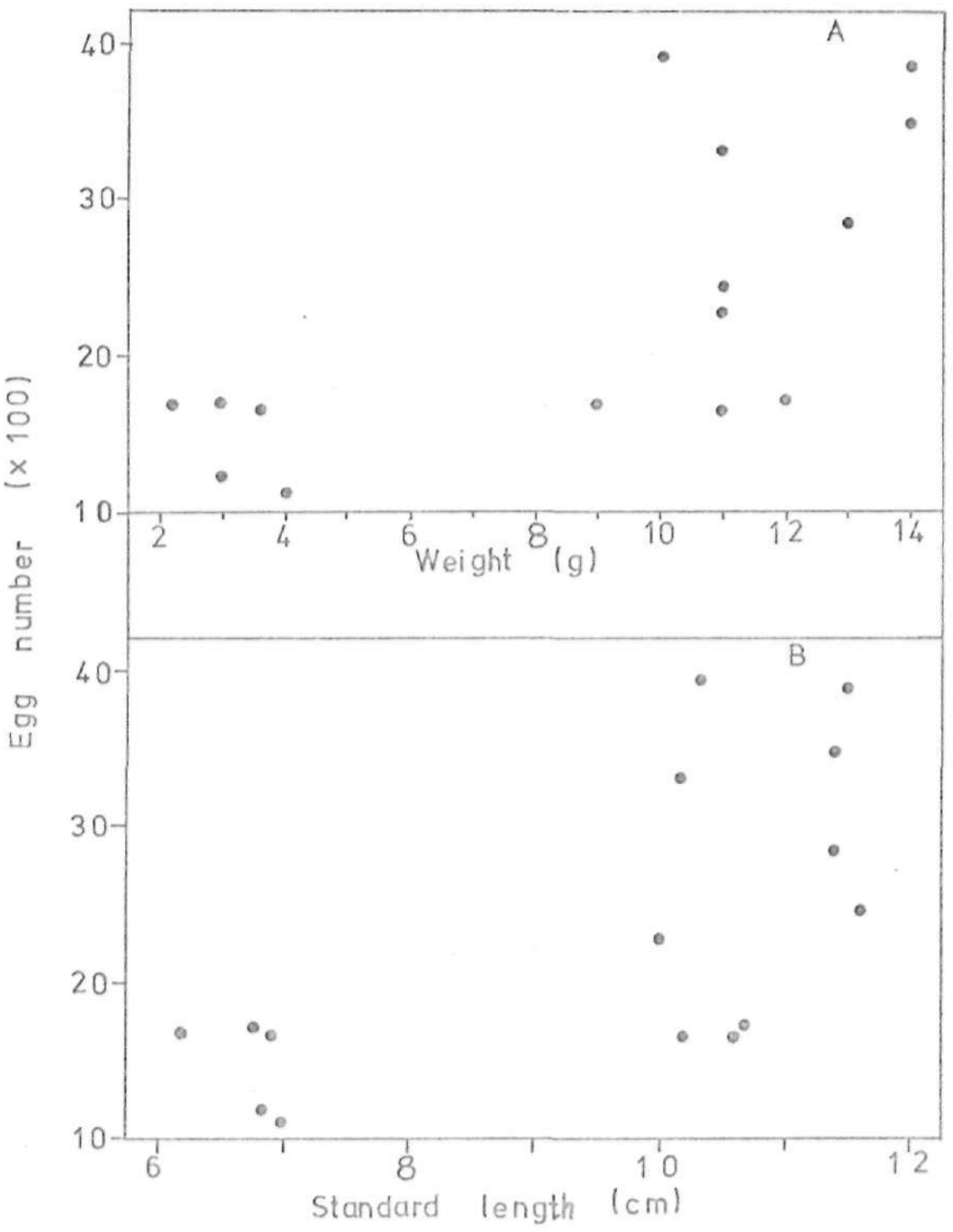


Fig. 5.7. (Physailia pellucida.) Relationship of egg numbers to weight and length of fish.

Table 5.15. Condition factor in relation to gonad stages of Physailia pellucida.

Gonad stages	CONDITION FACTOR Range	mean	S.D	Total number examined
Female				
1	0.6 - 1.2	0.9	0.2	89
11	0.6 - 1.2	1.0	0.1	100
111	0.6 - 1.5	0.9	0.2	100
1V	0.7 - 1.2	1.0	0.1	100
V	0.6 - 1.1	0.9	0.1	45
V1	0.7 - 1.1	0.9	0.1	10
Male				
1	0.7 - 1.3	1.0	0.2	35
11	0.7 - 1.3	0.9	0.2	35
111	0.4 - 1.3	0.9	0.2	32
1V	0.7 - 1.5	1.0	0.2	25
V	-	0.8	0.0	3
V1	-	-	-	-

Of about 48 specimens observed, the sex of 41 could be determined. Of these, 2 were males and 39 were females. Unlike the other schilbeids which showed differences in the length at which the males and females attain maturity, no size difference was noticed in Siluranodon auritus. The standard length of the smallest mature fish of each sex was 9.0cm (Table 5.16). Reynolds (1974) noticed that males and females attained maturity in Lake Volta at a standard length of 11cm.

Irregularity of specimens in samples makes the reproductive cycle very difficult to follow within a complete year, but it will be recalled that S. auritus is restricted to a few inlets to the lake (Chapter Two). Since about 85% of the specimens caught were mature (Table 5.17), it is likely that the fish migrate from the river to spawn in the lake and as 91% of the mature males and females were caught in the months of August and September, these months can be taken as the peak periods of breeding activity.

The fecundity (Table 5.18) ranges from 1249 to 1655 with a mean of 1451 ± 119. The overall data did not suggest an increase in fecundity with an increase in length or weight of fish (Fig. 5.8). Correlation co-efficients for both fecundity-length and fecundity-weight relationships were calculated; r = 0.046 and 0.263 respectively.

5.0.4. D I S C U S S I O N

Most tropical fish species are known to breed during the rains when the water level is high. Daget (1954), for example, observed it in the Upper Niger, Blache (1964) in Lake Chad, Reed et al (1967) in rivers of Northern Nigeria, Wellcome (1969) and Okedi (1969) in East African Lakes. Before the impoundment of the Middle Niger in 1968, studies conducted by Banks et al (1965),

Table 5.16. Size at maturity of Siluranodon auritus.

Gonad stages	Size classes (cm) 9.0	9.3	9.4	9.5	9.6	9.7	9.8	9.9	10.0	10.1	10.2	10.3	10.4	10.5	10.6	11.2	TOTAL
Female																	
III	-	-	-	-	1	-	2	2	5	-	-	1	-	1	-	-	12
IV	2	1	-	3	-	2	1	1	2	-	-	-	2	1	-	1	16
V	1	-	-	-	-	-	2	-	-	-	1	-	-	-	1	-	5
TOTALS	3	1	-	3	1	2	5	3	7	-	1	1	2	2	1	1	33
Male																	
IV	1	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	2

Table 5.17. Seasonal occurrence of different stages of gonads in samples of Siluranodon auritus.

Gonad stages	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	TOTALS
Female													
1	-	-	-	-	-	2	-	-	-	-	-	-	2
11	-	-	-	-	-	1	-	-	-	1	2	-	4
111	1	1	1	-	-	-	-	-	-	1	4	4	12
1V	-	-	-	-	-	-	-	-	-	-	9	7	16
V	-	-	-	-	-	-	-	-	-	-	1	4	5
TOTALS	1	1	1	-	-	3	-	-	-	2	16	15	39
Male													
1V	-	-	-	-	-	-	-	-	-	-	1	1	2

Table 5.18. The fecundity of Siluranodon auritus in Lake Kainji.

S.L. of fish (cm)	Wt. of fish (g)	Gonad wt.(g)	Fecundity
9.0	10	0.45	14.5
9.5	8	0.46	1455
9.5	11	0.57	1630
9.5	11	0.46	1477
9.7	10	0.40	1376
9.7	10	0.38	1367
9.8	10	0.32	1249
10.0	11	0.39	1340
10.0	11	0.55	1601
10.4	12	0.66	1655
10.4	11	0.46	1481
10.5	11	0.38	1350
10.6	13	0.51	1521
11.2	14	0.38	1398

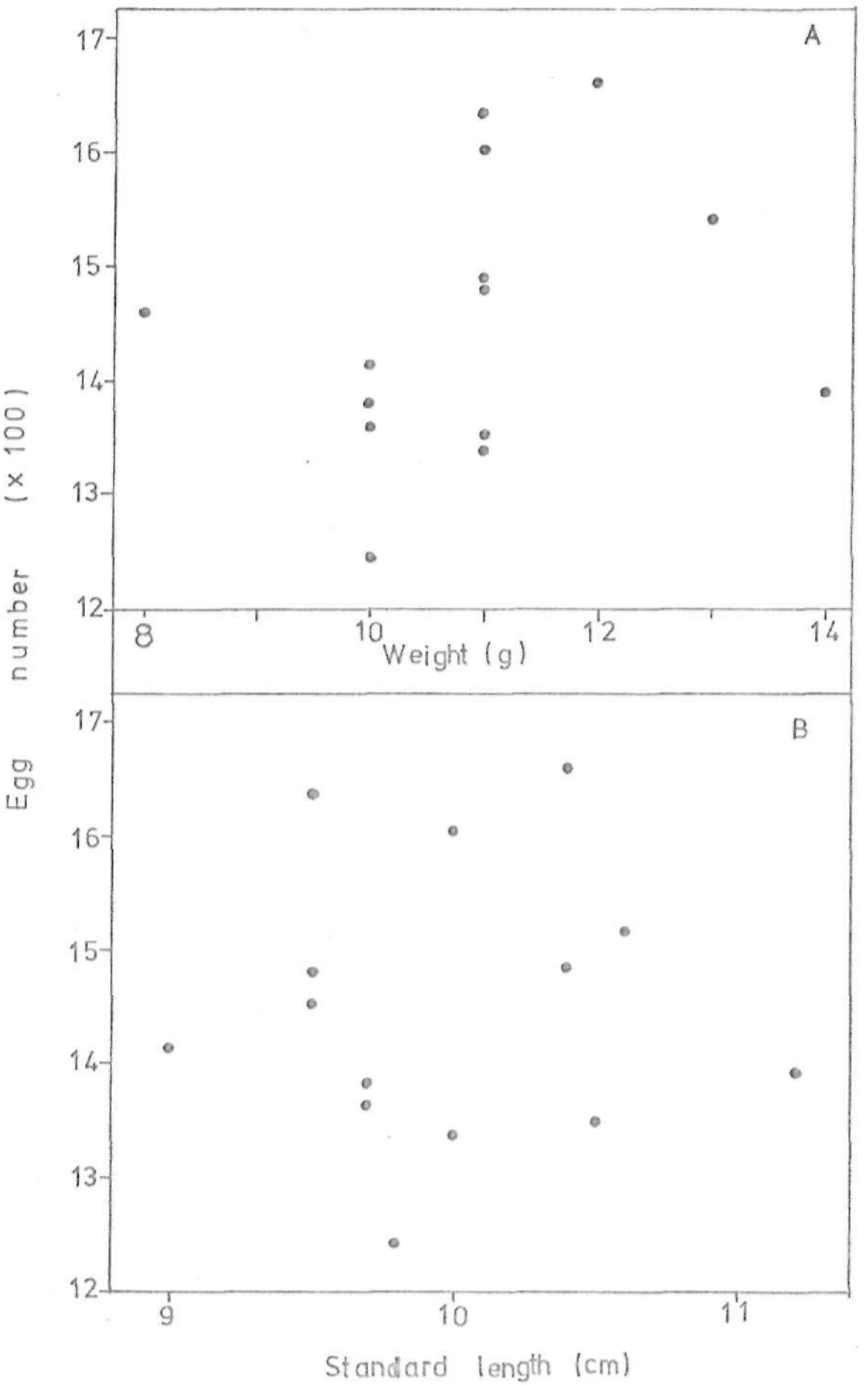


Fig. 5.8. (Siluranodon auritus.) Relationship of egg numbers to weight and length of fish.

Imevbore (1970b) and Motwani & Kanwai (1970) revealed that several species of fish, including the schilbeids, breed during the rainy season. At that time breeding took place mostly between June and September during an annual cycle and the swamps served as spawning grounds. The swamps were also found to offer food and protection for the young fish (Imevbore & Bakare, 1974). After the formation of the lake, it was found that the breeding season for most species remained virtually the same (Imevbore & Okpo, 1975; Willoughby, 1974; Lewis, 1973a and Lelek, 1972) despite the changes in the environment.

Previous observations on the reproductive biology of the schilbeids in the Niger and the Lake are very few. The only information available on the reproductive biology of the schilbeids in the Niger is that of Imevbore (1970b) who gave information on sex ratio and fecundity of a very few E. niloticus and Schilbe mystus. Lelek (1972) also published some information on gonad development in E. niloticus and S. mystus during the initial period of the formation of the lake. Unfortunately, no information on other species of the schilbeids is available for comparison with this work.

In other water bodies, Greenwood (1957) observed that S. mystus in Lake Victoria breeds during the local rains. In Lake Volta, E. niloticus was found to spawn in June and July which also coincide with the rainy season (Reynolds, 1967). Reynolds (1974) also observed that P. pellucida breeds almost throughout the year with two peak periods of breeding activities, the first between July and October and the second in February. For Siluranodon auritus, Reynolds (1974) found ripe gonads from August to February but in this study ripe gonads were found in the months of July to December. In Lake Chad, E. niloticus breeds

at the start of the floods (Blache, 1964). In the Upper Niger S. mystus spawns during the flood (Daget, 1954). Reed et al (1967) found gravid females of E. niloticus and S. mystus in July and August during the rains. All the studies cited above show similar breeding seasons to the Kainji species investigated.

In Lake Kainji, the males mature at lower lengths than the females. Reynolds (1974) noted that the males of the pelagic fish of Lake Volta including P. pellucida mature at a smaller size than the females. This was also noted in Eutropius depressirostris by Groenewald (1964) and S. mystus and E. niloticus in the River Niger before the impoundment (Imevbore, 1970b). The same phenomenon was noted in Barbus by Qasim & Qayyum (1964) and Reynolds (1973, 1974) and in many clupeids by Reynolds (1974), Ben-Tuvia (1960) and Mathur (1964). The proportion of mature fish in the samples was small when compared wtih the number of non-mature fish. It was also noticed that not all the fish which have attained breeding age or size were actually in breeding condition. This shows that the minimum age or size at maturity quoted earlier may not apply to every specimen. The attainment of maturity is therefore controlled by innate physiological conditions and environmental factors which seem not to be age or size dependent.

The high sex ratio in E. niloticus between August and November (Table 5.3) is associated with breeding activities. During the breeding season, more females are expected to associate with males particularly in a situation where there are few males in the population. A preponderance of females during the breeding season was also seen in Hilsa ilisha by Mathur (1964) in Opisthopterus tardoore by Radharkrishnan (1963) and in Mystus aor by Saigal (1964). In S. mystus a high sex ratio was found during

the non-breeding season. The reason for this might be associated with sampling variations or the behaviour pattern of the fish which might be different from that of E. niloticus. In Siluranodon auritus only two males were captured and nearly all the females captured were gravid. This might indicate sexual segregation with females arriving at the spawning grounds before the males (Ehrenbaum, 1909; Scheuring, 1929), although in some fish e.g. Catostomus sp. and Semotilus sp. the males arrive first (Lagler et al, 1962). In P. pellucida wide variations in sex ratio did not occur throughout the year. Imevbore (1970b) noted more males than females in S. mystus and an almost 1:1 ratio in E. niloticus collected from the Coffer dam area of River Niger. Reynolds (1974) found more males than females in Siluranodon auritus and the opposite in P. pellucida of the Lake Volta in Ghana. The preponderance of females in species other than the schilbeids has been reported in some freshwater species in tropical and temperate countries. Willoughby (1974) noted this in some species of Synodontis while Reynolds (1974) recorded the same in clupeids and Barbus species. In the temperate region Penczak (1967) and Lelek (1959) recorded more females than males in Leuciscus leuciscus and Squalius cephalus respectively. Preponderance of the females may be an adaptation for the survival of the species in their new environment; since the more the females, the higher their population fecundity. This is however based on the assumption that one male is capable of fertilizing eggs from several females. Sex ratio divergencies might also be explained by partial segregation of ripe forms, either through habitat preferences or in school formation, thus one sex might become more vulnerable to capture than the others (Reynolds, 1974).

Analysis of egg sizes and the reproductive cycle show that

Physailia pellucida is unique among the schilbeids of Lake Kainji. Unlike the other species which spawn once during a short annual breeding season, P. pellucida was found to spawn several times during the prolonged breeding season. Most species with a prolonged spawning season are fractional spawners. Reynolds (1974) observed that P. pellucida in Lake Volta is a fractional spawner. Fractional spawning and prolonged spawning seasons are characteristics of some tropical and subtropical species of fish. In temperate water only a small number of fish exhibit fractional spawning, while none exist in the Arctic region (Nikolsky, 1963). Fractional spawning has evolved in some species as an adaptation to food supply. According to Nikolsky (1963) it also ensures the preservation of the species under unfavourable spawning conditions.

Apart from Siluranodon auritus, all the other species show an increase in fecundity with an increase in length and weight of the fish. This is a general trend in most fishes (see Bagenal, 1957, 1966; Pope et al, 1961; Pitt, 1964; Fagade & Olaniyan, 1972; Mann, 1973, 1974). In Siluranodon auritus, very narrow variations exists among the lengths and weights of specimen examined (Table 5.18) and this is thought to account for the narrow variations in their fecundity. Thus no general increase in fecundity was observed with increase in length or weight of fish. A similar situation was found in Ictalurus melas by Dennison & Bulkley (1972). There are a number of factors which determines the total fecundity of a fish but these factors are found to vary from one fish to another. Generally, the following have been found to have some influences on the number of eggs to be produced by the individuals.

(a) Egg laying habits and care of the young :- Viviparous species and species exercising parental care produce less eggs than those species which broadcast their eggs and leave

them unattended.

(b) Egg sizes/size of fish :- In some Salmonidae those with large eggs produced fewer eggs than those with smaller eggs. The fecundity of fish is also related to the variation in size of fish. Egg numbers increase with increase in size of fish (see also previous section).

(c) Geographical location :- Variations have been found in the same species of fish located on different latitudes e.g. Pike (Nikolsky, 1963).

(d) Food supply :- Well fed fish have larger fecundity than starving fish (Bagenal, 1969; Scott, 1962).

