# SOME BIOLOGICAL ASPECTS OF THE FISH FAMILIES - MOCHOKIDAE, BAGRIDAE AND MORMYRIDAE IN ZARIA AREA

BY

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THESIS APPROVAL

This thesis by MONEKE, Chibueze Cephas meets the regulations governing the award of the degree of Master of Science of Ahmadu Bello University and is approved for its contribution to scientific knowledge.

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I declare that this work is wholly the author's and has not been part of any presentation for any other qualification.

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# D E D I C A T I O N

TO

MY

"BELOVED"

PARENTS.

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ABSTRACT

Some biological aspects of the fisn families - Mochokidae, ridae and Mormyridae were investigated in Zaria area, Les were got from the "Sabongari" market in Zaria from month of June to December, 1981.

Eight rnormyrid, three bagrid and one mochokid species were found in the samples.

The fishes were found to feed on variety of food items. The mormyrids were principally insectivorous with exceptions of Mormyrops deliciosus which was piscivorous and Hyperopisus that was principally herbivorous. in the bagrid, Auchenog1anis occidentalis depended highly on immature insects, while Bagrus docmac was principally piscivorous. The only mochokid, Synodontis schall fed principally on immature insects, seeds and algae.

There were more females in the samples than the males, The fishes were found to breed during the rains, between June and September. The fecundity was estimated and was found to be high for Synodontis schall and Marcusensis senegalensis. The length-weight relationship indicated allometric growth for most of the species.

## CHAPTER ONE

## INTRODUCTION.

Two closely related spectres haunt the future world: a shortage of food and a shortage of energy. In both cases, the trend in world consumption appears to be outstripping our capability to produce, especially in the developing parts of the globe. All the same, man in his bid to better his environment continues to struggle in no little measure.

Dam construction is a multipurpose venture which primarily, is created for the generation of hydro-electricity, irrigation, urban water supply and fisheries. Hydro-electricity generates electrical energy. Irrigation is now a common practice that abolishes seasonality in cultivation, hence boosting food production.

Such constructions and ultimate formation of reservoirs is a common practice in Kaduna State especially in Zaria area. It is a thing of interest to note that the surface area of all the rivers in Zaria area have been extensively expanded through the construction of dams to form reservoirs. The Galma river which is more than others in all parameters, was damned to form the Zaria dam with a surface area of 484 hectares. The University lake was formed from Kubani river and it has a surface area of 110 hectares. The University farm lake was formed from Makwaiye river and this reservoir has a surface area of 14 hectares. Bomo lake was formed from the same Makwaiye river and it has a surface area of 9 hectares. The primary dual purpose, accomplished by these Zaria water bodies are urban water

supply and irrigation. Secondarily, they are the main source of fish protein in this area. In Galma river, fishing is concentrated principally above and below the dam site. The major source of the fish samples was from this river.

Zaria which is in the Northern Guinea Savanna, is located on Longitude $7^{o}$ 42'E and Latitude $11^{o}$ 03'N. It is 540 metres above sea level. It has a tropical continental climate (Hore, 1970), with distinctly marked rainy and dry season. The rainy season is from the month of May to September or early October when strong winds blow and rainfall increases (Walter, 1967). The mean annual rainfall in Zaria for 1981, was shown to be 345.5 mm (Titwits, 1981). The distribution of this rain is not advantageous from ichthyological point of view. The rainy season gives too much water resulting in high turbidity. The mean sediment content, calculated by the Water Board for the period 1969 - 1974 in water supply reservoirs, reached the value of 556 ppm (Mian et. al, 1976). The dry season is from October to March or early April. Truswell and Cope (1963), described the soil of Zaria as originating from a basement complex of older metasediments consisting mainly of schists and granites. McCurry (1973), noted that Zaria area is underlaid by poorly exposed rocks of Precambrian and early migmatites and remnants of an ancient metasedimentary sequence. These poorly exposed rocks are covered with alluvial deposits. These deposits are composed of mostly laterite, sand and clay materials. As the laterite and sandy materials prevail

in the majority of the cases in the existing rivers, a very intensive disappearance of water into the underground layers occur very often. It is, therefore, difficult to maintain high enough water levels during the dry season which in turn limits the fish productivity.

Changes in the hydrological status of an environment, can change the physio-chemical situation of the water body in that environment, and this will in turn affect the existing aquatic fauna. Also, the seasonal changes in meteorological conditions and consequent fluctuations in the river and lake levels have important effect on the movements, spawning, growth and maturity of the fishes.

Riverine fish contribute enormously to the protein balance of the rural population. The nominal catch of fresh-water fish as given in the Year book of Fishery Statistics (FAO, 1976) is about 10 million tonnes. In Africa, nearly half of the 1.4 million tonnes caught in 1975 came from rivers (Welcomme, 1976). The Food and Agricultural Organisation, predicted an expected shortage of fish yield from marine resource which is the major source of the fish meal. For example, all the frozen fish that is imported into Nigeria are marine fishes. The best hope for future increase in fish supplies, will lie on farming small areas of inland or brackish waters where factors governing their production can be controlled (Lowe-McConnell, 1977). Before one can comfortably undertake a viable fish propagation project, there is that high need for a . . .

preliminary study of the biology of the particular fish in question. For example, a carnivorous fish will need to be provided with feed consisting of high protein content.

Some work on fish biology, has been done on tropical rivers of Africa. The initial studies, were the taxanomic investigations by Boulenger (1908 - 1916), Irvine (1947) and Welman (1948). Jonglei Investigation Team (1954), explored the fisheries of the Nile Sudd in Southern Sudan. Intensive but short-duration studies on the Kafue river by the Universities of Idaho and Michigan in 1971, did much to shed light in the growth and mortality rates of certain species. Elsewhere, workers have been gathering information on the fisheries and general ecology of the Shire river, the Okavango delta (Botswana Society, 1976).

In South America most of the major river systems have been investigated to some extent. Bonnetto (1975), has given an over view of the Argentinian studies of Parana river, while Godoy (1975) has summarized a life's work on the Brazilian Guassu tributary of the same river. Work on the Orinoco system has been more restricted, and although Mago-locia (1970) and more recently an FAO project have carried out some investigations, understanding of this system is still minimal. Some smaller river systems have been investigated in more detail, including the Rupununi by Lowe-McConnell (1964).

Studies on Asiatic river systems, are more restricted.

A series of workers, from Chevey and Le Poulain (1940) onwards have observed the fishery of the Mekong river. These observations have provided the basis for detailed information on migration patterns, but otherwise little has been published of the biology of individual species or the dynamics of their populations (Welcomme, 1979). Some studies have been carried out on the Indian sub-continent which have been summarized by Jhingran (1975).

Here in Nigeria, a lot of work has been done on Kainji lake. Such studies include those by Willoughby (1974), on the ecology of the Mochokidae; Ajayi (1972), on the biology of Bagridae; Blake (1977 a & b), on the biology of Mormyridae. In addition, Arawomo (1972, 76), studied the ecology of the genera Citharinus and Distichodus; Olatunde (1977), studied the biology of the Schilbeidae; Imevbore and Bakare (1970), studied the food and feeding habits of non-cichlid fishes. Fagade and Olaniyan (1972), worked on the biology of West African shad (Ethmalosa fimbriata in the Lagos lagoon. Fagade and Olaniyan (1973), also studied the food and feeding inter-relationship of fishes in the Lagos lagoon. Daget (1954, 1957) and Banks, Holden and McConnell (1965), made observations on the breeding biology of mormyrid fishes from Niger river, but they did not carry out detailed investigations of individual species.