Scott (1956) studied egg size and egg number in trout, Salmo gairdnerii found that only egg sizes are genetically controlled while the egg number varies with environmental and physiological conditions. A comparison of the total fecundity of the schilbeids with some other common catfishes in the Family Mochokidae in Lake Kainji shows that the fecundity of the schilbeids is generally low (Table 5.19).

Breeding grounds and actual spawning were not observed for any of the schilbeid species because of the gill net method of capture. Although mature fish and fish with running gonads were found in the Lake, it is not known whether the fish actually spawn in the lake or migrate to adjacent inlets to spawn. Daget (1954) in his study of the fish species of the Upper Niger observed migration of breeding fish from the river to the swamps to spawn. Blache (1964) also observed that E. niloticus in Lake Chad made seasonal migration to the river to spawn. It is not known whether the schilbeids still undertake such migrations after the creation of the lake. Since mature and running specimens of E. niloticus and P. pellucida were found in samples it is likely

Table 5.19. Comparison of the fecundity of Family Schilbeidae with other Catfishes in the Family Mochokidae.

	No examined	Standard Length (cm)	Range of Estimated fecundity	Number of eggs per gram wet weight of Ovaries	Source
Synodontis batensoda	5	15.0 - 18.2	6850 - 20400	2445	Lake Kainji (Willoughby, 1974)
S. schall	99	15.0 - 26.0	7130 - 73000	1800	"
S. nigrita	35	10.0 - 13.5	952 - 11400	1421	"
S. membranaceous	8	29.0 - 31.9	33700 - 179000	1825	"
S. ocellifer	150	12.0 - 17.1	3500 - 72200	2292	"
Silurenodon auritus	14	9.0 - 11.2	1249 - 1655	-	**This study**
P. pellucida	15	6.2 - 11.6	1204 - 3923	-	"
E. niloticus	9	17.0 - 21.1	13,905 - 21841	2,044 - 2,710	"
Schilbe mystus	2	16.5 - 16.6	9037 - 9088	3059 - 3366	"
Schilbe mystus	2	27.0 - 28.4+	41,350 - 53,750	4289 - 7413	River Niger (Imevbore, (1970b)

+ Fork length

that these species have adapted to breeding and spawning in the lake, therefore such migration is not likely to take place. In the case of Schilbe mystus, migration from the lake to the river to spawn may occur. This is thought to be so in view of the few numbers of mature specimens in the samples. Moreover no individuals with running gonads were found in the lake during the breeding season. In Siluranodon auritus migration from the adjacent inlet to spawn in the lake was found to occur.

C H A P T E R S I X

The biochemical composition, nutritional value and exploitation of the schilbeids in Lake Kainji.

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6.0.1. I N T R O D U C T I O N

Very little is known of the biochemical composition of fresh-water fish from tropical Africa and it is only recently that interest in this area has been developed (see Deelstra, et al 1974; Andrian, 1957; Baruh and Gillard, 1959; Watts, 1957).

In Lake Kainji biological studies on most of the economically important fish families have been undertaken (references already cited) but their biochemical composition and nutritive values have not been determined.

The purpose of the investigation reported in this chapter is to examine some aspects of the biochemical composition of the three common schilbeid species in Lake Kainji and to attempt to evaluate their nutritive values.

6.0.2. M A T E R I A L S AND M E T H O D S

1. Methods of obtaining fish specimens

The method of obtaining fish specimens was by the small mesh nets which have been described in Chapter Two. Fish used for the determination of chemical composition were removed from the gill nets within a few minutes of being caught and were immediately transferred into an ice-chest containing crushed ice in order to prevent deterioration of the flesh. The fish were removed from the ice-chest in the laboratory and kept in a deep freeze until needed. All the fish used were frozen for no more than one week before analyses.

2. Determination of water content.

The frozen fish were thawed and the guts were removed; excess water on the external surface was dried with filter papers. The fish were separated into species. All the fish were weighed and

each species was arranged in separate enamel trays and dried in an oven at 80°C for 24 hours. The dried specimens were weighed in order to determine the amount of moisture lost. The specimens were ground into fine powder using a mortar and pestle and the powder for each species was preserved in labelled bottles for subsequent analyses.

3. Determination of the Ash content, Total organic matter and mineral elements.

Ash content was determined by incinerating about 10g of each powdered sample in a muffle furnace set at 800°C. The specimens were left in the furnace and frequently examined in order to know when complete ashing had been achieved. The weight of the ash content was recorded for each species.

The value for total organic matter was obtained by subtracting the ash weight from the weight of the powder incinerated (Lighstein & Oginsky, 1965).

Calcium, Copper, Iron, Magnesium, Potassium, Sodium and Zinc were determined. 5ml of distilled water plus four drops of conc. HCl were added to the ash collected. All were mixed until the ash was dissolved into the solution. The mixture was transferred into a 100ml volumetric flask and made up to the known volume with distilled water.

The elements were determined by the use of Atomic Absorption Spectro-photometer (Perkin-Elmer model 306) with digital read-out. Before using the spectro-photometer, the appropriate cathode lamp corresponding to the element to be determined was fitted. Already prepared standard solutions of each element were used to standardize the spectro-photometer before each determination.

4. Determination of proteins.

The protein contents of the specimens were determined from the total nitrogen which, in turn, was determined by the Kjeldahl method as recommended by the Association of Official Analytical Chemists (AOAC) (1965). The procedure was as follows:

0.1g of fish powder was weighed into a digestion flask. The following were added; 5g of Potassium sulphate, traces of Cupric sulphate and 25.0ml of Conc. Sulphuric Acid (H_2SO_4). The mixture was digested for at least 8 hours at 15.6°C (60°F). Four replicates including a blank were set up for each sample.

After digestion, 100ml of distilled water was poured into a volumetric flask which already contained anti-bumping granules. The digested sample was added to the water in the volumetric flask. Six drops of Methyl Red indicator and 100ml of 50% Sodium Hydroxide (NaOH) were added to the mixture. The four replicates were treated similarly and set up ready for distillation.

About 50ml of 0.1N H_2SO_4 were pipetted into a conical flask and two drops of Methyl Red were added. The conical flask containing the 0.1N H_2SO_4 was put in the position to collect the distillate from the mixture in the volumetric flask and distillation was carried out for 40 minutes.

The distillate collected into the flask already containing 0.1N H_2SO_4 was titrated with 0.1N NaOH until the pink colour changed to about light yellow.

5. Determination of Lipids.

The AOAC method of Lipid determination was used. Three replicates were set up for each sample. The procedure was as follows:

10g of the fish powder weighed into the thimble. The thimble and the contents were weighed. 500ml round bottom flask already

containing anti-bumping granules was weighed. About 300ml of Petroleum ether (boiling point 60° - 80°C) were poured into the round bottom flask. The thimble containing the powdered dry fish sample was introduced into the Soxhlet extractor, and boiled for at least six hours at 60°C. At the end of the extraction the thimble with its contents was removed, dried at 50°C for at least twenty-four hours and weighed. The amount of the lipid extracted was calculated from the differences in the weights. The solvent containing the extracted lipid was distilled off until only the lipids were left and the lipid so recovered was weighed.

6. Determination of Carbohydrates.

Carbohydrates were calculated by the difference method. The amount of protein plus lipid subtracted from the total organic matter is assumed to give value for carbohydrates.

6.0.3. R E S U L T S

The average values of the chemical composition are as seen in Table 6.1. In all the species, the protein contents are the highest followed by the lipids and carbohydrates in that order. Table 6.2 shows the average mineral contents in each species. As expected, Calcium formed the main bulk of the mineral pool. Potassium, Sodium and Magnesium also made significant contributions while the other elements contributed very little to the mineral reserve in the fish. Calories have been calculated using conversion factors, 5.5 KCal/g for protein, 4.1 KCal/g for carbohydrates and 9.5 KCal/g for lipids (Winberg, 1971). Table 6.3 shows the calorific values of the three species. Physailia pellucida had the highest calorific value while Schilbe mystus had the lowest.

Table 6.1. Chemical composition of the schilbeids.

SAMPLES	AVERAGE CHEMICAL COMPOSITION g/100g of wet weight: Water	g/100g of dry weight: Ash	Organic matter	Lipid	Protein	Carbohydrate
Physailia pellucida	70.4	8.8	91.2	34.3	47.0	9.9
Eutropius niloticus+	74.0	10.8	89.2	29.4	54.2	5.6
Schilbe mystus	72.4	11.7	88.3	32.3	40.7	15.3

Table 6.2. **Mineral contents in the schilbeids.**

	AVERAGE MINERAL CONTENTS mg / 100g of dry weight						
SAMPLES	Calcium	Copper	Iron	Magnesium	Potassium	Sodium	Zinc
Physailia pellucida	2800	2.7	6.8	122	472	250	16.5
Eutropius niloticus	3250	1.7	5.9	127.5	607	312.5	9.9
Schilbe mystus	3800	2.6	5.0	139	504	300	10.5

Table 6.3. Calorific values of schilbeids.

	K cal / 100g.			
	Lipids	Protein	Carbohydrate	TOTAL
Physailia pellucida	325.9	258.5	40.6	625.0
Eutropius niloticus	279.3	298.1	23.0	600.4
Schilbe mystus	306.9	223.9	62.7	593.5

6.0.4. D I S C U S S I O N

The results of this work show that the schilbeids in Lake Kainji are rich in lipid, protein and essential mineral elements; and are of high calorific value. In view of these the schilbeids can therefore be depended upon as rich source of food. The Clariidae and the Schilbeidae contain more fat than any other tropical freshwater fish (Lagler et al, 1962). Schilbeids are known for their palatability (per. observation; Greenwood, 1957; Reed et al, 1967) and are of commercial importance both in Nigeria (Reed et al, 1967) and outside Nigeria (Latif, 1976). Therefore the suggestion that the schilbeids should be used in the productio of organic fertilizers rather than direct consumption (Blake, 1977b) does not seem to be valid.

Market surveys around villages adjacent to the lake show that E. niloticus and S. mystus were of some commercial importance. Despite the large population of P. pellucida, they are not yet exploited in commercial quantity. The local fishermen have to change their fishery technique to trap this species. P. pellucida is strongly attracted to light (Reynolds, 1970; Otobo, per. comm.), thus the best method of capture is by the use of lift nets ("atalla") and light (Reed et al, 1967; Hickling, 1961). Personal observation showed that the fishermen below the dam used this method to capture the clupeids and P. pellucida in commercial quantity. A combination of light with other methods e.g. D.C. shocker, dip nets and gill nets have also been used successfully by some workers e.g. Lelek (1973) and Reynolds (1970). Mid-water trawlings are also very efficient for the capture of P. pellucida and other schilbeids as well (Otobo, per. comm.). All these methods, however, require more hands and capital. Instead of allowing the fish resource to waste away, the government can

organise the fishermen into co-operatives and support them with funds and other infra-structures. The long term effect of such support will be advantageous :- (1) The living condition of the fishermen will improve. (2) The fish will become available to more people at cheaper prices and (3) Improved storage and distribution facilities will enable fish to reach the consumer in good condition.

C O N C L U S I O N S

It seems that the creation of the lake has had little or no effect on the schilbeids. Comparison of the pre-impoundment studies (Banks et al, 1965; Imevbore & Bakare, 1970; Motwani & Kanwai, 1970) with this work show that the diets and the breeding seasons remain the same. Changes in the abundance of the species was, however, noted. There is upward trend in the abundance of P. pellucida and E. niloticus while the number of S. mystus is declining. The reasons for the present level of abundance have been fully discussed in Chapter Two. The significant contribution of the schilbeids to the total fish population in the lake depends on the populations of Physailia pellucida and Eutropius niloticus. While a major drastic change in the present levels of abundance is unlikely in the near future, with the inevitable reduction of Povilla adusta which now forms an important constituent of the diet of E. niloticus, the numbers of E. niloticus in the lake may fall drastically. It is hoped, therefore, that before such a catastrophe occurs, the bottom of the lake will be soft enough to habour immature stages of insects and probably oligochaetes and molluscs which, though not important in its diet now, may become of great value in the future. The future of the schilbeids depends on their success in spawning in the lake and surrounding rivers. At present there is only indirect evidence to indicate that spawning takes place in the lake. Until the spawning grounds are located and fish are actually caught in the act of spawning it is difficult to say emphatically that spawning actually takes place in the lake. The ability of P. pellucida to breed almost all round the year, the high fecundity of E. niloticus, its ability to colonize a variety of habitats in the lake coupled with

a rich supply of food will help them to maintain their high population for a long time to come. The low abundance of S. mystus was found not to be as a result of low fecundity or scarcity of food, but rather a result of its adaptation to lotic environments and its inability to breed successfully in the lake. The relatively small number of mature individuals in the samples suggests that S. mystus has not adapted to breeding in the lake and this account for the low abundance and the present distribution which is restricted to the riverine parts of the lake (see also Chapter Two). The data for Siluranodon auritus suggest that the fish migrate from the adjacent inlets (e.g. River Shagunu) to breed in the lake. This habit can be taken as a major step towards the colonization of the lake if the breeding and subsequent spawning are successful.

It can be concluded that E. niloticus and P. pellucida have fully adapted to the lacustrine environment by their ability to feed, breed and spawn in the lake while S. mystus and Siluranodon auritus have adjusted but little to the lacustrine habit. S. mystus feeds in the lake and the river but probably breeds in the river while Siluranodon auritus feeds in the river but breeds and spawns in the lake.

Market surveys show that E. niloticus and S. mystus are of some commercial importance. Although a high population of P. pellucida is found in the lake, they are not yet exploited in commercial quantity. Suggestions were given as to the method of harvesting and how the government can be of help (see Chapter Six). If my suggestions are considered, it is hoped that the schilbeids in conjuction with the clupeids and the Tilapia species will form the main bulk of commercial fisheries of Lake Kainji in future.

S U M M A R Y

The biology of the Family Schilbeidae (Osteichthyes : Siluriformes) in Lake Kainji, Nigeria was studied. Samples were obtained with static gill nets of various stretched mesh sizes ranging from 1.3cm to 17.8cm. Nets were set overnight and removed in the mornings. Eleven stations located at the central basin of the lake were sampled as frequently as practicable once a month between October 1974 and September 1976.

The Family Schilbeidae is known to be present only in tropical Africa and Asian freshwaters. In Africa eight genera with several species are present. In Lake Kainji, Nigeria, there are four genera comprising five species. The five species are : Siluranodon auritus (GEOFFROY St. HILLAIRE), Physailia pellucida BOULENGER, Eutropius niloticus RUPPELL, Schilbe mystus (LINNAEUS) and Schilbe uranoscopus RUPPELL. None of these species is restricted to Lake Kainji or the Niger system. The external characteristics of the species are described.

Eutropius nilcticus and Physailia pellucida were the commonest and most abundant. In view of the gill net selectivity, the number of Physailia pellucida was under-estimated. Schilbe mystus was fairly common but not as abundant as the two species above. Siluranodon auritus was rare while Schilbe uranoscopus was very rare in the lake. The distribution pattern showed that Eutropius niloticus was commonly found in any part of the lake while Physailia pellucida is mainly pelagic and occurs in mixed shoals with the clupeids (Sierrathrissa leonensis and Pellonula afzeliusi). Schilbe mystus was common in the riverine and inshore areas of the lake. Siluranodon auritus was found in inlets adjacent to the lake and in lake creeks. Schilbe uranoscopus was found in the inshore and offshore stations. The populations of Eutropius niloticus and Physailia pellucida were found to be increasing

while that of Schilbe mystus was declining. The factors thought to be responsible for the present distribution and abundance are discussed.

The pectoral spines are satisfactory and reliable for use as a method for age and growth determinations in two of the species studied. Overlap of age groups was found in the two species. The females grow faster than males of the same age. Females attained higher maximum length and live longer than the males. Length-weight regression coefficients for various ages were calculated for each species and sex separately. The overall coefficients indicated that the weight did not increase faster than the cube of their length. The condition factors were calculated and these indicated that the fish were in good condition throughout the year. The length-frequency histograms for Physailia pellucida indicated a possibility of two age groups, the 0+ and 1+. The possible causes of annulus formation in the hard tissues of the Kainji schilbeids were discussed.

Sex, reproductive cycle and variations in the fecundity of the species were studied. Sexual dimorphism occurs in all the species; females were found to be larger than the males and only the males possess genital papilla. Sex ratio varied from species to species and from season to season and within age and size groups. There were more females in the population than males. Breeding condition was attained and spawning occurred mainly during the rainy season in Eutropius nilloticus, Schilbe mystus and Siluranodon auritus; while Physailia pellucida was in breeding condition almost all round the year but spawned mainly in the dry season. Spawning occurred once during the annual breeding cycle in Eutropius nilloticus and Schilbe mystus and more than once in Physailia pellucida. Fecundity was found to vary from species to

species. Fecundity increased with the length and weight of fish in E. niloticus, S. mystus and P. pellucida but not in Siluranodon auritus. The fish were in good condition during the breeding season.

The stomach contents were examined in order to study their food and feeding habits. Each species was found to feed selectively on different food items. Siluranodon auritus was a phytoplankton feeder. Small crustaceans and immature insects dominated the food of Physailia pellucida. Eutropius niloticus was an omnivore although it fed on insects more than any other food item. Schilbe mystus and Schilbe uranoscopus were mainly piscivorous. The differences in food habit were clearly advantageous in that it limited intra-specific competition. Dietary items varied with size or age of fish. Seasonal abundance of food organisms also influenced the feeding habits of the fish. Feeding intensity varied with seasons and time of the day. Feeding intensity was found to correlate with deposition of fats in the abdominal cavity of Eutropius niloticus and Schilbe mystus but not in Physailia pellucida. The schilbeids serve as food for other fish species in the lake.

Experiments were performed to determine the digestive enzymes present in the alimentary canals of the three common schilbeids in the lake. Trypsin and pepsin were present in all the three species. Pepsin activity was found to be higher than that of the trypsin. Of all the carbohydrases tested for, only amylase was found and was present in Eutropius niloticus and Schilbe mystus. There was none in Physailia pellucida. No lipase was detected in any of the species. The enzymes were correlated with the food habits of the species.

The biochemical composition and the nutritional value of

Physailia pellucida, *Eutropius niloticus* and *Schilbe mystus* were determined. The results showed that the schilbeids were of high nutritional value. Suggestions are made for harvesting of more schilbeids for consumption.

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R E F E R E N C E S

Adeniji, H. A. 1973. Preliminary investigation into the composition and seasonal variation of the plankton in Kainji Lake, Nigeria. In Man-made lakes, their problems and environmental effects. Geophys. Monogr. Ser. Vol. 17 (Eds. Ackermann, W. D., White, G. F., & Worthington, E. B.), pp. 617 - 619. AGU., Washington, D. C.