Nawar (1959a), recoreded the fecundity of Hyperopisus bebe in Nile, and made observations on five other species of mormyrid from this river (Nawar, 1959b). Okedi (1969),

described the size at first maturity, sex ratio and spawning periodicity of five small mormyrids from Lake Victoria and Corbet (1961), studied the food of non-cichlid fishes in the Lake Victoria basin with remarks on their evolution and adaptation to lacustrine conditions. Chilvers and Gee (1973), studied the food of Bagrus docmac in Lake Victoria.

The above publications, show in the first place that little or nothing has been done in other fresh-water bodies in this country apart from the Kainji lake. Secondly, there is no published work on the biology of the three fish families - Mochokidae, Mormyridae and Bagridae in Zaria area.

The aim of this study, is to investigate some aspects of the biology of these three fish families with emphasis in the following areas:-

(i) Length - weight relationship.

(ii) Food and feeding habits.

(iii) Sex and fecundity.

CHAPTER TWO

## MATERIALS AND METHODS.

### II.A. Market Survey.

The primary objective of this survey, was to ascertain the source of obtaining the samples. In this regard, the Zaria "Sabongari" market was visited several times. Information from the fish retailers confirmed that about 90% of their stock comes from River Galma. Visits were also made to the river near the dam to have discussions with the fishermen. Their cropping techniques showed that surface set gill net was principally used. Second in importance, was the cast net followed by clap net and bottom set gill nets. The fishermen also confirmed that the "Sabongari" market fish sellers were their main customers. For accessibility reasons, all my fish specimens were purchased from "Sabongari" market. Obtaining the fish samples, therefore involved frequent visits to the market. The visits were made two or three times a week depending on the quantity of each species available in the first two visits. On rare occasions, the market was visited once or four times in a week.

The collection was made mostly in the morning hours and sometimes in the evening periods. These were the two main periods that fishermen brought their catches to the market. Generally, fish specimens were more in the morning than in the evening periods. In the course of collection of the specimens from the market, random selection to cut across size ranges was employed. On the other hand, the prevailing

specific size range at a particular period, was noted.

II.B. The fish families.

These fish families were chosen because of their availability and commercial value in Zaria. The species in these families were identified (Reed et. al, 1967; Lewis, 1974).

II.B.1. Family Mormyridae.

Mormyridae is an aberrant family of fishes peculiar to tropical Africa (Lowe-McConnell, 1975). Of the endemic families, the Mormyridae has the most numerous genera (Sixteen) and two hundred species (Tarverne, 1972). These are especially abundant in Zaire and West Africa. It inhabits only fresh-water environment. Twenty-five species belonging to six genera are represented in Northern Nigeria (Reed et. al, 1967). Lake Kainji has eight genera and eighteen species (Lewis, 1974). In Zaria waters, there are eight different species belonging to seven genera.

These are:

Hyperopisus bebe (GUNTHER)

The body is laterally compressed and elongate with the head rounded. A very long anal fin distinguishes this species from all other mormyrids. It has a small, rayed dorsal fin situated well to the rear of the body. The rayed anal fin is about six times the length of the dorsal. The mouth is terminal. The colour of the body is golden brown and the head and dorsal surface often bear numerous tiny black spots (Fig.1).

Mormyrus rume CUVIER AND VALENCIENNES

The narrow elongated snout is down-curved and gives this

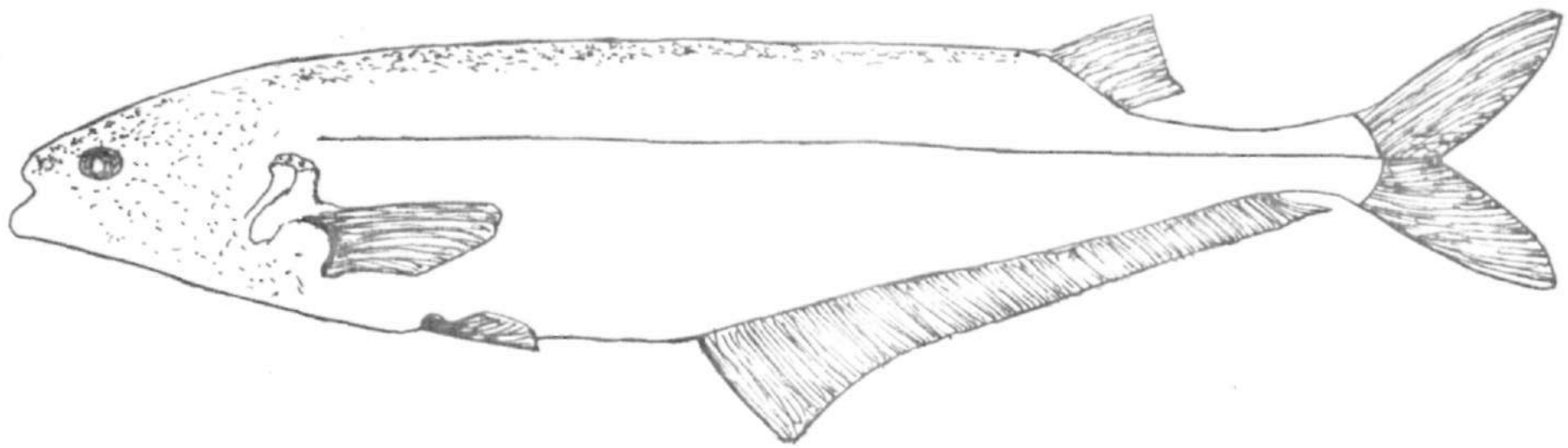


Fig. 1 Hyperopisus bebe $\times \frac{3}{4}$

species its common name "elephant snout fish". It has a small terminal mouth. The body colour is golden brown with no obvious spots or markings. The dorsal fin is about seven time the length of anal fin (Fig. 2).

Marcusenius senegalensis (STEINDACHNER)

This is a laterally compressed species of medium size with a prominent mental appendage. The caudal penduncle and dorsal profile is straight and slightly concave in front of the dorsal fin. The colour is uniform dark-brown with no markings (Fig. 3).

Mormyrops deliciosus (LEACH)

The body is elongated and almost round in section. The head is small, long and narrow. There are eighty-four to ninety-four scales in the lateral line. The colour is uniform dark-brown with no markings (Fig. 4).

Petrocephalus bovei (CUVIER AND VALENCIENNES)

The body is uniform silver in colour and fins are colourless apart from the anterior rays of the dorsal fin (sometimes the anal fin) and the outer rays of the caudal fin which are slightly pigmented. This species is a small fish with deep strongly compressed body, large eyes and inferior mouth (Fig. 5).

Hippopotamyrus pictus (MARCUSEN)

It has a rounded snout and inferior mouth. The body colouration is yellow-grey and there are usually two more or less prominent pale bands on each flank between the dorsal and

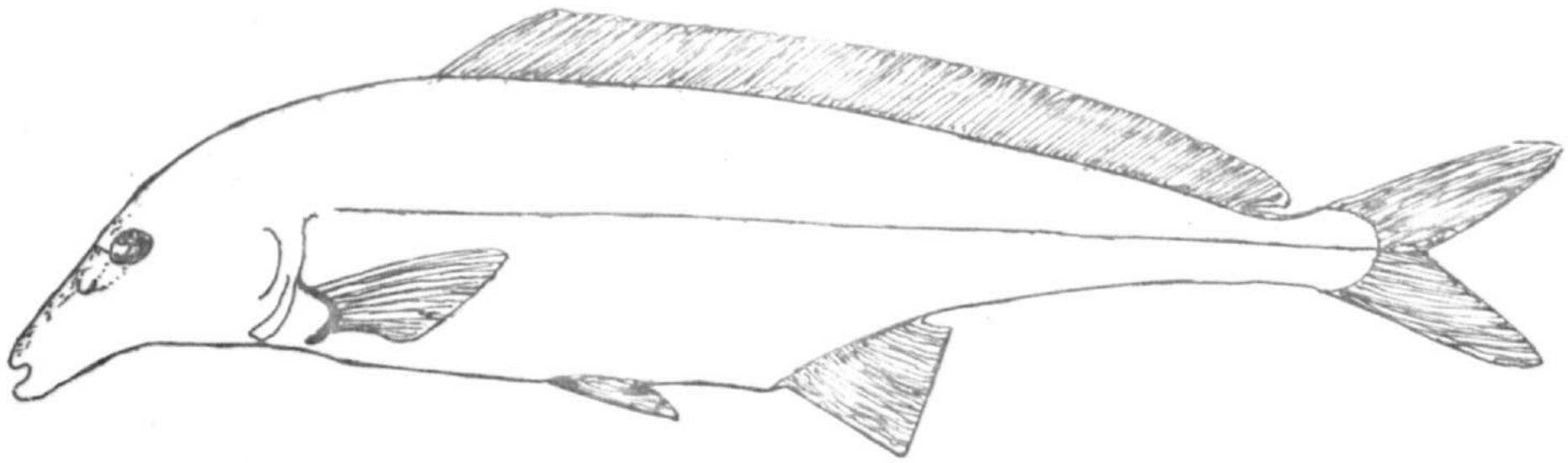


Fig. 2 Mormyrus rume (Actual Size)

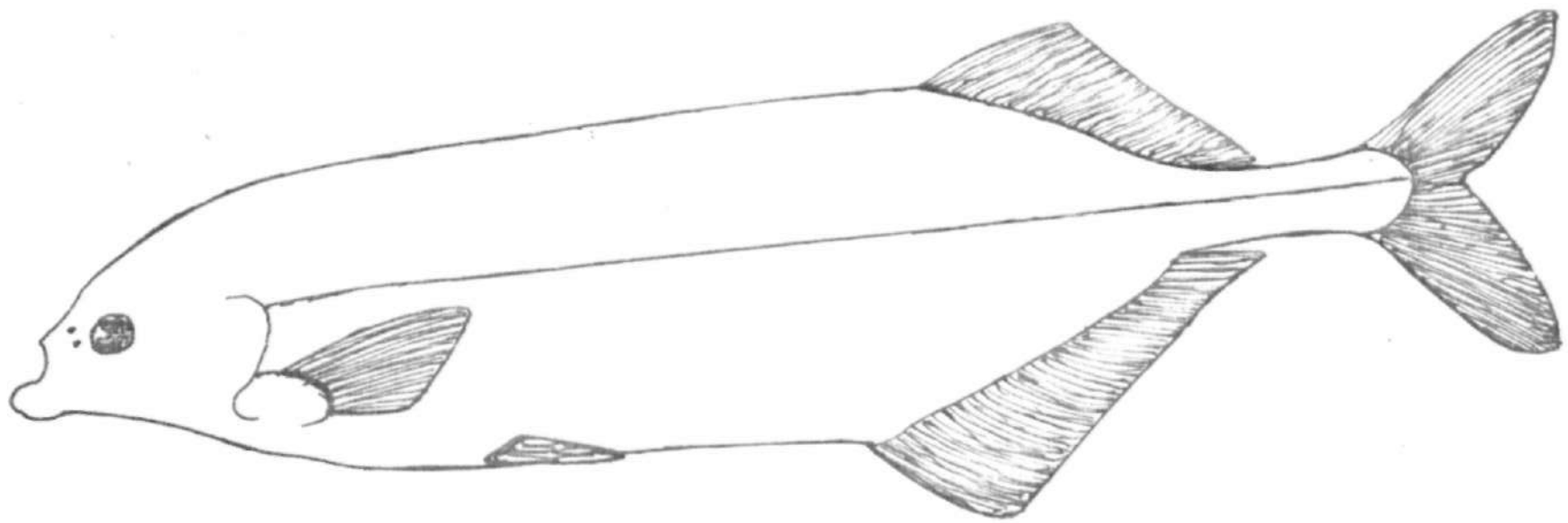


Fig. 3 Marcusenius Senegalensis (Actual Size)

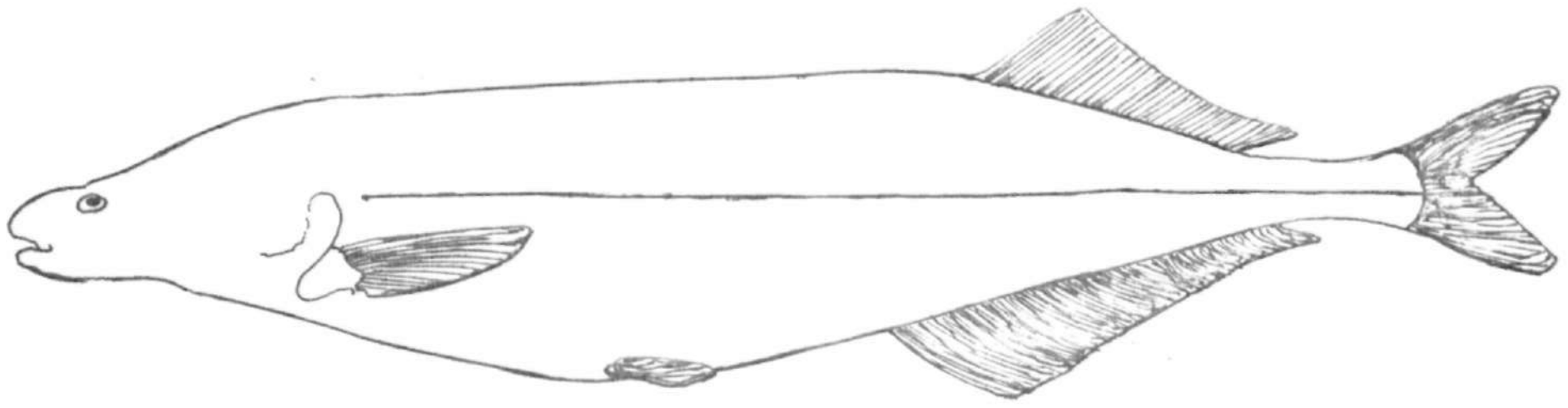
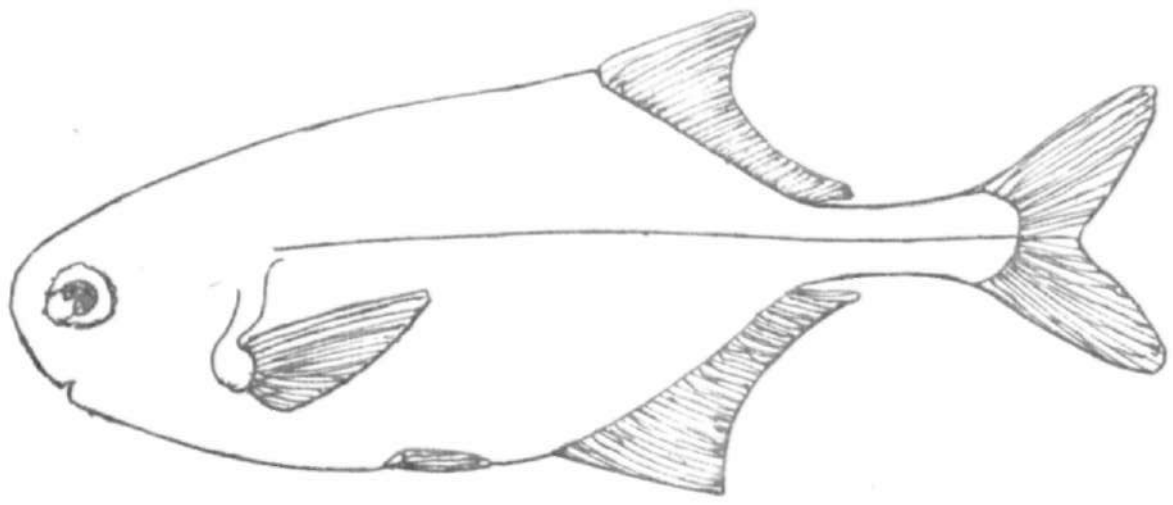