Adeniji, H. A. 1975. Some aspects of the limnology and fishery development of Kainji Lake, Nigeria. Arch. Hydrobiol., 75 : 253 - 262.

Ajayi, O. 1972. Biological studies on the family Bagridae (Pisces : Siluroidae) in Lake Kainji, Nigeria. M. Phil. Thesis. University of Ife, Ile-Ife, Nigeria.

Akintunde, E. 1976. The biology of Tilapia and Sarotherodon species in Lake Kainji, Nigeria. M. Phil. Thesis. University of Ife, Ile-Ife, Nigeria.

Al - Hussaini, A. H. 1949. On the functional morphology of the alimentary tract of some fish in relation to differences in their feeding habits : Cytology and physiology. Quart. J. Microscop. Sci., 90 : 322 - 354.

Andrian, J. 1957. Composition et valeur alimentaire de poissons conserves sous differents etats : echantillons africains sales et seches, farines industrielles et nuoc-mam. Ann. nutrition et aliment., 11 : 27. (cited by Deelstra et al, 1974).

A. O. A. C. 1965. Association of Official Agricultural Chemists' Handbook. Official methods of analysis (10TH ED.) (Ed. Horwitz, W.). AOAC., Washington.

Arawomo, G. O. 1972. The ecology of the genera Citharinus and Distichodus in Lake Kainji, Nigeria. M. Phil. Thesis. University of Ife, Ile-Ife, Nigeria.

Arawomo, G. O. 1976. Food and feeding of three Citharinus species in Lake Kainji, Nigeria. J. Fish Biol., 9 : 3 - 10.

Audenaerde, Dirk F. E. Thys van den. 1964. Revision of the genus Eutropiellus NICHOLS & LAMONTE (Pisces : Schilbeidae) with description of a new species from Lower Nigeria, Eutropiellus vandeweyeri sp. nov. Rev. Zool. Bot. Afr., LXIX (1 - 2) : 214 - 230.

Babkin, B. P. and Bowie, D. J. 1928. The digestive system and its function in Fundulus heteroclitus. Biol. Bull., 54 : 254 - 277.

Bagenal, T. B. 1957. The breeding and fecundity of long rough dab Hippoglossoides platessoides (Fabr.) and the associated cycle in condition. J. mar. biol. Ass. U.K., 36 : 339 - 373.

Bagenal, T. B. 1966. The ecological and geographical aspects of the fecundity of the plaice. J. mar. biol. Ass. U.K., 46 : 161 - 186.

Bagenal, T. B. 1968. Eggs and early life history Part 1 : Fecundity. In Methods for assessment of fish production in Freshwater. I.B.P. Handbook No. 3 (Ed. Ricker, W. E.), pp. 160 - 169. Blackwell, Oxford & Edinburgh.

Bagenal, T. B. 1969. The relationship between food supply and fecundity in brown trout, Salmo trutta L. J. Fish Biol., 1 : 167 - 182.

Bakare, O. 1968. Food and feeding habits of the non-cichlid fishes of the middle Niger, with particular reference to the Kainji Reservoir basin. M.Sc. Thesis. University of Ife, Ile-Ife, Nigeria.

Bakare, O. 1970. Bottom deposits as food of inland fresh water fish. In Kainji Lake Studies, Vol. 1, Ecology (Ed. Visser, S.A.), pp. 65 - 85. Univ. Press, Ibadan, Nigeria.

Baldwin, E. 1952. Dynamic aspects of Biochemistry. Cambridge, U. P., London & New York.

Balogun, R. A. and Fisher, O. 1970. Studies on the digestive enzymes of the common African toad, Bufo regularis Boulenger. Comp. Biochem. Physiol., 33 : 813 - 820.

Balon, E. K. 1971. Age and growth of Hydrocynus vittatus Castelnau, 1861 in Lake Kariba Sinazongwe area. Fish. Res. Bull. Zambia, 5 : 89 - 118.

Balon, E. K. 1974. Fish production of a tropical ecosystem. In Lake Kariba, a man-made tropical ecosystem in Central Africa (Eds. Balon, E. K. & Coche, A. G), pp. 253 - 264. D. W. Junks, The Hague.

Banks, J. W., Holden, M. J. & Mc-Connell, R. H. 1965. Fishery Report. In The First Scientific Report of the Kainji Biological Research Team (Ed. White, E.), pp. 21 - 42. Unpublished report to O. D. M., London.

Barrington, E. J. W. 1957. The alimentary canal and digestion. In The physiology of fishes, Vol. 1 (Ed. Brown, M. E.), pp. 109 - 161. Academic Press, New York.

Baruh, J. & Gillard, J. 1959. Composition en acides amines de poissons de consommation indigene courante au Katanga. Bull. Soc. Chim. Biol., 41 : 1017. (cited by Deelstra et al, 1974).

Bastl, I. 1974. The red-breasted bream Tilapia rendalli (Boulenger, 1896). In Lake Kariba, A man-made tropical ecosystem in Central Africa (Eds. Balon, E. K. & Coche, A. G.), pp. 311 - 318. W. Junk, The Hague.

Bayliss, L. E. 1935. Digestion in the plaice (Pleuronectes platessa). J. mar. biol. Ass. U.K., 20 : 73 - 91.

Ben-Tuvia, A. 1960. Synopsis of biological data on Sardinella aurita of the Mediterranean Sea and other waters. F. A. O. Fish Biol. Synops., 14 : 1 - 30. (cited by Reynolds, 1974).

Berg, L. S. 1940. Classification of fishes both recent and fossil. Trav. Inst. Zool. Acad. Sci. URSS, 5 : 87 - 517. Reprint, 1947. Edwards Brothers, Ann Arbor, Mich.

Bhatia, D. 1931a. A critical study of the scales of two specimens of starved and excessively fed trout, Salmo irideus. Journ. du Cons. pour l'expl. de la mer., 6 : 266 - 272.

Bhatia, D. 1931b. The production of annual zones in the scales of the rainbow trout (Salmo irideus) I. J. Exp. Zool., 59 : 45 - 60.

Bhatia, D. 1932. Factors involved in the production of annual zones on the scales of the rainbow trout (Salmo irideus) II. J. exp. Biol., 9 : 6 - 11.

Bhatt, V. S. 1970. Studies on the biology of some freshwater fishes Part IV. Mystus seenghala (Sykes). J. Bombay nat.

Hist. Soc., 67 : 194 - 211.

Bhatt, V. S. 1972. Studies on the biology of some freshwater fishes Part V. Mystus vittatus (Bloch). J. Bombay nat. Hist. Soc., 68 (3) : 556 - 572.

Bidwell, A. 1976. The effect of water level fluctuations on the biology of Lake Kainji, Nigeria. The Nig. Fld., XLI : 156 - 165.

Bilton, H. T. & Jenkinson, D. W. 1969. Age determination of Sockeye (Oncorhynchus nerka) and Chum (O. keta) salmon from examination of pectoral fin rays. J. Fish. Res. Bd. Can., 26 : 1199 - 1203.

Bishai, H. M. & Gideiri, Y. B. A. 1965. Studies on the biology of the genus Synodontis at Khartoum. I. Age and growth. Hydrobiologia, 26 : 85 - 97.

Blache, J. 1964. Les poissons du bassin du Tchad et Mayo Kebbi. Cah. Mem. O.R.S.T.O.M., No 4 : 1 - 483.

Blache, J.; Miton, F.; Stauch, A. et al. 1964. Les poissons du Bassin du Tchad et du bassin adjacent du Mayo Kebbi, etude systematique et biologique. O.R.S.T.O.M. Paris.

Blake, B. F. 1976. Report on the University of Ife - University of Reading, Kainji Biological Research Project 1973 - 1976. Unpublished report to O.D.M., London.

Blake, B. F. 1977a. The effect of the impoundment of Lake Kainji, Nigeria, on the indigenous species of mormyrid fishes. Freshwater Biol., 7 : 37 - 42.

Blake, B. F. 1977b. Lake Kainji, Nigeria; A summary of the changes within the fish population since the impoundment of

the Niger in 1968. Hydrobiologia, 53 : 131 - 137.

Blake, B. F. 1977c. Food and feeding of the mormyrid fishes of Lake Kainji, Nigeria, with special reference to seasonal variation and interspecific differences. J. Fish Biol., 11 : in press.

Boulenger, G. A. 1911. Catalogue of freshwater fishes of Africa in the British Museum, Natural History Vol. 1 : 283 - 301. British Museum, London.

Brown, M. E. 1946a. Growth of brown trout (Salmo trutta Linn.) II. The growth of two-year old trout at a constant temperature of 11.5°C. J. exp. Biol., 22 : 130 - 144.

Brown, M. E. 1946b. Growth of brown trout (Salmo trutta Linn.) III. Effect of temperature on the growth of two-year old trout. J. exp. Biol., 22 : 145 - 155.

Buchmann, A. 1929. Die Methodik fishereibiologischer Untersu chun gen an Meeresfischen. In Abderhalden, Handb. biol. ArbMeth. Abt. 9, 6 : 1 - 194. (cited by Willoughby, 1974).

Cerny, K. 1974. The silver catfish, Eutropius depressirostris (Peters, 1852). In Lake Kariba, A man-made tropical ecosystem in Central Africa. (Eds. Balon, E. K. & Coche, A. G.), pp. 333 - 342. W. Junk, The Hague.

Chesley, L. C. 1934. The concentration of proteases, amylase and lipase in certain marine fishes. Biol. Bull., 66 : 133 - 144.

Chevey, P. 1930. Sur divers rythmes cuitre que des rythmes thermiques susceptibles de marquer les ecailles des poissons de la zone intertropicale. C.R. Acad. Sci. Paris, 190.

(cited by Johnels, 1952).

Chevey, P. 1936. La methode de "lecture des ecailles" et les poissons de la zone intertropicale. Notes Inst. Oceanogr. Indochine, 29. (cited by Johnels, 1952).

Chitravadivelu, K. 1974. The plain squeaker Synodontis zambezensis Peters, 1852. In Lake Kariba, A man-made tropical ecosystem in Central Africa (Eds. Balon, E. K. & Coche, A. G.), pp. 298 - 310. W. Junk, The Hague.

Chugunova, N. S. 1959. Age and growth studies in fish. Israel Progr. Sci. Transl. Jerusalem (1963). (Translated from Russian).

Clayton, W. D. 1957. A preliminary survey of soil and vegetation in Northern Nigeria. Unpublished report. Samaru Regional Research Station, Northern Nigeria.

Cockson, A. & Bourne, D. 1972. Enzymes in the digestive tract of two species of euryhaline fish. Comp. Biochem. Physiol., 41A : 715 - 718.

Corbet, P. S. 1961. The food of non-cichlid fishes in the Lake Victoria basin, with remarks on their evolution and adaptation to lacustrine conditions. Proc. Zool. Soc. London, 136 : 1 - 101.

Cuerrier, Jean-Paul. 1951. The use of pectoral fin rays for determining age of sturgeon and other species of fish. Can. Fish. Cult., 11 : 10 - 18.

Cutler, D. W. 1918. A preliminary account of the production of annual rings in the scales of Plaice and Flounders. J. mar. biol. Ass. U.K., 11 : 470 - 496.

Daget, J. 1952. Memoire sur la biologie des poissons du Niger Moyen. I. Biologie et croissance des especes du genre Alestes. Bull. l'I. F. A. N., 14 : 191 - 225.

Daget, J. 1954. Les poissons du Niger Superieur. Bull. l'I. F. A. N., 36 : 1 - 391.

Daget, J. & Iltis, A. 1965. Poissons du Cote d'Ivoire (Eaux donces et saumatres) Memoirs del' I. F. A. N., 74 : 1 - 385. (cited by Mok, 1974).

De Bont, A. F. 1967. Some aspects of age and growth of fish in temperate and tropical waters. In the biological basis of freshwater fish production (Ed. Gerking, S. D.), pp. 67 - 88. Blackwell, Oxford.

Deelder, C. L. & Willemse, J. J. 1973. Age determination in freshwater teleosts based on annular structures in fin-rays. Aquaculture, 1 : 365 - 371.

Deelstra, H. A., White, O. & Wiggans, D. S. 1974. Nutritive value of fish of Lake Tangayika I. : Amino acid composition. Afr. J. Trop. Hydrobiol. Fish., 3 : 161 - 166.

Dennisson, S. G. & Bulkley, R. V. 1972. Reproductive potential of the black bullhead, Ictalurus melas, in Clear Lake, Iowa. Trans. Amer. Fish. Soc., 101 (3) : 483 - 487.

Domanevsky, L. N. 1962. The influence of predators on the formation of the fish fauna of the man-made Lake Cimljansk. Collected papers of the Area Conference dealing with classification, biology and fisheries utilization of freshwater man-made lakes of the Southern zone of the U.S.S.R. pp. 279 - 284. (In Russian) (cited by Lelek, 1972).

Donelly, B. G. & Caulton, M. S. 1969. A possible technique for age determination in Southern African siluroid fishes. Limnol. Soc. S. Afr., 12 : 13 - 16.

Ehrenbaum, E. 1909. Eier und larven von fishen. Tl. 2 : 217 - 413, in Nordisches Plankton, Lfg. 10. Kiel u. Leipzig. (cited by Reynolds, 1974).

Elder, H. Y. 1965. Biological effects of water utilization by hydro-electric schemes in relation to fisheries, with special reference to Scotland. Proc. Roy. Soc. Edinburgh (b), 69 : 246 - 271.

El-Zarka, S. E. 1971. Kainji Lake Research Project Interim Report 1969 - 1971. Unpublished Report to Kainji Lake Research Project, New Bussa, Nigeria.

El-Zarka, S. E. 1973. Kainji Lake, Nigeria. In Man-made lakes : their problems and environmental effects. Geophys. Monogr. Ser. 17 (Eds. Ackermann, W. C.; White, G. F. & Worthington, E: B.), pp. 197 - 219. AGU, Washington, D.C.

Ewer, D. W. 1966. Biological investigations on the Volta Lake, May 1964 - May 1965. In Man-made Lakes (Ed. Lowe-McConnell), pp. 21 - 31. Academic Press, London.

Fagade, S. O. 1974. Age determination in Tilapia melanotheron (Ruppell) in the Lagos Lagoon, Lagos, Nigeria. In Ageing of Fish. Proceedings of an International Symposium (Ed. Bagenal, T. G.), pp. 71 - 77. Unwin, Old Woking.

Fagade, S. O & Olaniyan, C. I. O. 1972. The biology of the West African Shad Ethmalosa fimbriata (Bowdich) in the Lagos Lagoon, Nigeria. J. Fish Biol., 4 : 519 - 533.

Fagade, S.O. & Olaniyan, C. I. O. 1973. The food and feeding inter-relationship of the fishes in the Lagos Lagoon. J. Fish Biol., 5 : 205 - 225.

Fish, G. R. 1960. The comparative activity of some digestive enzymes in the alimentary canal of Tilapia and perch. Hydrobiologia, 15 : 161 - 178.

Frank, S. 1974. The spotted squeaker, Synodontis nebulosus, the butter catfish, Schilbe mystus, the vundu, Heterobranchus longifilis and electric catfish, Malapterurus electricus. In Lake Kariba : A Man-made tropical ecosystem in Central Africa (Eds. Balon, E. K. & Coche, A. G.), pp. 325 - 332. W. Junk, The Hague.

Gaigher, I. G. 1969. A technique for age determinations in the silver barbel (Eutropius depressirostris). Newsl. Limnol. Soc. S. Afr. , 13 : 72 - 75.

Garrod, D. J. 1959. The growth of Tilapia esculenta in Lake Victoria. Hydrobiologia, 12 : 268 - 297.

Gornall, A. G., Bardawill, C. J. & David, M.M. 1949. Determination of serum proteins by means of the biuret reaction. J. biol. Chem., 177 : 751 - 766.

Graham, M. 1929. The Victoria Nyanza and its fisheries. Crown Agents, London. (cited by Greenwood, 1957).

Greenwood, P. H. 1957. The fishes of Uganda - III. The Uganda Journal, 21 (1) : 64 - 68 and 80.

Groenewald, A. A. vJ. 1964. The role of Eutropius depressirostris Peters (Pisces : Schilbeidae) as a predator in a

Lowveld impoundment in the Transvaal. Hydrobiologia, 23 : 267 - 273.

Hale, L. J. 1958. Biological laboratory data. 2nd Ed. Methuen, London.

Harding, D. 1964. Hydrology and fisheries in Lake Kariba. Verh. Internat. Verein. Limnol., 15 : 139 - 149.

Hellawell, J. M. 1971a. The food of the grayling Thymallus thymallus (L.) of the River Lugg, Herefordshire. J. Fish Biol., 3 : 187 - 197.

Hellawell, J. M. 1971b. The autecology of the chub, Squalius cephalus (L.), of the River Lugg and the Afon Llynfi III. Diet and feeding habits. Freshwat. Biol., 1 : 369 - 387.

Hellawell, J. M. 1971c. The autecology of the chub, Squalius cephalus (L.), of the River Lugg and Afon Llynfi. II. Reproduction. Freshwat. Biol., 1 : 135 - 148.

Hellawell, J. M. 1972. The growth, reproduction and food of the roach Rutilus rutilus (L.), of the River Lugg, Herefordshire. J. Fish Biol., 4 : 469 - 486.

Hellawell, J. M. 1974. The ecology of populations of dace, Leuciscus leuciscus (L.), from two tributaries of the River Wye, Herefordshire, England. Freshwat. Biol., 4 : 577 - 604.

Henderson, F. 1973. A limnological description of Kainji Lake 1969 - 1971. FI : DP/NIR 66/524/10.F.A.O., Rome.

Hickling, C. F. 1961. Tropical inland fisheries. Longman, London.

Hoar, W. S. 1957. The gonads and reproduction. In Physiology of fishes. Vol. I. (Ed. Brown, M. E.), pp. 287 - 321. Academic Press, New York.

Holcik, J. 1974. The green bream, Sargochromis codringtoni (Boulenger, 1908). In Lake Kariba, A Man-made tropical ecosystem in Central Africa. (Eds. Balon, E. K. & Coche, A. G.), pp. 280 - 298. W. Junk, The Hague.

Holden, M. J. & Reed, W. 1972. West African freshwater fish. Longman, London.

Hopson, A. J. 1967. The fisheries of Lake Chad, Nigeria. In Fish and fisheries of Northern Nigeria (Eds. Reed, et al) pp. 189 - 200. Govt. Printer, Kaduna.

Hora, S. L. 1938. The game fishes of India. Bombay Nat. Hist. Soc., 40 : 355 - 366.

Hora, S. L. 1941. Siluroid fishes of India, Burma and Ceylon - XI. Rec. Ind. Mus. Calcutta, 43 : 97 - 115.

Hynes, H. B. N. 1950. Food of freshwater stickle backs with a review of methods used in studies of food of fish. J. Anim. Ecol., 19 : 36 - 58.

Imevbore, A. M. A. 1970a. Some general features of the Kainji Reservoir basin. In Kainji Lake Studies, Vol. 1, Ecology (Ed. Visser, S. A.), pp. 17 - 26. Univ. Press, Ibadan, Nigeria.

Imevbore, A. M. A. 1970b. Some preliminary observations on the sex ratios and fecundity of the fish in the River Niger. In Kainji Lake Studies, Vol. 1, Ecology (Ed. Visser, S. A.),

pp. 87 - 98. Univ. Press, Ibadan, Nigeria.

Imevbore, A. M. A. & Bakare, O. 1970. The food and feeding habits of non-cichlid fishes of the River Niger in the Kainji Reservoir area. In Kainji Lake Studies, Vol. 1, Ecology (Ed. Visser, S. A), pp. 49 - 64. Univ. Press, Ibadan, Nigeria.

Imevbore, A. M. A. & Bakare, O. 1974. A pre-impoundment study of swamps in the Kainji Lake Basin. Afr. J. Trop. Hydrobiol. Fish., 3 : 79 - 93.

Imevbore, A. M. A. & Okpo, W. S. 1975. Aspects of the biology of the Kainji Lake fishes. In The ecology of Lake Kainji, the transition of river to lake. (Eds. Imevbore, A. M. A. & Adegoke, O. S.), pp. 163 - 178. Univ. Press, Ile-Ife, Nigeria.

Irvine, F. R. 1947. The fishes and fisheries of the Gold Coast. Crown Agents, London.

Ishida, J. 1936. Distribution of the digestive enzymes in the digestive systems of stomachless fishes. Annot. Zool. japon., 15 : 263 - 284.

Jensen, K. W. 1957. Determining age and growth of Tilapia nilotica, Tilapia galilea and Tilapia zillii, and Lates niloticus by means of their scales. K. norske Vidensk. Selsk. Forh., 30. (cited by De Bont, 1967).

Johnels, A. G. 1952. Notes on scale rings and growth of tropical fishes from the Gambia River. Arkiv for Zoologi, 3 (28) : 363 - 366.

Johnson, R. P. 1973. Observations on Tilapia in Kainji Lake, with emphasis on T. galilaea. FI : SF/NIR 24. Technical Report 3. F.A.O., Rome.

Karlman, S. G. 1973. Pelagic production in Kainji Lake. Fl : SF/NIR 24. Technical Report 3. F.A.O., Rome.

Keay, R. W. J. 1965. An outline of Nigerian vegetation. Govt. Printer, Lagos, Nigeria.

Lagler, K. F. 1956. Freshwater fishery biology. Brown Company, Iowa.

Lagler, K. F., Bardach, J. E. & Miller, R. R. 1962. Ichthyology. Michigan, U. P., Ann Arbor.

Latif, A. F. A. 1976. Fishes and fisheries of Lake Nasser. In The Nile, Biology of an acient river. (Ed. Rzoska, J.), pp. 299 - 307. D. W. Junks, The Hague.

Lawson, G. W., Petr, T., Biswas, S. et al. 1969. Hydrobiological work of the Volta Basin Research Project, 1963 - 1968. Bull. del' I.F.A.N. T., XXXI , ser. A, No.3 : 965 - 1003.

Lea, E. 1910. On the methods used in herring investigations. Publs. Circonst. Cons. perm. int. Explor. Mer., 53 : 7 - 174. (cited by Tesch, 1968).

Le Cren, E. D. 1947. The determination of the age and growth of the perch (Perca fluviatilis) from the opercular bone. J. Anim. Ecol., 16 : 188 - 204.

Le Cren, E. D. 1951. The length-weight relationship and seasonal cycle in gonad weight and condition in the perch (Perca fluviatilis). J. Anim. Ecol., 20 : 201 - 219.

Leentvaar, P. 1966. The Brokopondo Research Project, Surinam (RIVON). In Man-made Lakes (Ed. Lowe-McConnell, R. H.), pp. 33.- 42. Academic Press, London.

Lelek, A. 1959. The age, growth and sex ratio in the chub, Leuciscus cephalus (L.) from the Rokytna River. Zool. Listy, 8 : 365 - 376. (cited by Mann, 1976).

Lelek, A. 1972. Fish population of Kainji Lake, trends in their development and utilization, FAO / UNDP. FI : SF/NIR 24. Technical Report 2. F.A.O., Rome.

Lelek, A. 1973. Sequence of changes in fish population of the new tropical man-made lake, Kainji, Nigeria. Arch. Hydrobiol., 71 (3) : 381 - 420.

Lelek, A. 1975. Possible trends in the development of the fish fauna in Kainji Lake. In The ecology of Lake Kainji, the transition of river to lake. (Eds. Imevbore, A. M. A. & Adegoke, S. O.), pp. 157 - 162. Univ. Press, Ile-Ife, Nigeria.

Lelek, A. & El-Zarka, S. 1973. Ecological comparison of the pre-impoundment and post-impoundment fish faunas of the River Niger and Kainji Lake, Nigeria. In Man-made lakes : their problems and environmental effects. Geophys. Monogr. Ser. Vol. 17 (Eds. Ackermann, W. D, White, G. F., & Worthington, E. B.), pp. 655 - 660. AGU., Washington, D.C.

Lewis, D. S. C. 1973a. Report of the University of Ife - University of Southampton, Kainji Research Project 1970 - 1972. Unpublished Report to O. D. M., London.

Lewis, D. S. C. 1973b. An illustrated key to fishes of Kainji Lake, Nigeria. O.D.M., London.

Lewis, D. S. C. 1974a. The food and feeding habits of Hydrocynus forskali Cuvier and Hydrocynus brevis Gunther in Lake Kainji, Nigeria. J. Fish Biol., 6 : 349 - 363.

Lewis, D. S. C. 1974b. The effects of formation of Lake Kainji (Nigeria) upon the indigenous fish population. Hydrobiologia, 43 : 281 - 301.

Lighstein, H. C. & Oginsky, E. L. 1965. Experimental microbial Physiology. (1st Ed). Freeman, San Francisco.

Little, E. C. S. 1966. The invasion of Man-made lakes by plants. In Man-made Lakes (Ed. Lowe-McConnell, R. H.), pp. 75 - 86. Academic Press, London.

Lowe, R. H. 1955. The fecundity of Tilapia species. E. Afr. agric. J., 21 : 45 - 52. (cited by Willoughby, 1974).

Lowe-McConnell, R. H. 1964. The fishes of the Rupununi savanna district of British Guiana, South America. J. Linn. Soc. Zoology., 45 : 103 - 144.

Lowe-McConnell, R. H. 1965. Field Key of freshwater fishes likely to occur in the area above the Kainji Dams on the River Niger. In The First Scientific Report of the Kainji Biological Research Team (Ed. White, E.), pp. 43 - 64. Unpublished report to O.D.M., London.

Lowe-McConnell, R. H. 1972. Keys for the field identification of freshwater fishes likely to occur in or above the new man-made lakes, Lake Volta in Ghana and the Kainji Lake on

the River Niger in Nigeria. Ghana U.P., Accra.

Lowry, O. H., Rosebrough, N. J., et al. 1951. Protein measurement with the folin phenol reagent. J. biol. Chem., 193 : 265 - 275. (cited by Ogunbiyi & Okon, 1976).

MacKay, M. E. 1929. The digestive system of the eel-pont (Zoarces anguillaris). Biol. Bull., 56 : 243 - 249.

Mann, R. H. K. 1973. Observations on the age, growth, reproduction and food of the roach Rutilus rutilus (L.) in two rivers in Southern England. J. Fish Biol., 5 : 707 - 736.

Mann, R. H. K. 1974. Observations on the age, growth, reproduction and food of the dace, Leuciscus leuciscus (L.) in two rivers in Southern England. J. Fish Biol., 6 : 237 - 253.

Mann, R. H. K. 1976a. Observations on the age, growth, reproduction and food of the chub Squalius cephalus (L.) in the River Stour, Dorset. J. Fish Biol., 8 : 265 - 288.

Mann, R. H. K. 1976b. Observations on the age, growth, reproduction and food of the pike Esox lucius (L.) in two rivers in Southern England. J. Fish Biol., 8 : 179 - 197.

Marzolf, R. C. 1955. Use of pectoral spines and vertebrae for determining age and rate of growth of the Channel catfish. J. Wildl. Mgmt., 19 : 243 - 249.

Mathur, P. K. 1964. Studies on the maturity and fecundity of hilsa, Hilsa ilisha (Hamilton) in the upper stretches of the Ganga. Indian J. Fish, 11A : 423 - 448.

McGeachin, R. L. & Debnam, J. W. Jr. 1960. Amylase in fresh-water fish. Proc. Soc. exp. Biol. Med., 103 : 814 - 815.

McGowan, L. M. 1974. Ecological studies on Chaoborus (Diptera, Chaoboridae) in Lake George, Uganda. Freshwat. Biol., 4 : 1 - 23.

Mok, M. 1974. Biometrie et biologie des Schilbe (Pisces : Siluriformes) du bassin Tchadien, I partie - Morphologie comparee des 2 especes de Schilbe. Cah. O.R.S.T.O.M., Ser. Hydrobiol., VIII (2) : 119 - 135.

Motwani, M. P. & Kanwai, Y. 1970. Fishes and fisheries of the coffer-dammed right channel of the River Niger at Kainji. In Kainji Lake Studies, Vol. 1, Ecology (Ed. Visser, S. A.), pp. 27 - 48. Univ. Press, Ibadan, Nigeria.

NEDECO & Balfour Beatty. 1961. Niger Dams Project. NEDECO, The Hague; Balfour Beatty, London.

Nelson, N. 1944. A photometric adaptation of the Somogyi method for the determination of glucose. J. biol. Chem., 153 : 375 - 380.

Nikolsky, G. V. 1963. The ecology of fishes. Academic Press, New York.

Norris, E. R. & Elam, D. W. 1940. Preparation and properties of crystalline salmon pepsin. J. Biol. Chem., 134 : 443 - 454.

Nursall, J. R. 1969. Faunal changes in oligotrophic man-made lakes : experience on the Kananaskis River system. In Int. Symp. Man-made lakes (Ed. Obeng, L.), pp. 163 - 175. Ghana Acad. of Sci., Accra.

Ogunbiyi, O. A. & Eyo E. Okon. 1976. Studies on the digestive enzymes of the African fruit bat, Eidolon helvum (Kerr).

Comp. Biochem. physiol., 55A : 359 - 361.

Okedi, J. 1969. Observations of the breeding and growth of certain mormyrid fishes of the Lake Victoria basin (Pisces : Mormyridae). Revue Zool. Bot. Afr., 79 : 34 - 64.

Okedi, J. 1971. The food and feeding habits of the small mormyrid fishes of Lake Victoria, East Africa. Afr. J. Trop. Hydrobiol. Fish., 1 : 1 - 12

Otobo, F. O. 1974. The potential for clupeid fishery in Lake Kainji, Nigeria. Afr. J. Trop. Hydrobiol. Fish., 3 : 123 - 134.

Otobo, F. O. 1976a. Observations on meristic characters separating Pellonula afzeliusi Johnels, 1954 from Sierrathrissa leonensis Thys van den Andernaerde, 1969. J. Fish Biol., 8 : 303 - 310.

Otobo, F. O. 1976b. The evaluation of the beach seine as a fishing gear for Tilapia harvest in Kainji Lake, Nigeria. Arch. Hydrobiol., 78 : 375 - 382.

Oya, T., Kawakami, M. & Suzuki, S. 1927. On the digestive ferment in the pancreas of Anguilla japonica. J. Imp. Fisheries Inst. Japan, 22 : 105p.

Pannella, G. 1974. Otolith growth patterns : an aid in age determination in temperate and tropical fishes. In Ageing of fish. Proceeding of an International Symposium (Ed. Bagenal, T. G.), pp. 28 - 39. Unwin, Old Woking.

Pekkola, W. 1919. Notes on the habits, breeding and food of some White Nile fish. Sudan Notes and Records, 2 : 112 -

121. (cited by Imevbore & Bakare, 1970).

Pellegrin, J. 1913. Poissons nouveaux de l'Ogooue. Bull. Soc. Zool. France, 38 : 273. (cited by Trewavas, 1943).

Pellegrin, J. 1929. Silurides, Cyprinodonti des Acanthopterygiens du Cameroun, etc. Bull. Soc. Zool. France, 54 : 358 - 369. (cited by Trewavas, 1943).

Penczak, T. 1967. The Dace, Leuciscus leuciscus (L.) from Lodz Upland and adjacent areas Part I. Material for the knowledge of the biology of the dace. Acta Hydrobiol., 9 : 281 - 355. (cited by Mann, 1974).

Perry, W. G. 1967. An improved method of sectioning catfish spines for age and growth studies. Prog. Fish Cult., 29 : 12.

Petr, T. 1967. Food and preferences of the commercial fishes of the Volta Lake. Univ. of Ghana, V.B.R.P., Tech. Report X , 22 .

Petr, T. 1969. Fish population changes in the Volta Lake over the period January 1965 - September 1966. In Int. Symp. Man-made lakes (Ed. Obeng, L.), pp. 220 - 234. Ghana Acad. of Sci., Accra.

Petr, T. 1970. Macroinvertebrates of flooded trees in the man-made Volta Lake (Ghana) with special reference to the burrowing mayfly, Povilla adusta NAVAS. Hydrobiologia, 36 : 373 - 398.

Petr, T. 1973. Some factors limiting the distribution of Povilla adusta Navas (Ephemeroptera, Polymitarcidae) in

African Lakes. In. Proc. First Int. Conf. on Ephemeroptera (Eds. Peters, W. L. & Peters, J. G.), pp. 223 - 229. E. J. Brill, Leiden.

Pitt, T. K. 1964. Fecundity of the American plaice, Hippoglossoides platessoides (Fabr.) from the Grand Bank and Newfoundland area. J. Fish Res. Bd. Can., 21 : 597 - 612.

Pivnicka, K. 1974. The Zambezi barbel, Clarias gariepinus (Burchell, 1822). In Lake Kariba, A Man-made tropical ecosystem in Central Africa (Eds. Balon, E. K. & Coche, A. G.), pp. 318 - 325. W. Junk, The Hague.

Poinsard, F. & Troadec, J. P. 1966. Determination de l'age par la lecture des otolithes chez deux especes de Sciaenides Quest - Africains. J. Cons. perm. int. Explor. Mer., 30 : 291 - 307. (cited by Pannella, 1974).

Pope, I. A., Mills, D. H. & Scherer, W. M. 1961. The fecundity of the Atlantic, Salmo salar (Linn.). Freshwat. salm. Fish Res., 26 : 1 - 12. (cited by Fagade & Olaniyan, 1972).

Qasim, S. Z. & Qayyum, A. 1964. Studies on the biology of some freshwater fishes. J. Bombay nat. Hist. Soc., 61 : 74 - 98, 330 - 347. (cited by Reynolds, 1974).

Radharkrishman, N. 1963. Notes on the maturity and spawning of Opisthopterus tardoore (Cuvier). Indian J. Fish., 10A : 102 - 106. (cited by Reynolds, 1974).

Reed, W., Hopson, A. J., Yaro, I. et al. 1967. Fish and fisheries of Northern Nigeria. Govt. Printer, Kaduna.

Reynolds, J. D. 1967. Notes on juveniles of commercial fish

attracted to light on the Volta Lake, 1966 - 1967. Univ. of Ghana, V.B.R.P., Tech. Report X, 21.

Reynolds, J. D. 1970. Biology of the small pelagic fishes in the New Volta Lake in Ghana. Part I : The Lake and the fish : Feeding habits. Hydrobiologia, 35 : 568 - 603.

Reynolds, J. D. 1971a. Biology of small pelagic fishes in the New Volta Lake in Ghana II : Schooling and migrations. Hydrobiologia, 38 : 79 - 91.

Reynolds, J. D. 1971b. A guide to the external sexing of some West African freshwater fishes. Ghana J. Sci., 11 : 1 - 9.

Reynolds, J. D. 1973. Biological notes on Barbus species (Pisces : Cyprinidae) in the New Volta Lake in Ghana. Rev. Zool. Bot. Afr. (cited by Reynolds, 1974).

Reynolds, J. D. 1974. Biology of the small pelagic fishes in the New Volta Lake in Ghana. Part III : Sex and reproduction. Hydrobiologia, 45 : 489 - 508.

Roberts, T. 1967. A provisional check-list of the freshwater fishes of the Volta basin. J. West Afr. Sci. Assoc. 12 : 10 - 18.

Roberts, T. R. 1975. Geographical distribution of African freshwater fishes. Zoo. J. Lin. Soc., 57 : 249 - 319.

Roest, F. C. 1975. Evolution des populations piscicoles du Lac Kossou de 1972 et 1975. Project FNUD/AVB/FAO - IVC 526. Rapport Technique No. 32 : 50p.

Rounsefell, G. A. & Everhart, W. H. 1953. Fishery science : its methods and applications. J. Wiley, New York.

Saigal, B. N. 1964. Studies on the fishery and biology of the commercial catfishes of the Ganga River system. II. Maturity, spawnining and food of Mystus (Osteobagrus) aor (Hamilton). Indian J. Fish, 11A : 1. - 44.

Sandon, H. & El-Tayib, A. 1953. The food of some common Nile fish. Sudan Notes and Records, 34 : 205 - 229.

Scheuring, L. 1929. Die Wanderrungen der Fische. Ergeb. biol., Berlin, 5 : 405 - 691. (cited by Reynolds, 1974).

Scidmore, W. J. & Glass, A. W. 1953. Use of pectoral fin rays to determine age of the White sucker. Progv. Fish Cult., 15 : 114 - 115.

Scott, D. B. C. 1974. The reproductive cycle of Mormyrus kannume Forsk. (Osteoglossomorpha, Mormyriformes) in Lake Victoria, Uganda. J. Fish Biol., 6 : 447 - 454.

Scott, D. P. 1956. Effects of food quality on the fecundity of Kamloops Trout, Salmo gairdneri Kamloops Jordan Unpublished Thesis. University of British Columbia, British Columbia, Canada. (cited by Hoar, 1957).