Fig. 4 Mormyrops deliciosus $\times \frac{1}{2}$



x $1\frac{1}{4}$

Fig. 5 Petrocephalus bovei

anal fin. Black bars are present on the dorsal and anal fins, and on the middle rays of each lobe of the caudal fin (Fig 6).

Hippopotamyrus psittacus (BOULENGER)

This is mormyrid with short, deep laterally compressed body rounded snout and inferior mouth. The dorsal and anal fins are about opposite each other. The colour of the body and fins are uniform grey-brown (Fig. 7).

Pollimyrus isidori (CUVIER AND VALENCIENNES)

This is a very small species with strongly compressed body and rounded snout. The colouration is golden-brown with small dark spots on the body and head (Fig. 8).

II.B.2. Family Bagridae.

The family Bagridae, is one of the seven siluroid fish families generally found in Africa. They are also found in Asia, and sixteen genera and one hundred and two species are recognised (Lowe-McConnell, 1975).

In Northern Nigeria, the Bagridae is represented by five genera and eleven species (Reed et. al, 1967). In Lake Kainji there exists four genera and seven species (Lewis, 1974). Three genera and three species were found in Zaria area. The bagrid fishes are fresh-water dwellers. The existing species in Zaria area include:-

Bagrus docmac (FORSKAL)

The head of B. docmac is depressed and approximately as wide as it is long. The ornamentation of the cranium is not visible through the skin of the head. The maxillary barbels are relatively long, but they do not extend beyond the pelvic

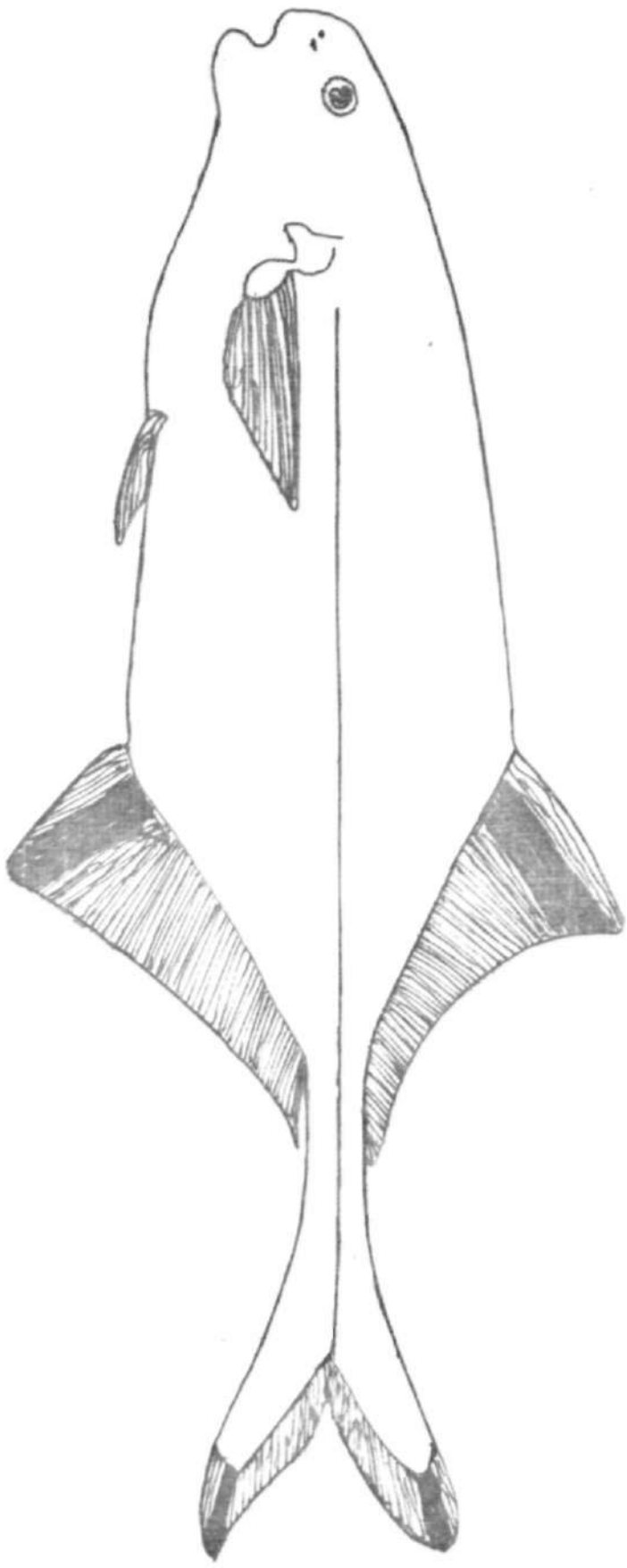


Fig. 6 Hippopotamyrus pictus x 1¼

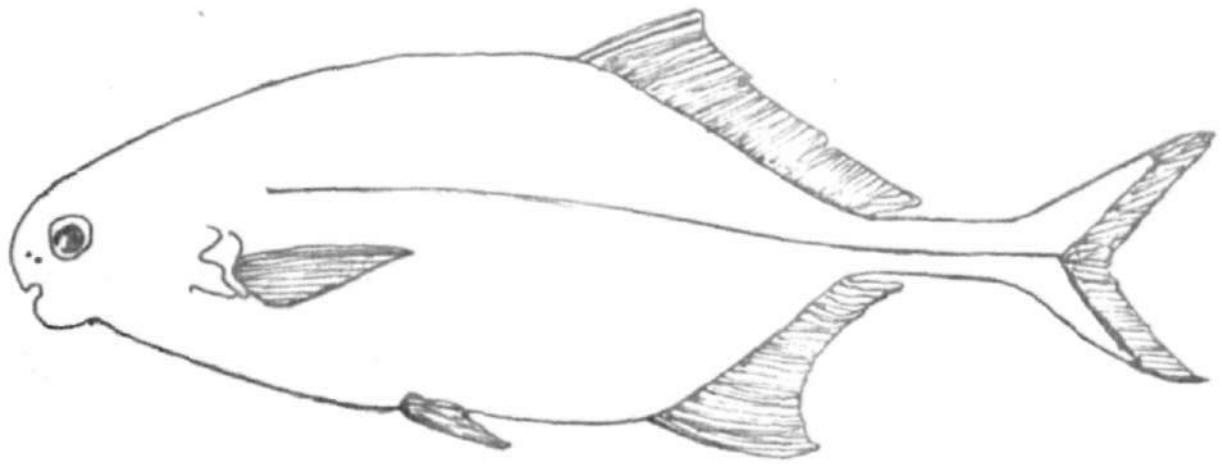


Fig. 7 Hippopotamyrus psittacus (Actual Size)