Scott, D.P. 1962. Effect of food quatity on fecundity of rainbow trout, Salmo gairdneri. J. Fish Res. Bd. Can., 19 : 715 - 731.

Sharonov, I. V. 1962. General notes about the formation of the ichthyofauna of the man-made Kuibychev Lake. Collected papers of the Area Conference dealing with classification, biology and fisheries utilization of freshwater man-made lakes of the Southern zone of the U.S.S.R. pp. 397 - 404. (In Russia) (cited by Lelek, 1972).

Simpson, A. C. 1951. The fecundity of plaice. Fish Invest., London. Ser. 2., 17 : 3 - 27.

Simpson, A. C. 1959. Method used for separating and counting the eggs in fecundity studies on the plaice (Pleuronectes platessa) and herring (Clupea harengus). Occ. Pap. Indo - Pacif. Fish. Coun. 59/12. (cited by Bagenal, 1968).

Sneed, K. E. 1951. A method for calculating the growth of Channel catfish, Ictalurus lacustris punctatus. Trans. Am. Fish. Soc., 80 : 174 - 183.

Somogyi, M. 1945. A new reagent for the determination of sugars. J. biol. Chem., 160 : 61 - 68.

Sullivan, M. X. 1907. The physiology of the digestive tract of elasmobranchs. Bull. U.S. Fisheries, 27 : 1 - 27.

Tafeda, H. 1961. Response of catfish barbels to taste stimuli. Nature, Lond., 192 : 343 - 344.

Tesch, F. W. 1968. Age and growth. In Methods for Assessment of fish production in Freshwater. IBP Handbook No. 3. (Ed. Ricker, W.E.), pp. 93 - 120. Blackwell, Oxford.

Thomson, J. S. 1904. The periodic growth of scales in Gadidae as an index of age. J. mar. biol. Ass. U.K., 7 : 1 - 109.

Torbor, J. G. 1972a. The food and feeding habits of some Lake Chad commercial fishes. Bulletin de l' IFAN. T. XXXIV, Ser. A. No 1.

Torbor, J. G. 1972b. Annual report for 1970. Lake Chad Research Station, Mallamfatori, Min. of Information, Lagos, Nigeria.

Trevelyan, W. E., Procter, D. P. & Harrison, J. S. 1950. Detection of sugars on paper chromatographs. Nature, Lond., 166 : 444 - 445.

Trewavas, E. 1943. New Schilbeid fishes from the Gold Coast, with a synopsis of the African genera. Proc. zool. Soc. Lond., 113 : 164 - 171.

Turner, J. L. 1970. The fish population of newly impounded Kainji Lake. FI : SF/NIR 24. Technical Report I. FAO, Rome.

Turner, J. L. 1971. The fish population of the newly impounded Kainji Lake in Nigeria. J. West Afr. Sci. Assoc., 16 : 49 - 58.

Van der Waal, B. C. W. & Schoonbee, H. J. 1975. Age and growth studies of Clarias gariepinus (Burchell) (Clariidae) in the Transvaal, South Africa. J. Fish Biol., 7 : 227 - 233.

Verbeke, J. 1959. Le regime alimentaire des poissons des Lacs Kivu, Edouard et Albert (Congo Belge). Explor. Hydrobiol. Lacs Kivu, Edouard et Albert (1952 - 1954). Res. Sci., Vol. 3, Fasc. 3. Inst. Roy. Sci. Nat. Bel'g., Bruxelles. pp. 1 - 16. (cited by Imevbore & Bakare, 1970).

Vijverberg, J. & Frank, Th. H. 1976. The chemical composition and energy contents of copepods and cladocerans in relation to their size. Freshwat. Biol., 6 : 333 - 345.

Vonk, H. J. 1927. Die Verdauung bei den Fischen. Z. vergleich. Physiol., 5 : 445 - 546.

Watts, J. C. D. 1957. The chemical composition of West

African fish I. The West-African Shad., E. fimbriata. Bull. l' I.F.A.N., 19 539 - 547.

Weinland, E. 1901. Zur Magen Verdauung der Haifische I & II. Z. Biol., 41 : 275p. (cited by Barrington, 1957).

Wellcome, R. L. 1969. The biology of the fishes of a small tropical stream. J. Zool. Lond., 158 : 485 - 529.

White, E. (Ed.) 1965. Preliminary report of the Kainji Biological Research Team. Unpublished report to O.D.M., London.

White, E. 1969. The place of biological research in the development of the resources of man-made lakes. In Int. Symp. Man-made lakes (Ed. Obeng, L.), pp. 37 - 49. Ghana Acad. of Sci., Accra.

Whitehead, V. 1969. Investigations into the food habits of some juvenile fish in the Volta Lake during the period October 1967 to March 1969, with some notes on distribution and abundance. Univ. of Ghana, V.B.R.P., Tech. Report X, 30.

Willoughby, N. 1974. The ecology of the genus Synodontis (Pisces : Siluroidei) in Lake Kainji, Nigeria. Ph.D. Thesis. University of Southampton, Southampton, U.K.

Winberg, G. G. (Ed.) 1971. Symbols, Units and Conversion factors in Studies of freshwater productivity. I.B.P. Section P.F.I.B.P. Central Office, London, (cited by Vijverberg & Frank, 1976).

Worthington, E. B. 1929. Report on the fishing of Lakes Albert and Kioga. Crown Agents, London. (cited by Greenwood, 1957)

Yonge, C. M. 1937. Evolution and adaptation in the digestive system of the metazoa. Biol. Revs., 12 : 87 - 115

Yung, E. 1899. Recherche sur la digestion des poissons. Arch. Zool. exptl. et gen., 7 : 121. (cited by Barrington, 1957).

APPENDIX TABLES

Appendix 1.

Monthly total number of *E. niloticus* captured in each station.

	A	C	D	G	H	J	K	L	M	N	O	TOTALS
1974												
Oct.	0	26	10	13	47	11	10	12	9	3	52	193
Nov.	0	26	10	16	41	29	26	30	26	8	35	247
Dec.	0	35	3	8	41	25	2	30	16	5	23	190
1975												
Jan.	0	5	1	13	26	13	2	31	10	12	28	141
Feb.	0	2	12	55	18	7	4	26	17	3	8	152
Mar.	0	9	19	7	19	16	9	11	5	3	1	99
Apr.	-	3	1	14	-	6	1	17	-	-	-	42
May	2	3	10	15	14	13	9	11	5	3	22	107
Jun.	2	17	-	34	-	8	10	23	15	3	-	112
Jul.	7	13	12	32	26	11	4	23	39	7	16	190
Aug.	-	-	-	6	-	4	2	13	-	-	-	25
Sept.	-	5	-	4	-	2	0	9	15	-	-	35
Oct.	-	-	-	-	-	14	10	16	-	-	-	40
Nov.	-	-	-	28	-	12	10	18	17	3	14	102
Dec.	-	-	-	-	-	11	2	-	-	-	-	13
1976												
Jan.	-	2	-	-	-	4	7	11	3	7	-	34
Feb.	0	-	24	3	-	1	6	-	6	2	-	42
Mar.	-	5	10	-	-	1	0	5	2	-	4	27
Apr.	-	2	-	-	-	1	1	6	2	-	-	12
May	0	5	-	-	-	16	1	0	-	-	-	22
Jun.	-	-	-	-	-	12	12	34	-	-	-	58
Jul.	-	-	-	-	-	4	-	-	-	-	-	4
Aug.	-	5	-	13	-	-	-	5	14	-	-	37
Sept.	11	10	-	13	-	-	-	-	-	-	-	34
TOTALS	22	173	112	274	232	221	128	331	203	59	203	1958

0 = No specimens in the samples taken.

\- = The station was not sampled.

Appendix 2 Total weights (g) of *E. niloticus* captured in each station for each month.

	A	C	D	G	H	J	K	L	M	N	O	TOTAL
1974												
Oct.	0	1374	615	804	2121	371	413	582	488	475	2168	9411
Nov.	0	949	377	1079	1735	1437	1204	1443	1067	806	1665	11762
Dec.	0	1659	211	489	2137	999	199	1569	938	529	1636	10360
1975												
Jan.	0	240	33	668	1267	561	77	848	469	725	1245	6133
Feb.	0	150	462	3005	779	302	192	837	874	230	361	1249
Mar.	0	459	756	283	769	657	309	408	144	166	36	7192
Apr.	-	30	35	1051	-	235	0	348	-	-	-	3987
May	30	86	346	801	242	289	325	230	179	270	438	3236
Jun.	0	786	0	1628	0	307	326	352	399	245	0	4043
Jul.	429	101	796	1428	1146	167	0	181	1395	245	309	6197
Aug.	-	-	-	291	-	281	75	496	-	-	-	1143
Sept.	-	159	-	200	-	0	0	566	548	-	-	1473
Oct.	-	-	-	-	-	604	120	762	-	-	-	1486
Nov.	-	-	-	1311	-	447	315	744	1054	93	903	4867
Dec.	-	-	-	-	-	492	37	-	-	-	-	529
1976												
Jan.	-	97	-	-	-	151	253	290	78	306	-	1175
Feb.	0	-	940	147	-	33	219	-	241	120	-	1700
Mar.	-	214	407	-	-	10	0	222	112	-	122	1087
Apr.	-	83	-	-	-	0	0	193	119	-	-	395
May	0	149	-	-	-	494	24	643	-	-	-	1310
Jun.	-	-	-	-	-	344	361	960	-	-	-	1665
Jul.	-	-	-	-	-	147	-	-	-	-	-	147
Aug.	-	305	-	890	-	-	-	78	341	-	-	1614
Sept.	506	403	-	557	-	-	-	-	-	-	-	1972
TOTALS	965	7244	4978	14632	10196	8328	4449	11752	8840	4210	8883	84583

0 = No specimens in the samples taken.

- = The station was not sampled.

Appendix 3.

Monthly total numbers of Schilbe mystus captured in each station.

	A	C	D	G	H	J	K	L	M	N	O	TOTALS
1974												
Oct.	0	1	0	0	0	0	2	0	0	0	0	3
Nov.	0	0	0	0	0	0	0	0	0	0	2	2
Dec.	0	0	4	0	0	0	5	0	0	0	0	9
1975												
Jan.	1	4	0	0	1	0	3	0	0	0	0	9
Feb.	4	0	0	0	0	0	1	0	2	0	0	7
Mar.	3	1	0	0	5	0	1	0	0	1	1	12
Apr.	-	0	4	0	-	0	3	2	-	-	-	9
May	6	0	2	0	0	0	3	1	1	4	0	17
Jun.	4	1	-	0	-	0	0	2	0	2	-	9
Jul.	2	2	0	0	1	0	1	4	1	18	0	29
Aug.	-	-	-	0	-	1	4	2	-	-	-	7
Sept.	-	0	-	0	-	1	2	1	1	-	-	5
Oct.	-	-	-	-	-	3	3	1	-	-	-	7
Nov.	-	-	-	0	-	0	2	0	0	0	0	2
Dec.	-	-	-	-	-	1	1	-	-	-	-	2
1976												
Jan.	-	0	-	-	-	0	0	4	2	0	-	6
Feb.	9	-	1	0	-	1	1	-	0	0	-	12
Mar.	-	0	0	-	-	0	5	1	2	-	1	9
Apr.	-	0	-	-	-	0	7	0	1	-	-	8
May	0	0	-	-	-	0	2	1	-	-	-	3
Jun.	-	-	-	-	-	1	0	0	-	-	-	1
Jul.	-	-	-	-	-	0	-	-	-	-	-	0
Aug.	-	0	-	0	-	-	-	0	2	-	-	2
Sept.	0	0	-	0	-	-	-	-	-	-	-	0
TOTAL	29	9	11	0	7	8	46	19	12	25	4	170

0 = No specimens in the samples taken.

- = The station was not sampled.

Appendix 4 Monthly total weights (g) of Schilbe mystus in each station.

	A	C	D	G	H	J	K	L	M	N	O	TOTALS
1974												
Oct.	0	21	0	0	0	0	0	0	0	0	0	21
Nov.	0	0	0	0	0	0	0	0	0	0	118	118
Dec.	0	0	138	0	0	0	157	0	0	0	0	295
1975												
Jan.	25	194	0	0	66	0	64	0	0	0	0	349
Feb.	140	0	0	0	0	0	30	0	48	0	0	218
Mar.	0	68	0	0	263	0	30	0	0	35	43	439
Apr.	-	0	58	0	-	0	71	93	-	-	-	222
May	45	0	71	0	0	0	118	75	39	277	0	625
Jun.	153	0	-	0	-	0	0	0	0	98	-	251
Jul.	135	118	0	0	33	0	0	74	0	250	0	610
Aug.	-	-	-	0	-	61	164	49	-	-	-	274
Sept.	-	0	-	0	-	80	79	38	44	-	-	241
Oct.	-	-	-	-	-	166	58	55	-	-	-	279
Nov.	-	-	-	0	-	0	72	0	0	0	0	72
Dec.	-	-	-	-	-	85	0	-	-	-	-	85
1976												
Jan.	-	0	-	-	-	0	0	238	196	0	-	434
Feb.	246	-	40	0	-	32	20	-	0	0	-	338
Mar.	-	0	0	-	-	0	181	69	98	-	235	583
Apr.	-	0	-	-	-	0	186	0	32	-	-	218
May	0	0	-	-	-	0	189	49	-	-	-	238
Jun.	-	-	-	-	-	0	0	0	-	-	-	0
Jul.	-	-	-	-	-	0	-	-	-	-	-	0
Aug.	-	0	-	0	-	-	-	0	0	-	-	0
Sept.	0	0	-	0	-	-	-	-	-	-	-	0
TOTALS	744	401	307	0	362	424	1419	740	457	660	396	5910

0 = No specimens in the samples taken.

- = The station was not sampled.

Appendix 5

Monthly total numbers of schilbeid species captured by the small nets.

		S. auritus	P. pellucida	E. niloticus	S. mystus	S. uranoscopus	TOTALS	No of samples
1974	Nov.	1	216	123	49	1	390	18
	Dec.	1	277	89	39	2	408	20
1975	Jan.	0	173	40	25	1	239	18
	Feb.	0	152	55	39	0	246	15
	Mar.	3	101	121	20	0	245	13
	Apr.	0	101	110	18	0	229	18
	May	0	0	42	3	0	45	9
	Jun.	0	2	63	10	0	75	10
	Jul.	3	17	94	3	0	117	15
	Aug.	17	30	54	6	0	110	13
	Sept.	20	255	27	1	0	303	10
	Oct.	1	625	105	2	0	733	16
	Nov.	0	46	39	2	0	87	8
	Dec.	0	433	59	1	0	493	13
1976	Jan.	0	47	26	0	0	73	10
	Feb.	0	359	38	2	0	399	7
	Mar.	2	532	144	2	0	680	14
	Apr.	0	45	26	2	0	73	5
TOTALS		48	3411	1258	224	4	4945	

Appendix 6.

Monthly total weights (g) of schilbeid species captured by the small nets.

		S. auritus	P. pellucida	E. niloticus	S. mystus	S. uranoscopus	TOTAL	No. of samples
1974	Nov.	13	1158	1459	582	27	3239	18
	Dec.	9	1591	2222	588	18	4428	20
1975	Jan.	0	1438	762	465	12	2677	18
	Feb.	0	1483	948	604	0	3035	15
	Mar.	28	836	1319	430	0	2613	13
	Apr.	0	956	1354	302	0	2612	18
	May	0	0	539	35	0	574	9
	Jun.	0	17	642	14	0	673	10
	Jul.	27	73	1070	55	0	1225	15
	Aug.	125	284	866	17	0	1292	13
	Sept.	172	1051	390	0	0	1613	10
	Oct.	11	2106	1515	86	0	3718	16
	Nov.	0	109	512	163	0	784	8
	Dec.	0	1886	727	25	0	2638	13
1976	Jan.	0	189	319	0	0	508	10
	Feb.	0	1592	541	62	0	2195	7
	Mar.	2	2217	2006	165	0	4390	14
	Apr.	0	192	155	185	0	532	5
TOTALS		387	17178	17346	3778	57	38746	

Appendix 7.

% Composition of major families by number - 1974

	J	F	M	A	M	J	J	A	S	O	N	D	% (mean)
Schilbeidae	39	25	28	26	39	28	43	28	27	33	40	35	32.6
Characidae	25	28	26	32	17	18	10	2	4	6	8	11	15.6
Mochokidae	11	13	15	14	14	11	13	45	42	31	23	20	21.0
Mormyridae	12	15	13	6	8	4	7	4	5	7	8	11	8.3
Bagridae	4	10	7	12	9	10	11	5	7	10	10	12	8.9
Citharinidae	2	2	2	4	1	2	2	1	1	1	3	4	2.1
Cyprinidae	4	1	2	2	2	3	4	2	1	1	1	1	2.0
Centropomidae	1	1	4	1	1	1	1	8	8	5	2	2	2.9
Cichlidae	1	2	1	3	4	18	8	1	1	2	1	1	3.6
Polypteridae	-	-	-	-	-	-	1	-	1	1	1	1	0.4
Others	-	1	1	1	1	-	1	-	-	1	1	1	0.7

Appendix 8.

% Composition of major families by number - 1975

	J	F	M	A	M	J	J	A	S	O	N	D	% (mean)
Schilbeidae	20.00	20.86	13.48	11.09	9.41	10.62	16.19	8.58	9.80	17.91	23.11	11.03	14.34
Characidae	24.67	32.20	26.60	28.34	25.15	11.31	10.98	7.73	4.27	16.04	15.74	10.29	17.78
Mochokidae	11.20	11.99	23.05	10.47	18.67	18.13	23.51	17.60	37.19	25.37	30.28	16.18	20.30
Mormyridae	12.27	8.08	6.38	21.36	3.71	4.06	4.40	3.00	10.55	9.33	7.77	11.03	8.50
Bagridae	12.40	14.47	7.21	6.57	7.83	4.16	16.06	17.16	6.53	14.18	9.36	34.56	12.54
Citharinidae	12.80	8.08	20.21	15.61	21.91	34.63	10.50	4.72	10.55	8.21	5.18	0.74	12.76
Cyprinidae	3.33	2.09	1.06	3.08	2.37	4.23	3.79	9.01	3.27	4.10	1.99	13.24	4.30
Centropomidae	3.06	1.04	1.30	3.08	7.75	7.98	10.50	21.03	11.81	4.48	6.37	2.21	6.72
Cichlidae	0.26	1.04	0.24	0.21	2.29	2.43	3.93	10.30	5.28	0.00	0.00	0.74	2.23
Polypteridae	-	-	-	-	7.91	0.35	0.00	0.86	0.50	0.37	0.20	0.00	0.85
Others	0.00	0.13	4.00	0.21	0.79	2.26	0.14	0.00	0.25	0.00	0.00	0.00	0.65

Appendix 9.