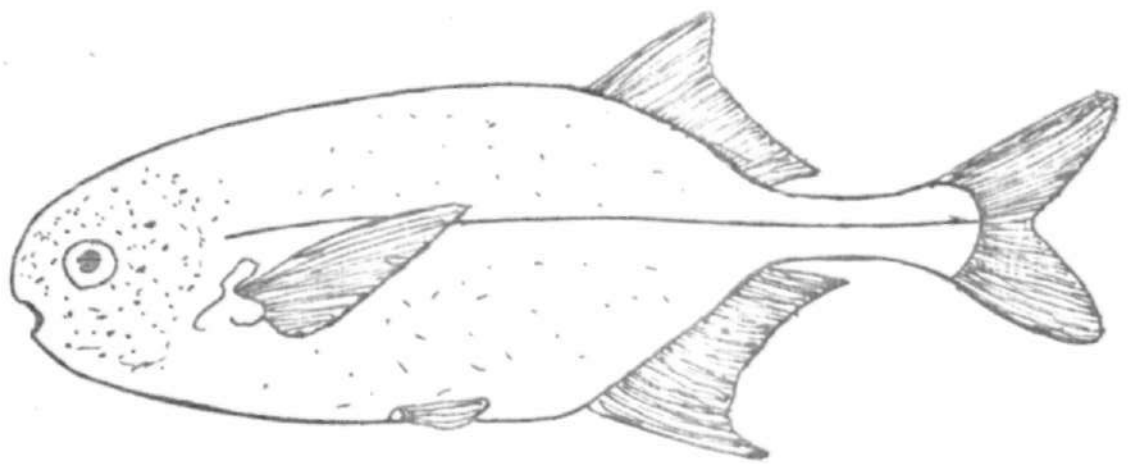


Fig. 8 Pollimyrus isidori X1½

fins. The colouration is uniform dark-brown or grey-brown on the back and sides and cream ventrally (Fig. 9).

Chrysichthys nigrodigitatus (LACEPEDE)

It has four pairs of simple barbels. The adipose fin is relatively short for this species and usually has a dark blotch on it. The dorsal fin has no filament. The caudal fin is deeply forked and has the upper lobe prolonged into a filament. The body is elongate and round in section and the head is obtusely pointed. The body colouration is silvery blue-grey and the fins have a little bit of pinkish colouration (Fig. 10).

Auchenoglanis occidentalis (CUVIER AND VALENCIENNES)

The dorsal fin is large and sail-shaped and the adipose fin is rounded posteriorly. The maxillary barbels, which are usually black do extend to the level of the eye. The colour is yellowish and the body and fins are usually with large olive marks which give reticulated effect (Fig. 11).

II.B.3. Family Mochokidae

The mochokidae is another siluroid family endemic to Africa. It is represented by nine genera and one hundred and fifty-five species (Lowe-McConnell, 1975). They are also fresh-water dwellers. This family is represented in Northern Nigeria by twenty-five species belonging to three genera (Reed et. al, 1967). In Lake Kainji one genus represented by sixteen species was found (Lewis, 1974).

Only one genus represented by a species is found in Zaria. This is Synodontis schall.

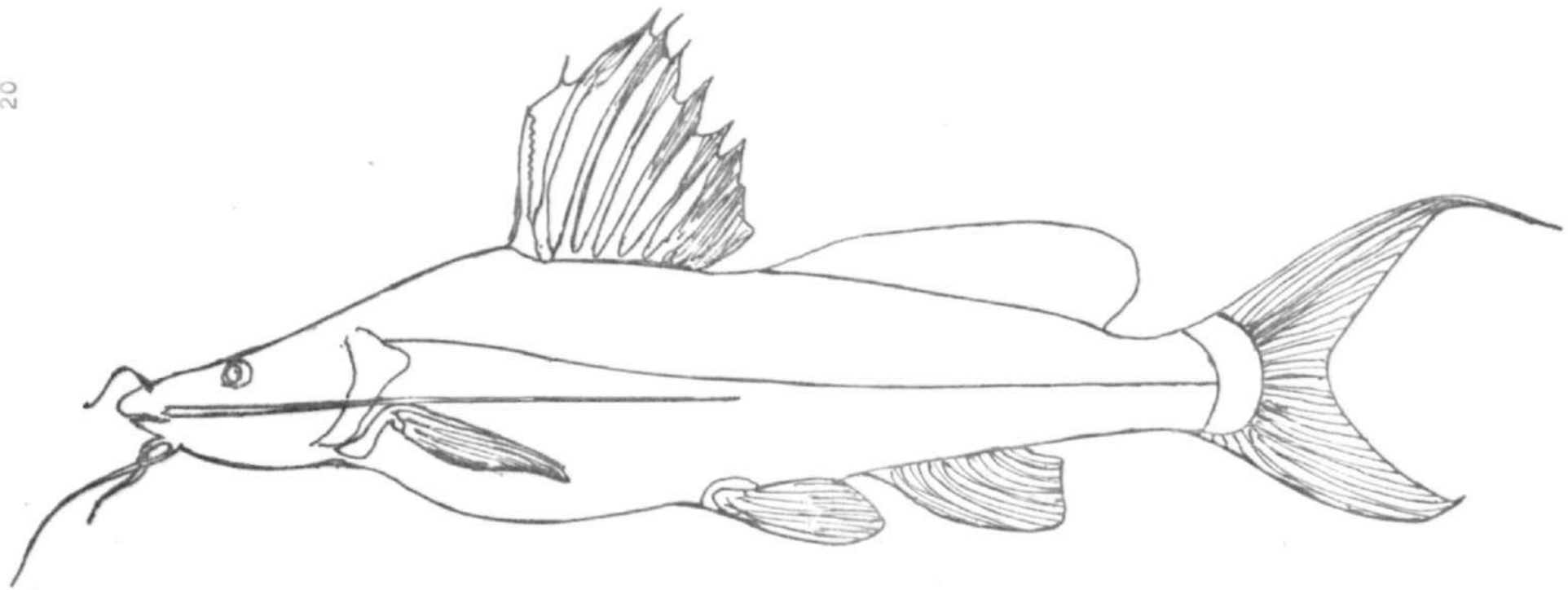


Fig. 9 Bagrus docmac $\times \frac{1}{3}$

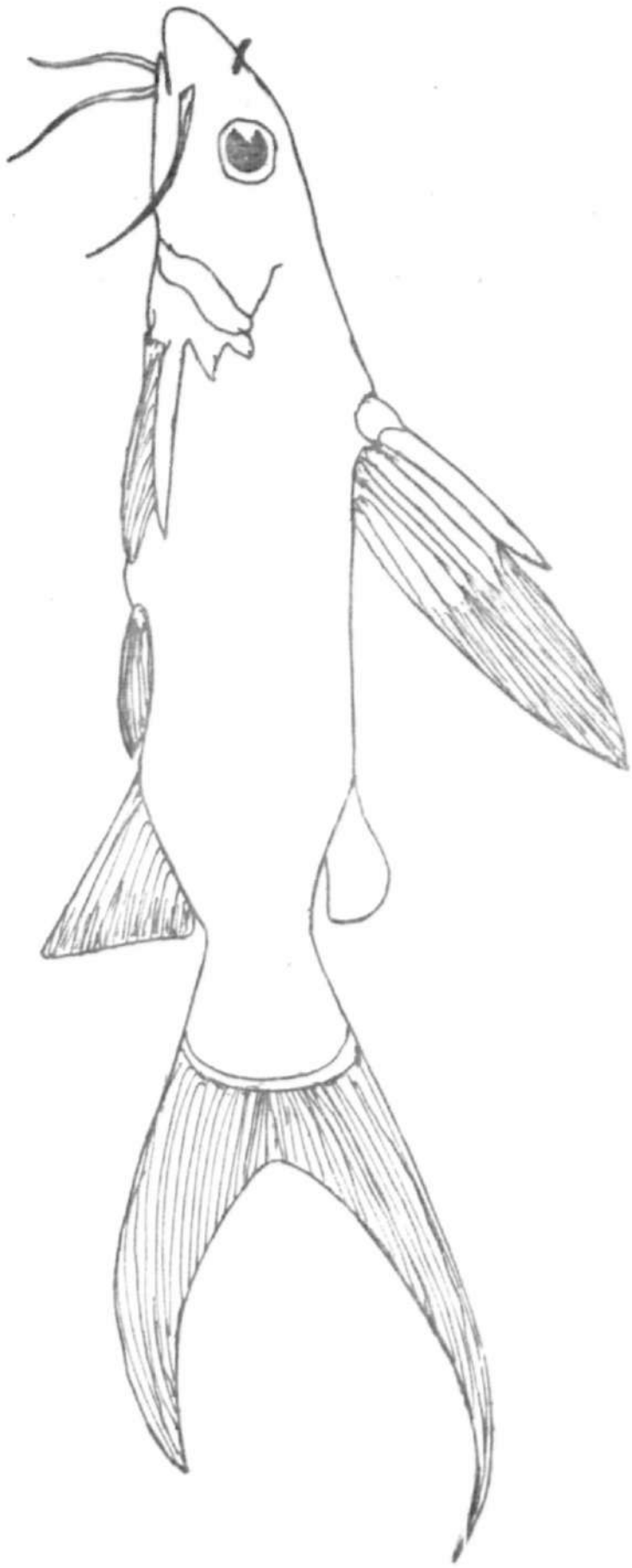


Fig. 10 Chrysichthys nigrodigitatus (Actual Size)



Fig. 11 Auchenoglanis occidentalis (Actual Size)

Synodontis schall (BLOCH SCHNEIDER)

The skin is usually villose both above the humeral process and on flanks. The mandibular barbels bear small branches. The snout is relatively pointed. The colouration is yellowish-brown and smaller specimens often have numerous minute dark spots on the body and fins. The maxillary barbel usually has a narrow membrane, visible only at its base (Fig. 12).

## II.C. Laboratory Measurements

### II.C.1. Length and Weight measurements.

Fish bought, were brought to the laboratory for analysis and routine measurements. Each fish was measured for total length and standard length using a measuring board. These two parameters, were determined to the nearest 0.1cm. The weight of the fish specimens, was determined to the nearest 0.1gm using a spring balance. The weight of the gonad, was determined to the nearest .01gm using Metler electronic balance.

(i) Total length (in cm):- This was measured from the tip of the snout to the longest lobe or filament of the caudal fin, when the margins of both lobes are pressed together.

(ii) Standard length (in cm):- It is the length from 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, which includes the stomach and gonad was determined on



Fig. 12 Synodontis schall x $\frac{1}{3}$

a spring balance to the nearest 0.1g.

II.C.2. Assessment of stomach fullness and contents.

The abdomen was opened lengthwise and the stomach fullness was estimated, using the method employed by Olatunde (1978b), see table 1. If the stomach fullness fall in between the basic scores on the table, points were awarded as appropriate. Finally the stomach and its content was cut off and preserved in 5% formalin for later examination.

Stomach analysis

Hynes (1950), presented a review of fish gut content analysis. He advocated for using more than one of the normal techniques to avoid a biased picture of the importance of the items in the diet. Hynes (1950), however, observed that whenever any of the recognised methods was used, the results show similar trend in the importance of the major food items.

Generally, the method to be used will actually depend on how it is particularly suitable for the fish being examined.

Hynes (1950), in his review examined six methods:-

The occurence method.

The number method.

The dominance method.

The volume method.

The weight method.

The fullness and point method.

Table 1. Classification of stomach fullness.

| STOMACH SIZE | DESCRIPTION | POINTS |
|---|---|---|
| Full stomach | The stomach bulges considerably with food. | 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 |

In this study, the stomach contents were analysed using the Points and Frequency of occurence methods.

ai Points method.

With certain reservations, Hynes (1950) regarded the "points system" devised by Swynnerton and Worthington (1940), as being the best of all the methods for general purposes. This system awards points to each food item, consideration being given to size and abundance of food items and to fullness of stomach. Each of the preserved fish stomachs, was opened with a scissors and forceps. The content of each fish stomach was separated in a petri-dish containing 10ml of water using a dissecting needle. The food items were broadly grouped into Insecta, Mollusca etc. Points were awarded to the individual dietary items. Due regard was given to the size and abundance of the food items. The sum of the points given to the individual dietary items was equal to the points awarded to the stomach size earlier. All the points gained by each food item was summed up and scaled down to percentages to give percentage relative composition of all the food items. The percentage contribution made by each food item was determined for each month. Dissecting microscope was used for identification of the food items. Sometimes compound microscope was used to identify very small organisms like the copepods and algae.

aii Frequency of occurence method.

In this method, the number of fish stomachs in which each food item occurred is expressed as a percentage of the total number of fish examined.

II.C.3. Sex determination and classification of gonads.

Although the sexes of some of the fish species were discernible from the external characteristics, (e.g. Synodontis schall with only the male possessing a genital papillae) sex generally was determined by internal examination. The abdomen was cut open and gonads examined to determine the sex.

After the sex had been determined, the maturity of the gonads of all the three families, were classified according to maturity scale modified from Nikolsky (1963) and Olatunde (1978a); as shown in Table 2.

Fully matured ovaries in stage four were removed, weighed with a metler electronic balance of P1200 (Pmax = 1200) and kept in labelled specimen bottles containing Simpson's (1951) fluid. The ovarian wall was cut open at one or two places to facilitate easier penetration of the fluid. Simpson's fluid helps to break down the ovarian tissue and harden the eggs (Olatunde, 1978a).

a. Fecundity estimation.