% Composition of major families by number - 1976

	J	F	M	A	M	J	J	A	S	% (mean)
Schilbeidae	14.24	15.90	9.50	4.61	7.67	25.42	3.17	20.30	24.05	13.87
Characidae	22.57	26.01	17.65	15.16	12.80	8.47	3.17	4.57	20.25	14.52
Mochokidae	25.00	25.72	16.97	18.81	25.59	12.71	11.11	22.84	18.99	19.75
Mormyridae	16.32	8.67	9.73	5.37	6.58	5.51	5.56	3.55	6.33	7.51
Bagridae	10.76	15.03	38.24	44.91	21.39	16.10	50.00	34.01	21.52	28.00
Citharinidae	3.82	3.76	3.39	1.92	9.14	4.24	1.59	6.60	4.43	4.32
Cyprinidae	3.82	2.02	0.68	3.45	10.79	10.17	11.11	3.55	1.90	5.28
Centropomidae	2.78	1.45	2.49	4.03	3.29	13.56	12.70	4.06	1.90	5.14
Cichlidae	0.35	1.16	1.36	1.15	2.38	3.81	1.59	0.00	0.00	1.31
Polypteridae	0.35	0.00	0.00	0.38	0.00	0.00	0.00	0.51	0.00	0.14
Others	0.00	0.29	0.00	0.19	0.37	0.00	0.00	0.00	0.63	0.16

Appendix 10.

Preparation of spines for sectioning.

The spines were fixed in formol-calcium for at least 24 hours, then removed from the fixative, washed in distilled water and transferred into decalcifying fluid. The decalcification period varied with the length of the spine (6 - 12 hours). The time of fixation and decalcification was shortened by mixing the fixative and decalcifying fluid together in various proportions depending on the length of the spine. This method reduces the time of fixation and decalcification to between 6 and 10 hours.

Formol - calcium fixative (Hale, 1958)

Formaldehyde, 40%	10 ml.
Calcium chloride (anhydrous) aq. sol.	10 ml.
Distilled water	80 ml.
$CaCO_3$ (powdered)	Add excess

Decalcifying fluid (Perry, 1967)

Solution A	Sodium citrate	50g.
	Distilled water	250cc.
Solution B	Formic Acid	125cc.
	Distilled water	125cc.

Mix Solution A and B.

Appendix 11.

Length frequency distribution of age groups of female Eutropius niloticus. (Age was determined from spine sections)

Standard length (cm)	Age groups				
	0+	1+	2+	3+	4+
7.1 - 7.5	1				
7.6 - 8.0	1				
8.1 - 8.5	4				
8.6 - 9.0	2	2			
9.1 - 9.5	6	5			
9.6 - 10.0	10	10			
10.1 - 10.5	-	27			
10.6 - 11.0	-	23			
11.1 - 11.5	1	17			
11.6 - 12.0	2	11			
12.1 - 12.5	2	10	1		
12.6 - 13.0	1	7	2		
13.1 - 13.5	2	17	1		
13.6 - 14.0	-	18	7		
14.1 - 14.5	3	22	15		
14.6 - 15.0		22	10		
15.1 - 15.5		11	20		
15.6 - 16.0		1	12		
16.1 - 16.5		2	17		
16.6 - 17.0		3	12		
17.1 - 17.5			17		
17.6 - 18.0			16	1	
18.1 - 18.5			12	2	
18.6 - 19.0			10	1	
19.1 - 19.5			18	1	
19.6 - 20.0			9	-	1
20.1 - 20.5			3	9	
20.6 - 21.0			1	8	
21.1 - 21.5			2	2	
21.6 - 22.0			-	2	
22.1 - 22.5			1	3	
22.6 - 23.0			-	3	
23.1 - 23.5				2	
23.6 - 24.0				-	
24.1 - 24.5				1	
24.6 - 25.0					
25.1 - 25.5					1
25.6 - 26.0					-
26.1 - 26.5					1

Appendix 12.

Length frequency distribution of age groups of male *Eutropius niloticus*. (Age was determined from spine sections)

Standard length (cm)	Age groups 0+	1+	2+	3+
7.6 - 8.0	1			
8.1 - 8.5	1			
8.6 - 9.0	2	4		
9.1 - 9.5		4		
9.6 - 10.0		7		
10.1 - 10.5		9		
10.6 - 11.0		4	1	
11.1 - 11.5		9	1	
11.6 - 12.0		5	2	
12.1 - 12.5		6	1	
12.6 - 13.0		2	-	
13.1 - 13.5		3	9	
13.6 - 14.0			9	1
14.1 - 14.5			7	
14.6 - 15.0			5	3
15.1 - 15.5			4	2
15.6 - 16.0				1
16.1 - 16.5				1
16.6 - 17.0				-
17.1 - 17.5				1
17.6 - 18.0				-
18.1 - 18.5				1

Appendix 13.

Length frequency distribution of age groups of female Schilbe mystus. (Age was determined from spine sections)

Standard length (cm)	Age groups 0+	1+	2+	3+
9.1 - 9.5	5			
9.6 - 10.0	5	1		
10.1 - 10.5	7	1		
10.6 - 11.0	6	2		
11.1 - 11.5	3	1		
11.6 - 12.0	5	-		
12.1 - 12.5	2	1		
12.6 - 13.0	-	-		
13.1 - 13.5	5	1		
13.6 - 14.0	1	5	1	
14.1 - 14.5		4	-	
14.6 - 15.0		8	7	
15.1 - 15.5		5		
15.6 - 16.0		9		
16.1 - 16.5		6	1	
16.6 - 17.0		4		
17.1 - 17.5		2		
17.6 - 18.0		5		
18.1 - 18.5		6		
18.6 - 19.0		1		
19.1 - 19.5		1		
19.6 - 20.0				
20.1 - 20.5				
20.6 - 21.0			1	

Appendix 14.

Length frequency distribution of age groups of male Schilbe mystus. (Age was determined from spine sections)

Standard length (cm)	Age groups 0+	1+	2+
8.1 - 8.5	1		
8.6 - 9.0	3		
9.1 - 9.5	5		
9.6 - 10.0	-		
10.1 - 10.5	2		
10.6 - 11.0			
11.1 - 11.5			
11.6 - 12.0		2	
12.1 - 12.5		-	
12.6 - 13.0		-	
13.1 - 13.5		1	1
13.6 - 14.0		2	1
14.1 - 14.5		-	-
14.6 - 15.0		2	3
15.1 - 15.5			1
15.6 - 16.0			1
16.1 - 16.5			1
16.6 - 17.0			1

Appendix 15. **Comparison of observed lengths with calculated lengths - Eutropius niloticus.**

Female	Observed standard length when captured (cm)			Calculated standard length				
Age	Range	Mean	S.D	Age	Range	Mean	S.D	Number of fish examined
1+	9.0 - 16.9	12.5	1.95	1	7.1 - 14.5	10.3	1.73	211
2+	12.2 - 22.5	17.0	1.97	2	10.2 - 20.0	15.1	1.93	187
3+	17.8 - 24.5	22.1	1.49	3	15.5 - 22.4	19.7	1.55	35
4+	20.0 - 26.5	24.0	3.50	4	19.5 - 24.1	22.4	2.55	3
Male								
1+	8.6 - 13.2	10.9	1.25	1	7.2 - 11.7	8.9	1.20	52
2+	10.5 - 15.3	13.8	1.01	2	8.0 - 14.0	12.4	1.00	41
3+	13.8 - 18.4	15.7	1.27	3	13.5 - 16.2	14.2	1.06	9

Appendix 16. Comparison of observed lengths with calculated lengths - Schilbe mystus.

Female	Observed standard length when captured (cm)			Calculated standard length				Number of fish examined
Age	Range	Mean	S.D	Age	Range	Mean	S.D	
1+	10.0 - 14.9	13.5	1.48	1	8.5-13.2	10.9	1.42	24
2+	13.8 - 19.5	16.5	1.34	2	11.6-17.5	14.1	1.19	47
3+	16.1 & 20.6	18.4	3.18	3	16.1&18.1	17.1	1.41	2
Male								
1+	10.1 - 14.8	13.1	1.61	1	6.0-10.6	8.4	1.50	8
2+	13.3 - 16.8	15.4	1.12	2	11.3-14.4	13.3	1.15	7

Appendix 17. The degree of error resulting from uncorrected back-calculated standard lengths of Eutropius niloticus.

Sex	Age	Number of fish examined	Mean calculated standard lengths (cm) Uncorrected	Corrected	Difference	% Error
Female	1	211	8.9 (1.71)	10.3 (1.73)	1.4	13.6
	2	187	13.7 (2.00)	15.1 (1.93)	1.4	9.3
	3	35	18.6 (1.75)	19.7 (1.55)	1.1	5.6
	4	3	21.2 (1.79)	22.4 (2.55)	1.2	5.4
Male	1	52	7.4 (1.31)	8.9 (1.20)	1.5	16.9
	2	41	10.9 (1.20)	12.4 (1.00)	1.5	12.1
	3	9	13.0 (0.72)	14.2 (1.06)	1.2	8.5

Standard deviations are in brackets.

Appendix 18. The degree of error resulting from uncorrected back-calculated standard lengths of Schilbe mystus

Sex	Age	Number of fish examined	Mean Calculated Standard lengths (cm) Lea (1910) method Uncorrected	LeCren (1947) method Corrected	Difference	% Error
Female	1	24	10.1 (1.51)	10.9 (1.42)	0.8	7.3
	2	47	13.2 (1.36)	14.1 (1.19)	0.9	6.4
	3	2	16.5 (0.64)	17.1 (1.41)	0.6	3.5
Male	1	8	8.4 (1.50)	8.4 (1.50)	0.0	0.0
	2	7	13.3 (1.15)	13.3 (1.15)	0.0	0.0

Standard deviations are in brackets.

Appendix 19. Statistical analysis for significant differences between standard lengths of females and males of Eutropius niloticus and Schilbe mystus.

Species	Age	Sex	Mean standard length	't'	Mean significantly different?	Level of significance (P)	Degree of freedom
E. niloticus	1	Female	10.3	6.826	Yes	0.001	261
		Male	8.9				
	2	Female	15.1	12.827	Yes	0.001	226
		Male	12.4				
	3	Female	19.7	12.505	Yes	0.001	42
		Male	14.2				
S. mystus	1	Female	10.9	4.139	Yes	0.001	30
		Male	8.4				
	2	Female	14.1	1.709	Yes	0.1	52
		Male	13.3				

Appendix 20. Condition factor analysis - Eutropius niloticus.

Months	Number examined	Range	Mean	Standard deviation
Jan.	50	0.89 - 1.47	1.15	0.11
Feb.	50	0.63 - 1.39	1.06	0.13
Mar.	50	0.61 - 1.35	1.10	0.12
Apr.	50	0.70 - 1.38	1.08	0.12
May	50	0.81 - 1.26	1.09	0.12
Jun.	50	0.65 - 2.33	1.13	0.25
Jul.	50	0.86 - 1.57	1.13	0.13
Aug.	50	0.92 - 1.64	1.14	0.14
Sept.	50	0.85 - 1.58	1.11	0.12
Oct.	50	0.65 - 1.51	1.17	0.13
Nov.	50	0.97 - 1.55	1.17	0.09
Dec.	50	0.94 - 1.67	1.16	0.13

Appendix 21. Condition factor analysis - Schilbe mystus.

Months	Number examined	Range	Mean	Standard deviation
Jan.	36	0.92 - 1.56	1.15	0.17
Feb.	42	0.93 - 2.08	1.20	0.20
Mar.	38	0.90 - 1.81	1.22	0.15
Apr.	28	0.91 - 1.39	1.16	0.12
May.	22	0.95 - 1.43	1.17	0.12
Jun.	7	1.12 - 1.46	1.24	0.11
Jul.	14	0.96 - 1.63	1.21	0.16
Aug.	10	1.13 - 1.80	1.29	0.19
Sept.	7	1.04 - 1.45	1.19	0.15
Oct.	6	1.12 - 1.39	1.24	0.09
Nov.	48	0.94 - 1.62	1.15	0.14
Dec.	46	0.86 - 1.59	1.13	0.16

Appendix 22. Condition factor analysis - Physailia pellucida.

Months	Number examined	Range	Mean	Standard deviation
Jan.	50	0.45 - 1.09	0.88	0.13
Feb.	50	0.65 - 1.17	0.98	0.12
Mar.	50	0.52 - 1.26	1.01	0.16
Apr.	50	0.73 - 1.23	0.98	0.12
May	-	- -	-	-
Jun.	-	- -	-	-
Jul.	9	0.84 - 1.53	1.04	0.22
Aug.	22	0.71 - 1.52	1.09	0.27
Sept.	50	0.64 - 1.24	0.99	0.13
Oct.	50	0.54 - 1.20	0.93	0.14
Nov.	50	0.64 - 1.14	0.89	0.14
Dec.	50	0.60 - 1.17	0.90	0.13

Appendix 23.

Protein concentration in the extracts

Fish	Mg protein assayed
P. pellucida	0.31
E. niloticus	0.68
S. mystus	0.55

All were diluted to give approximately the same protein concentration.

Appendix 24 Set up of test tubes and contents before incubation.

Test tubes	Remarks	Enzyme-Substrate mixture 1.8ml substrate 0.2ml. Enzyme Extract		Enzyme activity on Test
A_1	Control	Buffered 1% Casein	(Boiled)	Trypsin
A_2	"	"	"	"
A_3	Test	"	(Normal)	"
A_4	Test	"	"	"
B_1	Control	"	(Boiled)	Pepsin
B_2	"	"	"	"
B_3	Test	"	(Normal)	"
B_4	Test	"	"	"
C_1	Control	Buffered 25% Olive oil emulsion	(Boiled)	Lipase
C_2	"	"	"	"
C_3	Test	"	(Normal)	"
C_4	Test	"	"	"
D_1	Control	Buffered 1% Starch	(Boiled)	Amylase
D_2	"	"	"	"
D_3	"	"	"	"
D_4	Test	"	(Normal)	"
D_5	Test	"	"	"
D_6	Test	"	"	"
E_1	Control	Buffered 1% Sucrose	(Boiled)	Invertase
E_2	"	"	"	"
E_3	"	"	"	"
E_4	Test	"	(Normal)	"
E_5	Test	"	"	"
E_6	Test	"	"	"
F_1	Control	Buffered 1% Lactose	(Boiled)	Lactase
F_2	"	"	"	"
F_3	Test	"	(Normal)	"
F_4	Test	"	"	"
G_1	Control	Buffered 1% Maltose	(Boiled)	Maltase
G_2	"	"	"	"
G_3	Test	"	(Normal)	"
G_4	Test	"	"	"

Appendix 24 cont'd.

H_1	Control	Buffered 1% CMC	(Boiled)	Cellulase
H_2	"	"	"	"
H_3	"	"	"	"
H_4	Test	"	(Normal)	"
H_5	Test	"	"	"
H_6	Test	"	"	"

Appendix 25 Amino acid determination using the method of Lowry et al (1951).

The blank, standard and Test samples were prepared as follows :-

1. 1 ml of standard, 1 ml^{+} of test samples A_1 - 4 and 0.1^{+} ml of Test samples B_1 - 4 were taken. The standard and test samples were made up to 5ml with distilled water. A Blank was prepared with 5ml distilled water. 4ml of Solution C^{++} were added to the Blank, the standard and test samples above. They were allowed to stand for 10 minutes. 0.4ml of Folins reagent was added and mixed immediately. The mixtures were allowed to stand for at least 30 minutes. The colour developed was read at O.D 550.

+ Various other concentrations equivalent to (0.1 - 0.5ml) were also tried.

++ Solution C was prepared freshly by taking 50ml of 2% Na_2CO_3 in 0.1N NaOH and 1ml of solution B prepared by mixing equal volumes of 1% $CuSO_4$ $5H_2O$ and of 2% KNa tartarate.

Appendix 26 Quantitative determination of sugars using Nelson (1944) and Somorgi (1945) methods.

The blank, standard and test samples were prepared as follows:- 1 ml of standard, 0.1 ml^{+} of test samples D_1, D_4 and 0.1 ml^{+} of test samples E_1 E_4; F_1 F_4; G_1 G_4 already diluted 100 times were taken. The standard and test samples were made up to 1 ml. A blank was prepared with 1 ml of distilled water. 1 ml of combined Copper reagent^{++} was added to the Blank, the standard and test samples above. They were boiled for twenty minutes and cooled in water. 1 ml of Arsenomolybdate colour reagent was added to the Blank, Standard and test samples. 10 ml of water were finally added to the above. The colour developed was read at O.D 540

+ Other concentrations ranging from 0.05 ml to 0.5 ml were also tried.

++ Prepared freshly each day by adding 1 ml of reagent B to 25 ml of reagent A.

Appendix 27 List of buffered substrates and reagents used in the enzymology experiments.

A For determination of activity of Protease.

Substrate for Trypsin activity.

1% Casein in 0.1 m Tris - HCL pH 8.1

Substrate for Pepsin activity.

1% Casein in 0.1 m Glycine - HCL pH 2.0

Reagents

Standard Tyrosine solution (50 Mg/ml)

10% Trichloacetic Acid (TCA)

Folin's reagent

2% Na_2CO_3 in 0.1N NaOH

1% $CuSO_4 \cdot 5H_2O$

2% KNa tartarate

B For determination of activity of Lipase.

Substrate = 25% Olive oil emulsion in 0.01m PO_4 pH 7.0

Reagents

95% ethanol

Phenolphthalin indicator

0.05 m NaOH

C For determination of activity of Carbohydrases

Substrates for Amylase activity

1% starch in 0.1 m Na Acetate pH 5.0

Substrate for Invertase activity

1% Sucrose in 0.1 m Na Acetate pH 5.0

Substrate for Lactase activity

1% Lactose in 0.1 m Na Acetate pH 5.0

Substrate for Maltase activity

1% Maltose in 0.1 m Na Acetate pH 5.0

Appendix 27 cont'd.

Substrate for Cellulase activity

1% Carboxy methyl cellulose (CMC) in 0.1m

Na Acetate pH 5.0

Reagents

Copper reagent A

25g Sodium carbonate (anhydrous)

20g Sodium bicarbonate

25g Potassium sodium tartarate

Copper reagent B

15% Copper sulfate containing one to two drops of concentrated Sulphuric acid per 100ml.