Bagenal (1971), reviewed the major methods used for

Table 2. Gonad maturity stages in the three families - Mochokidae, Bagridae and Mormyridae.

| Maturity Stages | Gonad condition | DESCRIPTION OF GONADS Female | Male |
|---|---|---|---|
| I | Virgin | Ovary very small. Usually gonad type not very discernible in some specimens. | Testes very small, not usually easily identifiable in some specimens |
| II | Immature or developing. | Gonad type easily discernible. Ovary is of small size. Eggs not distinguishable to the naked eye. | Testes clearly visible to the naked eye, but very thin and transluscent. |
| III | Matured or developed. | Eggs visible to the naked eye. In mormyrids, ovary forms about 2% of the body weight. In bagrids and mochokids ovary forms about 10% of the body weight. | A rapid increase in testes size. Testes become white and swollen with conspicous finger-like outgrowths in bagrids and mochokids. |
| IV | Full, matured | For mormyrids, ovary form about 5% of the body weight, but in bagrids and mochokids it forms about 15%. Eggs are not shed even with slight pressure on the abdomen. Gonads have achieved their maximum weight. | In mormyrids testes changes from transparent to slightly pale-rose colour. In mochokids and bagrids, testes are white anteriorly and orange-rose posteriorly. |

Table 2 contd.

| Maturity Stages | Gonad condition | Female | Male |
|---|---|---|---|
| V | Running or Spawning | In mochokids, eggs are shed with slight pressure on the abdomen. In bagrids and mormyrids, no running ovary was found. | In mormyrids, bagrids and mochokids, no running testes was found. |
| VI | Spent and recovering (spawned). | Eggs have been shed. Ovaries flaccid, look like empty sacs. Few ova still present in the ovaries. Eventually, all the remaining eggs are absorbed and ovary condition returns to stage 2. | In bagrids, no spent testes was observed In mormyrids and mochokids, there were spent testes, with finger-like empty outgrowths in case of mochokids. Testes returns to stage 2. |

estimation of fecundity. He defined fecundity as the number of ripening eggs prior to the next spawning.

The fecundity was estimated by sub-sampling using the dry gravimetric method modified after Simpson (1959). The preserved ovaries were stored for three to four months. After this period, the Simpson's fluid was decanted off. The eggs were then washed as many times as possible until all the ovarian tissues and unwanted materials have been decanted off. Care was taken not to lose the eggs during washing. After washing, the eggs were poured into a filter paper (of 12.5cm, I Qualitative) in a funnel to drain the remaining water. After filtration, the eggs were transferred into a petri-dish with two filter papers (12.5cm, I Qualitative). Excess moisture was absorbed by the filter papers. Clumps of eggs were gently broken and spread in a layer. The eggs of the mormyrids were relatively soft, so great care was taken during spreading. The eggs were air dried for at least 24 hours at room temperature ($24\pm1^{o}C$). For mormyrid specimens, drying for up to 26 hrs. gave a better result. On the other hand, anything more than this period, caused production of oily fluid from the eggs. This sticks the eggs together making the counting more difficult. For the bagrid and mochokid specimens, drying for 24 hours was adequate. After drying the fecundity of each fish was determined by weighing all the eggs from the fish, and then three random sub-samples of two hundred eggs

each was weighed. The ratio of total weight of eggs to the mean weight of the sub-samples was then multiplied by two hundred to give an estimate of the fecundity of the fish. The metler electronic balance (Type H4 Cap. - 160) which can register a weight of .001g was used. The eggs were well mixed before each sub-sample was removed and all countings and weighings were done in the same room to ensure that the moisture content of the eggs was in equillibrium with that of the room air.

# CHAPTER THREE

# RESULTS

## III.A. FOOD AND FEEDING HABITS.

### III.A.1. The Composition of the stomach contents.

The list below, is the comprehensive food types and their groupings as found in the stomach. Pennak, (1978) and Mellanby (1971) were used for identification.

(a) CRUSTACEA

This group includes:- ostracods, clam shrimps, copepod (cyclops), cladocerans and decaped (prawns)

(b) ARACHNIDA

The water-mites and water-spiders were found in this group.

(c) MOLLUSCA

In this group, the gastropods and lamellibranchs were found. Most of the time, empty shells of both gastropods and lamellibranchs were seen.

(d) ANNELIDA

Only oligochaetes were found and it was not common.

(e) BOTTOM DEPOSITS

Very small sizes of sand and gravel which perhaps picked up accidentally with the food were present. Detritus, although not common was present.

(f) PLANT ORIGIN

(i) Algae:- Microspora sp., Thalassiothrix sp., Anabaena sp., Oscillatoria sp., Skujaella sp., desmids and diatoms.

(ii) The plant remains:- This included leaves and fragments of wood materials.

(iii) The seeds:- The most commonly found seeds belong to the family Graminae e.g maize grains.

(g) FISH

(i) Fish remains:- This includes the skulls, spines, vertebrae, musculature, scales and sometimes the eye lens.

(ii) Whole fish:- These were still almost intact but many a time are devoid of the external structures like - scales, fins, barbels and original colour which makes it difficult to be easily classified.

(iii) Fish eggs:- Probably may belong to other fishes.

(h) INSECTA

(i) Insect remains:- These were made up of various insect parts.

(ii) Coleoptera:- This included those families that are semi-aquatic i.e Dytiscidae -

Cybister sp., Acilus sp., Agabus sp., Hydroporus sp., and Hydrovatus sp.

Hydrophilidae - Berosus sp. (this was the commonest in this order).

Elmidae - Zaitzevia sp.

(iii) Hemiptera:- This included the semi-aquatic and aquatic forms. Corixidae (waterboatman) - Corixid sp.

Notonectidae (backswimmers) - Notonecta sp.

Belostomatidae (giant waterbugs) - Belostoma sp.

(iv) Hymenoptera:- Terrestrial ants. It was not common and only one species - Crematogaster sp. was present.

(v) Ephemeroptera:- In this order, only the nymph forms were present.

(vi) Odonata:- In this order, the nymph forms of two sub-orders - Anisoptera and Zygoptera, were present.

(vii) Trichoptera:- Only the larval forms were present. Most commonly found was the Hydropsyche sp. and in rare cases Nectopsyche sp.

(viii) Megaloptera:- Only a larval form was rarely present.

(ix) Lepidoptera:- Only one larval form was found to represent this order.

(x) Diptera:- This included families like -

Chironomidae (both larval and pupal forms) - Chironomus sp. (most common), Pentaneura sp. and Corynoneura sp.

Heleidae - Palpomyia sp. (common) and Forcipomyia sp.

Culicidae - both larval and pupal forms of Chaoborus sp.

Stratiomyidae - Oxycera sp.

Tabanidae - Tabanus sp. and Chrysops sp.

Syrphidae - Eristalis sp.

Anthomyiidae - Limnophora sp.

Tipulidae - Tipula sp.

(i) OTHERS

All digested unidentifiable food contents were grouped here.