Arsernomolybdate colour reagent

Benedict's qualitative reagent

200g Sodium sulphate (anhydrous)

All made to one litre.

Standard glucose solution (50ug/ml)

For protein determination

Biuret reagent.

Appendix 28 Results of the Lipase activity determination

A *Schilbe mystus* (First fish)

Samples	Volume of 0.05M NaOH used	Remarks
C_1 Control	0.24	
C_2 Control	0.23	
C_3 Test	0.24	No lipase activity
C_4 Test	0.25	No lipase activity

B *Schilbe mystus* (Second fish)

Samples	Volume of 0.05M NaOH used	Remarks
C_1 Control	0.41	
C_2 Control	0.40	
C_3 Test	0.42	No lipase activity
C_4 Test	0.41	No lipase activity

C *Eutropius niloticus*

Samples	Volume of 0.05M NaOH used	Remarks
C_1 Control	0.60	
C_2 Control	0.60	
C_3 Test	0.62	No lipase activity
C_4 Test	0.62	No lipase activity

D *Physailia pellucida*

Samples	Volume of 0.05M NaOH used	Remarks
C_1 Control	0.50	
C_2 Control	0.55	
C_3 Test	0.55	No lipase activity
C_4 Test	0.55	No lipase activity

Appendix 29 Result of Proteases activities.

A *Schilbe mystus* (First fish)

Samples	O.D. at 550	Remarks
Blank	0.00	
Standard	0.27	
A_1 Control	0.08	No trypsin activity.
A_2 Control	0.04	No trypsin activity.
A_3 Test	0.28	Trypsin activity present.
A_4 Test	0.26	Trypsin activity present.
B_1 Control	0.01	No pepsin activity.
B_2 Control	0.01	No pepsin activity.
B_3 Test	0.25	Pepsin activity present.
B_4 Test	0.25	Pepsin activity present.

B *Schilbe mystus* (Second fish)

Samples	O.D. at 550	Remarks
Blank	0.00	
Standard	0.28	
A_1 Control	0.10	No trypsin activity.
A_2 Control	0.12	No trypsin activity.
A_3 Test	0.39	Trypsin activity present.
A_4 Test	0.44	Trypsin activity present.
B_1 Control	0.03	No pepsin activity
B_2 Control	0.02	No pepsin activity
B_3 Test	0.34	Pepsin activity present
B_4 Test	0.38	Pepsin activity present

C *Eutropius niloticus*

Samples	O.D. at 550	Remarks
Blank	0.00	
Standard	0.28	
A_1 Control	0.07	No trypsin activity
A_2 Control	0.06	No trypsin activity
A_3 Control	0.10	Low trypsin activity
A_4 Control	0.10	Low trypsin activity

Appendix 29 cont'd.

B_1 Test	0.06	No trypsin activity
B_2 Test	0.06	No trypsin activity
B_3 Test	0.41	High trypsin activity
B_4 Test	0.32	High trypsin activity

D Eutropius niloticus — Samples A (repeat) using various concentrations of A_1 - 4 samples.

Samples	O.D. at 550	Remarks
Blank	0.00	
Standard	0.28	
A_1 Control	0.10	No trypsin activity
A_1 Control	0.12	No trypsin activity
A_2 Control	0.10	No trypsin activity
A_2 Control	0.12	No trypsin activity
A_3 Test	0.12	No trypsin activity
A_3 Test	0.16	Low trypsin activity
A_4 Test	0.14	Low trypsin activity
A_4 Test	0.17	Low trypsin activity

E Physailia pellucida

Samples	O.D. at 550	Remarks
Blank	0.00	
Standard	0.30	
A_1	0.08	No trypsin activity
A_2	0.09	No trypsin activity
A_3	0.15	Low trypsin activity indicated.
A_4	0.15	Low trypsin activity indicated
B_1	0.05	No pepsin activity
B_2	0.04	No pepsin activity
B_3	0.42	High pepsin activity indicated.
B_4	0.37	High pepsin activity indicated.

F Physailia pellucida — Repeat experiments using different concentration of A_1 - 4 samples

Blank	0.00	
Standard	0.28	
A_1	0.13	
A_2	0.13	
A_3	0.32	Trypsin activity indicated
A_4	0.32	Trypsin activity indicated

Appendix 30 The result of Carbohydrase activity.

A *Schilbe mystus* (First fish)

Samples	O.D. at 540	Remarks
Blank	0.00	
Standard	0.19	
D_1 Control	0.04	No amylase activity
D_4 Test	1.70	Strong amylase activity observed
E_1 Control	0.28	No invertase activity
E_4 Test	0.25	No invertase activity
F_1 Control	0.22	No lactase activity
F_3 Test	0.19	No lactase activity
G_1 Control	0.19	No maltase activity
G_3 Test	0.21	No maltase activity

B *Schilbe mystus* (Second fish)

Sample	O.D. at 540	Remarks
Blank	0.00	
Standard	0.19	
D_1 Control	0.00	No amylase activity
D_4 Test	0.60	High amylase activity observed
E_1 Control	0.19	No invertase activity
E_4 Test	0.21	No invertase activity
F_1 Control	0.19	No lactase activity
F_4 Test	0.19	No lactase activity
G_1 Control	0.19	No maltase activity
G_4 Test	0.17	No maltase activity

C *Schilbe mystus* Sample E (repeat)

Sample	O.D. 550	Remarks
Blank	0.00	
Standard	0.28	
E_1 Control	0.31	No invertase activity
E_2 Control	0.28	No invertase activity
E_4 Test	0.31	No invertase activity
E_5 Test	0.35	No invertase activity

Appendix 30 cont'd.

D *Eutropius nilotieus*

Sample	O.D. 550	Remarks
Blank	0.00	
Standard	0.19	
D_1 Control	0.00	No amylase activity
D_4 Test	0.10	Low amylase activity indicated
E_1 Control	0.15	No invertase activity
E_4 Test	0.14	No invertase activity
F_1 Control	0.22	No lactase activity
F_3 Test	0.21	No lactase activity
G_1 Control	0.20	No maltase activity
G_3 Test	0.21	No maltase activity

E *Physailia pellucida*

Samples	O.D. 540	Remarks
Blank	0.00	
Standard	0.19	
D_1	0.02	No amylase activity
D_4	0.05	No amylase activity
E_1	0.02	No invertase activity
E_4	0.02	No invertase activity
F_1	0.22	No lactase activity
F_4	0.18	No lactase activity
G_1	0.19	No maltase activity
G_4	0.15	No maltase activity

Appendix 31

Female Eutropius niloticus : Number of mature and immature specimens in samples.

Age Groups	Gonad Condition	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	TOTAL
0+	Immature	30	9	19	8	15	20	20	4	5	25	2	2	159
	Mature	-	-	-	-	-	-	-	-	-	-	-	-	-
1+	Immature	54	71	52	75	54	38	21	33	24	30	10	9	471
	Mature	1	-	-	-	-	-	-	-	-	1	1	3	6
2+	Immature	88	102	86	50	61	63	31	35	38	49	15	13	631
	Mature	16	3	-	-	-	-	-	-	-	13	5	9	46
3+	Immature	10	12	30	9	10	1	6	3	3	4	2	-	90
	Mature	7	1	-	-	-	-	-	-	1	4	4	3	20
4+	Immature	-	1	-	-	-	-	-	-	-	-	-	-	1
	Mature	-	1	1	-	-	-	-	-	-	-	-	-	2
	TOTAL EXAMINED	206	200	188	142	140	122	78	75	71	126	39	39	1426

Appendix 32

Male Eutropius niloticus : Number of mature and immature specimens in samples.

Age Groups	Gonad Condition	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	TOTAL
0+	Immature	3	5	10	6	8	12	7	5	2	8	1	1	68
	Mature	-	-	-	-	-	-	-	-	-	-	-	-	-
1+	Immature	3	10	7	7	7	13	7	10	3	4	1	1	73
	Mature	-	-	-	-	-	-	-	-	1	-	-	-	1
2+	Immature	4	7	13	6	10	38	8	12	1	3	-	-	102
	Mature	5	1	-	-	-	-	-	-	8	5	1	1	21
3+	Immature	-	3	-	1	-	3	1	2	1	-	1	-	12
	Mature	-	-	-	-	-	-	-	-	1	-	-	1	2
	TOTAL EXAMINED	15	26	30	20	25	66	23	29	17	20	4	4	279

Appendix 33

Female - Schilbe mystus : Number of mature and immature specimens in samples.

Age Groups	Gonad Condition	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	TOTAL
0+	Immature	6	21	22	13	21	11	13	6	-	1	5	1	120
	Mature	-	-	-	-	-	-	-	-	-	-	-	-	-
1+	Immature	1	12	7	3	7	6	6	3	1	1	-	1	48
	Mature	-	-	-	-	-	-	-	-	-	1	3	-	4
2+	Immature	2	7	4	4	5	4	3	6	1	4	3	2	45
	Mature	-	-	-	-	-	-	-	-	-	1	2	-	3
3+	Immature	2	2	1	4	1	3	-	3	-	3	-	1	20
	Mature	-	-	-	-	-	-	-	1	-	-	1	-	2
	TOTAL EXAMINED	11	42	34	24	34	24	22	19	2	11	14	5	242

Appendix 34

Male - Schilbe mystus : Number of mature and immature specimens in samples.

Age Groups	Gonad Condition	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	TOTAL
0+	Immature	-	-	-	1	3	5	1	-	-	-	-	-	10
	Mature	-	-	-	-	-	-	-	-	-	1	-	-	1
1+	Immature	-	1	1	1	3	4	3	-	1	1	-	-	15
	Mature	-	-	-	-	-	-	1	-	-	-	-	-	1
2+	Immature	-	-	-	-	2	1	1	1	-	-	-	-	5
	Mature	-	-	-	1	-	-	1	-	1	1	-	-	3
3+	Immature	-	-	-	-	-	1	-	-	-	-	-	-	1
	Mature	-	-	-	-	-	-	-	-	-	-	-	-	-
	TOTAL EXAMINED	-	1	1	2	8	11	7	1	2	3	-	-	36

Appendix 35 Condition factor of Eutropius niloticus.

Female Gonad Stage I

S.L.	Wt.	'K'	S.L.	Wt.	'K'	S.L.	Wt.	'K'
8.2	7	1.3	13.5	26	1.1	15.0	35	1.0
8,8	6	0.9	13.6	25	1.0	15.0	39	1.2
10.0	11	1.1	14.0	28	1.0	15.2	34	1.0
10.5	13	1.1	14.0	33	1.2	15.4	41	1.1
10.5	12	1.0	14.0	27	1.0	15.4	38	1.0
11.3	14	1.0	14.1	30	1.1	15.4	41	1.1
11.5	17	1.1	14.1	31	1.1	15.5	36	1.0
11.6	18	1.2	14.2	28	1.0	15.5	40	1.1
11.8	20	1.2	14.4	27	0.9	15.5	40	1.1
12.0	19	1.1	14.4	31	1.0	15.7	45	1.2
12.2	21	1.2	14.4	32	1.1	16.5	46	1.0
12.5	20	1.0	14.5	29	1.0	17.0	60	1.2
12.7	23	1.1	14.5	37	1.2	17.0	51	1.0
13.2	27	1.2	14.5	33	1.1	18.5	66	1.0
13.5	17	0.7	14.8	33	1.0	20.0	54	0.7
13.5	25	1.0	14.9	34	1.0	20.5	93	1.1
13.5	25	1.0	14.9	34	1.0			
Female Gonad Stage II								
13.4	30	1.2	15.5	24	0.6	17.5	58	1.1
13.4	56	2.3	15.5	47	1.3	17.5	58	1.1
13.6	27	1.1	15.5	38	0.7	17.6	61	1.1
14.0	32	1.2	15.9	35	0.9	18.0	66	1.1
14.0	30	1.1	16.0	40	1.0	18.1	95	1.6
14.0	27	1.0	16.0	42	1.0	18.2	67	1.1
14.0	36	1.3	16.1	45	1.1	18.4	67	1.1
14.5	37	1.2	16.2	25	0.6	18.5	72	1.1
14.5	33	1.1	16.4	43	1.0	18.6	100	1.6
14.5	32	1.0	16.5	47	1.0	18.8	76	1.1
14.5	28	1.0	16.5	46	1.0	19.5	82	1.1
14.6	34	1.1	16.5	43	1.0	19.7	105	1.4
15.0	40	1.2	16.8	58	1.2	20.0	105	1.3
15.0	36	1.1	16.8	45	1.0	21.0	93	1.0
15.1	39	1.1	17.0	53	1.1	22.5	135	1.2

S.L. = Standard length (cm) 'K' = Condition factor

Wt. = Weight of fish (g)

Appendix 35 cont'd.

S.L.	Wt.	'K'	S.L.	Wt.	'K'	S.L.	Wt.	'K'
Female Gonad Stage II cont'd.								
15.1	38	1.1	17.0	55	1.1	25.5	220	1.3
15.4	37	1.0	17.0	47	1.0			
Female Gonad Stage III								
14.6	36	1.2	18.0	64	1.1	19.4	96	1.3
15.4	41	1.1	18.2	64	1.1	19.5	74	1.0
15.9	43	1.1	18.5	76	1.2	19.5	79	1.1
17.3	57	1.1	18.5	70	1.1	19.6	89	1.2
17.4	54	1.0	18.5	75	1.2	20.5	109	1.3
17.6	59	1.1	19.2	87	1.2	22.0	132	1.2
17.6	65	1.2	19.2	79	1.1	22.2	120	1.1
Female Gonad Stage IV								
17.5	64	1.2	19.5	73	1.0	21.0	133	1.4
18.0	59	1.0	20.5	91	1.1	21.8	133	1.3
19.1	65	1.0	20.6	112	1.3	22.8	165	1.4
Female Gonad Stage V								
14.5	35	1.1	16.5	54	1.2	20.0	87	1.1
14.8	42	1.3						
Female Gonad Stage VI								
18.0	75	1.3	21.0	139	1.5			
Male Gonad Stage I								
10.0	11	1.1	11.3	15	1.0	14.3	34	1.2
10.3	13	1.2	12.2	22	1.2	14.6	35	1.1
Male Gonad Stage II								
11.5	16	1.1	13.2	33	1.4	14.5	38	1.2
12.5	25	1.3	13.8	29	1.1	14.7	34	1.1
13.0	25	1.1	13.9	28	1.0	15.0	35	1.0
13.0	25	1.1	14.0	30	1.1	15.1	33	1.0
13.2	24	1.0	14.4	38	1.3	15.3	40	1.1
13.2	26	1.1	14.5	32	1.0	15.5	41	1.1
Male Gonad Stage III								
13.4	27	1.1	13.7	29	1.1	14.5	35	1.1
13.5	34	1.4	14.0	45	1.6	14.9	30	0.9
13.5	33	1.3	14.0	31	1.1	15.0	38	1.1

Appendix 35 cont'd.

Male Gonad Stage III cont'd.

S.L.	Wt.	'K'	S.L.	Wt.	'K'	S.L.	Wt.	'X'
13.5	24	1.0	14.0	33	1.2	15.1	38	1.1
13.6	28	1.1	14.2	30	1.0			
Male Gonad Stage IV								
13.5	29	1.2	14.0	30	1.1	14.5	32	1.0
13.6	32	1.3	14.4	36	1.2	15.0	35	1.0

Appendix 36 Condition factor of Schilbe mystus.

Female Gonad Stage I

S.L.	Wt.	'K'	S.L.	Wt.	'K'	S.L.	Wt.	'K'
8.6	7	1.1	10.0	10	1.0	10.7	13	1.1
9.2	9	1.2	10.1	9	0.9	10.8	13	1.0
9.2	9	1.1	10.2	12	1.1	10.9	17	1.3
9.3	10	1.2	10.2	12	1.1	10.9	15	1.2
9.5	9	1.0	10.2	11	1.0	11.0	13	1.0
9.5	10	1.2	10.3	14	1.3	11.0	14	1.1
9.5	9.5	1.1	10.3	12	1.1	11.0	17	1.3
9.5	11	1.3	10.3	13	1.0	11.0	12	1.0
9.5	10	1.2	10.3	10	1.0	11.1	15	1.1
9.5	10	1.2	10.3	12	1.1	11.4	19	1.2
9.6	10	1.1	10.5	11	1.0	11.4	17	1.1
9.6	11	1.2	10.5	10	0.9	11.4	14	1.0
9.8	11	1.2	10.5	11	1.0	11.6	16	1.0
9.9	15	1.5	10.5	11	1.0	13.0	24	1.1
9.9	10	1.0	10.5	11	1.0	13.0	27	1.2
9.9	11	1.1	10.6	18	1.5	13.1	25	1.1
9.9	11	1.1	10.6	13	1.1	13.4	32	1.3
10.0	11	1.1	10.6	13	1.1	13.4	31	1.3
10.0	11	1.1	10.6	12	1.0	13.4	31	1.3
13.5	24	1.0	14.5	34	1.1	16.1	44	1.1
13.6	30	1.2	14.6	36	1.2	17.8	72	1.3
13.6	35	1.4	14.9	37	1.1	18.0	71	1.2
14.0	42	1.5	15.0	41	1.2	18.1	69	1.2
14.0	29	1.1	15.4	35	1.0	18.4	76	1.2
14.1	34	1.2	15.5	40	1.1	18.7	86	1.3
14.4	32	1.1	15.5	43	1.2	19.5	80	1.1
14.5	36	1.2						

Female Gonad Stage II

10.5	13	1.1	13.4	30	1.2	14.0	32	1.2
10.8	12	1.0	13.4	26	1.1	14.0	38	1.4
11.7	19	1.2	13.5	32	1.3	14.0	34	1.2
11.9	19	1.1	13.5	28	1.1	14.0	37	1.3
12.2	22	1.2	13.7	27	1.1	14.2	35	1.2
12.5	26	1.3	13.8	38	1.4	14.3	32	1.1
12.5	25	1.3	13.9	31	1.2	14.4	33	1.1

Appendix 36 cont'd.

Female Gonad Stage II cont'd.

S.L.	Wt.	'K'	S.L.	Wt.	'K'	S.L.	Wt.	'K'
14.4	35	1.2	15.5	45	1.2	17.0	66	1.3
14.4	32	1.1	15.5	46	1.2	17.2	82	1.6
14.5	30	1.0	15.5	44	1.2	17.2	84	1.3
14.5	37	1.2	15.6	45	1.7	17.2	77	1.5
14.5	36	1.2	15.9	52	1.3	17.5	66	1.2
14.6	37	1.2	16.0	46	1.1	18.0	76	1.3
14.6	37	1.2	16.0	51	1.2	18.1	75	1.3
14.6	40	1.3	16.0	47	1.1	18.2	85	1.4
14.7	35	1.1	16.0	49	1.2	18.2	69	1.1
14.7	36	1.1	16.0	44	1.1	18.2	98	1.6
14.8	36	1.1	16.0	55	1.3	18.5	81	1.3
14.8	36	1.1	16.2	53	1.2	18.5	76	1.2
15.0	36	1.1	16.5	49	1.1	18.5	80	1.3
15.0	38	1.1	16.5	55	1.2	18.5	70	1.1
15.0	36	1.1	16.6	57	1.2	18.5	78	1.2
15.0	40	1.2	16.6	53	1.2	18.8	88	1.3
15.0	42	1.2	16.6	95	2.1	19.0	90	1.3
15.4	43	1.2	16.9	65	1.3	19.3	87	1.2
15.5	39	1.0	17.0	58	1.2	19.5	100	1.3
20.6	125	1.4	23.5	235	1.8			
Female Gonad Stage III								
14.9	40	1.2	18.0	82	1.4	18.5	85	1.3
15.3	48	1.3						
Male Gonad Stage I								
9.0	10	1.4	10.1	11	1.1	11.5	20	1.3
9.2	11	1.4	10.2	12	1.1	13.2	29	1.3
9.2	10	1.3	10.3	12	1.1	13.6	31	1.2
9.5	10	1.2	10.5	13	1.1	13.9	42	1.6
9.5	11	1.3	10.5	11	1.0	13.9	32	1.2
10.0	11	1.1	11.0	17	1.3	14.0	35	1.3
10.0	10	1.0	11.3	15	1.0	14.4	36	1.2
10.0	18	1.8	11.3	14	1.0	14.5	33	1.1
10.1	11	1.1						

Appendix 36 cont'd.

Male Gonad Stage II

S.L.	Wt.	'K'	S.L.	Wt.	'K'	S.L.	Wt.	'K'
9.1	11	1.5	14.5	32	1.0	16.8	68	1.4
10.5	14	1.2	14.6	35	1.1	17.6	75	1.4
13.2	31	1.3	15.0	40	1.2	18.0	69	1.2
13.3	27	1.1	15.5	49	1.3			
14.0	33	1.2	16.2	50	1.2			

Male Gonad Stage III

9.3	10	1.2	15.4	41	1.1	15.8	55	1.4
14.8	38	1.2						

Male Gonad Stage IV

15.0	42	1.2	16.6	61	1.3

Appendix 37 Condition factor of Physailia pellucida.

Female Gonad Stage I

S.L.	Wt.	'K'	S.L.	Wt.	'K'	S.L.	Wt.	'K'
5.9	1.8	0.9	8.2	4.8	0.9	9.7	10	1.1
5.9	1.4	0.7	8.5	4.8	0.9	9.8	8	0.9
6.2	2	0.8	8.8	5.8	0.9	9.8	9	1.0
6.3	2	0.8	8.9	7.0	1.0	9.8	9	1.0
6.4	2.2	0.8	8.9	5.0	0.7	9.9	9	0.9
6.6	2.2	0.8	9.1	8	1.1	9.9	11	1.1
6.7	2.4	0.8	9.2	8	1.0	10.0	9.0	0.9
6.8	2.4	0.8	9.2	6	0.8	10.0	9.2	0.9
6.8	2.4	0.8	9.3	9.5	1.2	10.0	9.8	1.0
6.8	2.4	0.8	9.4	8	1.0	10.0	10	1.0
7.0	2.4	0.7	9.4	9	1.1	10.0	11	1.1
7.1	3.0	0.8	9.4	9	1.1	10.0	11	1.1
7.2	2.4	0.6	9.5	6.3	0.7	10.0	11	1.1
7.2	2.6	0.7	9.6	8	0.9	10.0	12	1.2
7.5	2.6	0.6	9.6	8.6	1.0	10.1	11	1.1
7.5	3.0	0.7	9.6	10	1.1	10.1	11	1.1
7.8	3.8	0.8	9.6	11	1.2	10.2	9	0.8
7.9	4.0	0.8	9.6	8.1	0.9	10.2	10	0.9
7.9	3.6	0.7	9.7	8.8	1.0	10.2	11	1.0
10.2	12	1.1	10.5	11	1.0	11.0	12	0.9
10.3	9	0.8	10.5	12	1.0	11.0	13	1.0
10.3	10	0.9	10.5	12	1.0	11.2	13	0.9
10.3	11	1.0	10.5	12	1.0	11.4	11	0.7
10.3	11	1.0	10.7	11	0.9	11.5	12	0.8
10.3	12	1.1	10.9	9.2	0.7	11.5	11	0.7
10.4	11	1.0	10.9	11	0.8	11.5	13	0.9
10.4	12	1.1	10.9	15	1.2	11.6	10	0.6
10.5	9	0.8	10.9	19	1.5	11.6	12	0.8
10.5	10	0.9	11.0	11	0.8	12.0	10.3	0.6
10.5	11	1.0	11.0	12	0.9			

Female Gonad Stage II

8.9	6	0.9	9.5	10	1.2	9.6	10	1.1
9.0	8	1.1	9.5	10	1.2	9.6	10	1.1
9.1	7.2	0.9	9.5	10	1.2	9.8	8	0.9
9.3	9	1.1	9.6	7	0.8	9.8	9	1.0

Appendix 37 cont'd.

Female Gonad Stage II cont'd.

S.L.	Wt.	'K'	S.L.	Wt.	'K'	S.L.	Wt.	'K'
9.4	7	0.8	9.6	9	1.0	9.8	9	1.0
9.4	7	0.8	9.6	9	1.0	9.8	9	1.0
9.5	9	1.1	9.6	9	1.0	9.8	9.6	1.0
9.8	10	1.1	10.2	10	1.1	10.5	11	1.0
9.8	10	1.1	10.2	10	1.1	10.5	11	1.0
9.9	9	0.9	10.2	10	1.1	10.5	11	1.0
9.9	10	1.0	10.2	10	1.1	10.5	11	1.0
10.0	9	0.9	10.2	11	1.1	10.5	11	1.0
10.0	9	0.9	10.2	12	1.1	10.5	11	1.0
10.0	10	1.0	10.3	10	0.9	10.5	12	1.0
10.0	10	1.0	10.3	10	0.9	10.6	9	0.8
10.0	10	1.0	10.3	11	1.0	10.6	10	0.8
10.0	10	1.0	10.3	11	1.0	10.6	10	0.8
10.0	10	1.0	10.3	13	1.2	10.6	11	0.9
10.0	10	1.0	10.4	9	0.8	10.6	11	0.9
10.0	11	1.1	10.4	11	1.0	10.6	12	1.0
10.1	9	0.9	10.4	11	1.0	10.6	12	1.0
10.1	9	0.9	10.4	11	1.0	10.6	12	1.0
10.1	10	1.0	10.5	6	0.6	10.7	12	1.0
10.1	10	1.0	10.5	10	0.9	10.8	10	0.8
10.1	10	1.0	10.5	10	0.9	10.8	11	0.9
10.2	9	0.8	10.5	10	0.9	10.8	11	0.9
10.2	10	1.1	10.5	11	1.0	10.8	12	1.0
10.8	12	1.0	11.1	13	1.0	11.4	11	0.7
10.9	10	0.8	11.2	8.5	0.6	11.4	14	0.9
10.9	11	0.8	11.2	11	0.8	11.6	12	0.8
10.9	13	1.0	11.2	13	0.9	11.7	12	0.7
11.0	12	0.9	11.3	12	0.8	11.8	14	0.9
11.0	12	0.9	11.3	13	0.9	12.6	13	0.7
11.1	11	0.8						

Female Gonad Stage III

5.9	1.7	0.8	6.5	2	0.7	6.6	3	1.0
5.9	2.2	1.1	6.5	2.1	0.8	6.7	2.1	0.7
6.0	2	0.9	6.5	2.3	0.8	6.7	2.4	0.8
6.1	2	0.9	6.5	3	1.1	6.7	3.6	1.2
6.1	3	1.3	6.5	3	1.1	6.8	2.3	0.7

Appendix 37 cont'd.

Female Gonad Stage III cont'd.

S.L.	Wt.	'K'	S.L.	Wt.	'K'	S.L.	Wt.	'K'
6.2	3.2	1.3	6.5	3	1.1	6.8	2.6	0.8
6.4	2	0.8	6.5	3	1.1	6.8	2.6	0.8
6.4	2.2	0.8	6.5	3	1.1	6.8	2.7	0.9
6.5	2	0.7	6.6	2	0.7	6.8	2.8	0.9
6.5	2	0.7	6.6	2.4	0.8	6.8	3	1.0
6.5	2	0.7	6.6	3	1.0	6.8	3	1.0
6.9	2	0.6	10.1	11	1.1	10.6	10	0.8
6.9	2.2	0.7	10.2	10	0.9	10.6	11	1.0
6.9	2.8	0.9	10.3	8	0.7	10.6	11	1.0
6.9	2.6	0.7	10.3	9	0.8	10.7	11	0.9
6.9	4	1.2	10.3	9	0.8	10.7	18	1.5
7.0	3	0.9	10.3	9	0.8	10.8	9	0.7
7.0	3	0.9	10.4	9	0.8	10.8	10	0.8
7.0	3.4	1.0	10.4	10	0.9	10.8	11	0.9
7.0	4	1.2	10.4	11	1.0	10.8	18	1.4
9.2	9	1.2	10.4	12	1.1	10.9	12	0.9
9.3	8	1.0	10.5	10	0.9	11.0	9	0.7
9.6	10	1.1	10.5	10	0.9	11.0	13	1.0
9.8	7	0.7	10.5	10	0.9	11.1	10	0.7
9.8	8	0.9	10.5	11	1.0	11.1	12	0.9
9.9	8	0.8	10.5	11	1.0	11.1	12	0.9
9.9	10	1.0	10.5	11	1.0	11.2	12	0.9
9.9	10	1.0	10.5	11	1.0	11.2	17	1.2
10.0	8	0.8	10.5	11	1.0	11.4	14	0.9
10.0	8	0.8	10.5	12	1.0	11.5	13	0.9
10.1	11	1.1	10.6	10	0.8	11.5	13	0.9
11.5	13	0.9	11.7	11	0.7	12.0	11	0.6
11.5	17	1.1	11.7	12	0.7	12.4	11	0.6
11.6	16	1.0						

Female Gonad Stage IV

5.6	2	1.1	6.5	3.2	1.2	9.8	8	0.9
6.0	2	0.9	6.5	3.4	1.2	9.9	9	0.9
6.0	2	0.9	6.7	3.4	1.1	9.9	9	0.9

Appendix 37 cont'd.

Female Gonad Stage IV cont'd.

S.L.	Wt.	'K'	S.L.	Wt.	'K'	S.L.	Wt.	'K'
6.2	2.2	0.9	6.8	3	1.0	9.9	10	1.0
6.2	2.6	1.1	6.9	3.0	1.1	10.0	8	0.8
6.2	2.8	1.2	6.9	3.6	1.1	10.0	8	0.8
6.3	2.2	0.9	7.0	3.2	0.9	10.0	9	0.9
6.3	2.4	1.0	7.0	3.4	1.0	10.0	10	1.0
6.4	2.2	0.8	7.0	3.4	1.0	10.0	10	1.0
6.4	2.6	1.0	7.0	3.4	1.0	10.0	10	1.0
6.5	2.4	0.9	7.0	3.8	1.0	10.0	10	1.0
6.5	2.8	1.0	7.0	4	1.2	10.0	11	1.1
6.5	3.0	1.1	9.4	8	1.0	10.1	11	1.1
6.5	3.2	1.2	9.5	6	0.7	10.2	9	0.8
6.5	3.2	1.2	9.7	8	0.9	10.2	10	0.9
10.2	10	0.9	10.5	11	1.0	11.0	12	0.9
10.2	11	1.0	10.5	12	1.0	11.0	12	0.9
10.3	10	0.9	10.5	12	1.0	11.0	12	0.9
10.3	10	0.9	10.5	12	1.0	11.0	12	0.9
10.3	10	0.9	10.6	10	0.8	11.0	13	1.0
10.3	10	0.9	10.6	11	0.9	11.1	13	1.0
10.4	9	0.8	10.6	11	0.9	11.2	12	0.9
10.4	10	0.9	10.6	11	0.9	11.3	13	0.9
10.4	10	0.9	10.7	11	0.9	11.3	14	1.0
10.4	10	0.9	10.7	12	1.0	11.4	13	0.9
10.4	11	1.0	10.8	11	0.9	11.4	13	0.9
10.4	12	1.1	10.8	11	0.9	11.4	14	0.9
10.5	10	0.9	10.8	12	1.0	11.5	13	0.9
10.5	10	0.9	10.8	12	1.0	11.5	13	0.9
10.5	11	1.0	10.9	12	0.9	11.5	13	0.9
10.5	11	1.0	10.9	12	0.9	11.5	14	0.9
10.5	11	1.0	10.9	12	0.9	11.5	14	0.9
10.5	11	1.0	11.0	9	0.7	11.6	11	0.7
10.5	11	1.0						
Female Gonad Stage V								
6.0	2.2	1.0	6.5	3	1.1	7.2	2.2	0.6
6.1	1.8	0.8	6.6	2.0	0.7	7.2	3.0	0.8
6.1	2.0	0.9	6.6	2.4	0.8	7.4	3.0	0.7
6.1	2.4	1.1	6.6	2.8	1.0	10.0	8	0.8

Appendix 37 cont'd.

Female Gonad Stage V cont'd.

S.L.	Wt.	'K'	S.L.	Wt.	'K'	S.L.	Wt.	'K'
6.2	1.8	0.8	6.6	2.8	1.0	10.1	8	0.8
6.2	2.6	1.1	6.6	3.0	1.0	10.2	10.5	1.0
6.2	2.4	1.0	6.7	2.2	0.7	10.2	10.5	1.0
6.3	2.0	0.8	6.7	3.4	1.1	10.3	11	1.0
6.3	2.3	0.9	6.8	3.1	1.0	10.4	10	0.9
6.4	2.2	0.8	6.9	2.8	0.9	11.0	11	0.8
6.4	2.2	0.8	6.9	3.4	1.0	11.0	13	1.0
6.5	2.2	0.8	7.0	3.0	0.9	11.1	12	0.9
6.5	2.2	0.8	7.0	3.6	1.0	11.4	12	0.8
6.5	2.4	0.9	7.1	2.8	0.8	11.5	14	0.9
6.5	2.6	0.9	7.1	4.0	1.1			
Female Gonad Stage VI								
5.7	2.0	1.1	6.2	1.8	0.8	7.1	3.6	1.0
5.9	1.6	0.8	6.2	2.4	1.0	10.1	9.6	0.9
5.9	2.2	1.1	6.5	2.0	1.1	12.0	14	0.8
6.0	1.9	0.9						
Male Gonad Stage I								
6.0	2	0.9	9.4	10	1.2	9.8	7.8	0.8
8.5	6	1.0	9.4	10.5	1.3	9.9	10	1.0
8.6	8	1.3	9.5	6	0.7	10.0	7.2	0.7
8.7	8	1.2	9.5	7	0.8	10.1	8	0.8
8.8	7	1.0	9.5	8	1.0	10.2	10	0.9
9.0	6	0.8	9.5	8.2	1.0	10.2	11	1.0
9.0	8	1.1	9.5	9	1.1	10.3	10	0.9
9.2	7	0.9	9.5	9	1.1	10.5	10	0.9
9.2	9	1.2	9.5	9	1.1	10.8	11	0.9
9.3	9	1.1	9.5	10	1.2	11.0	6	0.5
9.4	8	1.0	9.6	8	0.9	11.2	12	0.9
9.4	9	1.1	9.6	10	1.1			
Male Gonad Stage II								
5.5	1.2	0.7	9.5	7.5	0.9	10.0	9	0.9
5.5	1.4	0.8	9.5	8.4	1.0	10.0	10	1.0
5.6	1.4	0.8	9.5	9	1.1	10.0	10	1.0
5.8	2	1.0	9.5	9	1.1	10.1	9	0.9
6.0	1.2	0.6	9.5	9.2	1.1	10.2	11	1.0

Appendix 37 cont'd.

Male Gonad Stage II cont'd.

S.L.	Wt.	'K'	S.L.	Wt.	'K'	S.L.	Wt.	'K'
6.3	1.8	0.7	9.5	10	1.2	10.3	10	0.9
6.3	2.8	1.1	9.5	10	1.2	10.3	10	0.9
6.6	2.4	0.8	9.6	8.6	1.0	10.5	8.4	0.7
8.7	7	1.1	9.6	10	1.1	11.0	13	1.0
9.2	8.1	1.0	9.8	7	0.7	11.0	17	1.3
9.5	7	0.8	9.8	10	1.1	12.0	12	0.7
9.5	7	0.8	9.9	9	0.9			
Male Gonad Stage III								
5.5	1.8	1.1	6.1	2	0.9	9.0	7	1.0
5.6	1.6	0.9	6.1	2.1	0.9	9.0	7	1.0
5.7	1.8	1.0	6.1	2.2	1.0	9.1	7	0.9
5.7	2	1.1	6.3	2	0.8	9.4	3.2	0.4
6.0	2	0.9	6.4	2.4	0.9	9.5	10	1.2
6.0	2	0.9	7.1	2.2	0.6	9.5	10	1.2
9.6	7.6	0.9	9.8	9	1.0	10.5	9	1.2
9.6	10	1.1	10.0	9	0.9	10.5	15	1.3
9.8	8	0.9	10.0	10	1.0	10.6	10	0.8
9.8	9	1.0	10.2	8	0.8	11.6	12	0.8
9.8	9	1.0	10.3	7	0.6			
Male Gonad Stage IV								
5.5	2	1.2	7.0	3.4	1.0	9.5	13	1.5
5.7	1.4	0.8	9.0	7	1.0	9.5	13	1.5
6.0	2	0.9	9.2	7	0.9	9.6	8	0.9
6.1	1.8	0.8	9.3	7.8	1.0	10.0	8	0.8
6.1	2	0.9	9.4	8.0	1.0	10.0	9	0.9
6.2	2.0	0.8	9.5	6	0.7	10.0	10	1.0
6.2	2.2	0.9	9.5	6.4	0.7	10.0	10	1.0
6.3	2.0	0.8	9.5	8.2	1.0			
6.7	2.4	0.8	9.5	9.0	1.0			
Male Gonad Stage V								
6.3	2	0.8	9.8	8	0.8	11.1	11	0.8