Table 3. Percentage composition and relative importance of dietary items in the stomachs of Marcusenius senegalensis.

| Food Items | %Frequency of Occurrence | % Total Points |
|---|---|---|
| Insect remains | 71.1 | 12.5 |
| Adult Insects | | |
| Coleoptera | 2.2 | 0.3 |
| Hemiptera | 2.2 | 0.2 |
| Immature Insects | | |
| Ephemeroptera Nymph | 16.6 | 4.1 |
| Dragonfly Nymph | 9.0 | 2.2 |
| Damselfly Nymph | 9.0 | 2.3 |
| Megaloptera Larvae | 7.8 | 1.8 |
| Trichoptera Larvae | 30.0 | 6.6 |
| Coleoptera Larvae | 26.7 | 5.8 |
| Diptera Larvae + Pupae | | |
| Chironomid Larvae | 92.2 | 37.3 |
| Chironomid Pupae | 30.0 | 4.5 |
| Chaoborus Larvae | 4.4 | 0.8 |
| Chaoborus Pupae | 6.7 | 1.2 |
| Heleidae Larvae | 17.8 | 1.2 |
| Stratiomyidae Larvae | 2.2 | 0.3 |
| Anthomyiidae Pupae | 2.2 | 0.3 |
| TOTAL INSECTA | | 81.4 |

| Food Items | % Frequency of Occurrence | % Total Points |
|---|---|---|
| Fish eggs | 9.0 | 0.7 |
| TOTAL FISH | | 0.7 |
| Ostracods | 24.4 | 2.0 |
| Clam shrimps | 17.8 | 3.2 |
| Copepod (cyclops) | 1.1 | 0.1 |
| TOTAL CRUSTACEA | | 5.3 |
| Hydracarina | 16.7 | 0.7 |
| TOTAL ARACHNIDA | | 0.7 |
| Oligochaetes | 7.8 | 3.5 |
| TOTAL ANNELIDA | | 3.5 |
| Detritus | 17.8 | 1.5 |
| TOTAL BOTTOM DEPOSITS | | 1.5 |
| Algae | 5.6 | 0.3 |
| Plant remains | 2.2 | 0.3 |
| Seeds | 37.8 | 4.8 |
| TOTAL PLANT ORIGIN | | 5.4 |
| OTHERS | | 1.5 |

## III.A.2. FOOD AND FEEDING HABITS OF MARCUSENIUS SENEGALENSIS

### a. The food items selected.

Table 3 shows the relative importance of the food items in M. senegalensis. The table shows that insects formed the major food items taken by this species. The points method indicates that insect formed up to 81.4% of the total food items. Crustaceans and plant materials formed considerable proportion of the total food items. The rest of the food items were of minor importance.

A closer look at the individual food items, shows that chironomid larvae and to a lesser extent, the pupae formed a significant proportion of the insects taken. Chironomid larvae occurred in almost all the stomachs examined. They scored about 92.2% in percentage frequency of occurence and 37.3% by points. Trichopteran larvae and coleopteran larvae formed a relatively sizeable proportion of the insects taken by scoring 6.6% and 5.8% respectively in percentage total points. Ephemeropteran nymphs (4.1% by points) is also of some importance. The dragonfly and damselfly nymphs could be considered to play a small role in the food proportion of the insects but not to be compared with any of the former. Clam shrimps and ostracods were important in the crustacean group. It is interesting to note that, upon all the variety of animal food items taken by this species, there were also some food items of plant origin in their diets. Seeds were of importance, as shown in table 3. The food items suggests

that M. senegalensis is an omnivore, although it could be said to be principally insectivorous.

b. Monthly feeding intensity.

The numerical value of fish with food and those with empty stomachs were recorded for each month throughout the period of investigation. The percentage of fish with food for each month was therefore calculated.

Fig. 13, shows that M. senegalensis had a high rate of feeding intensity throughout the period of investigation (> 68%). The peak of the feeding intensity was in the month of November when all the fish samples were found to have food in their stomachs. The lowest period was in the month of July.

C. Monthly variations in the food items selected.

The food item selected at any time by the fish, will depend on preference and abundance. Fig. 14 shows the trend throughout the period of investigation. The chironomid larvae which dominated the diet was found to contribute about 40% of the stomach contents from the month of June to September. This coincided with the period of rainy season and may depict a period of abundance for the chironomid larvae. Fig. 14 shows that, the fish took the highest proportion of both Ephemeroptera and Trichoptera in the month of October. This period coincided with the month when chironomid larvae was less abundant in the stomach contents. The Coleoptera larvae was most noticed

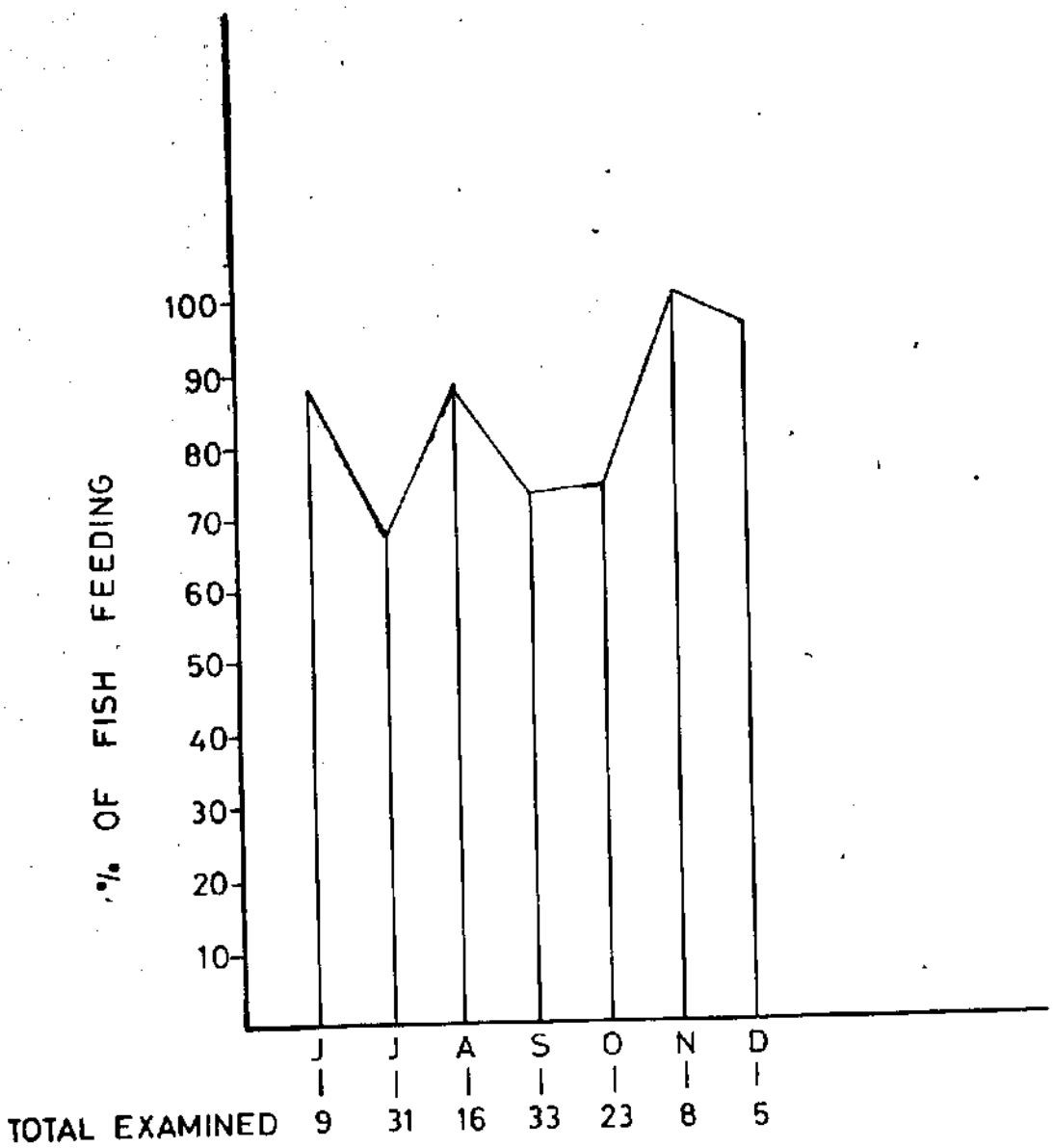



Fig. 13 (Marcusenius senegalensis.)
Monthly feeding intensity pattern

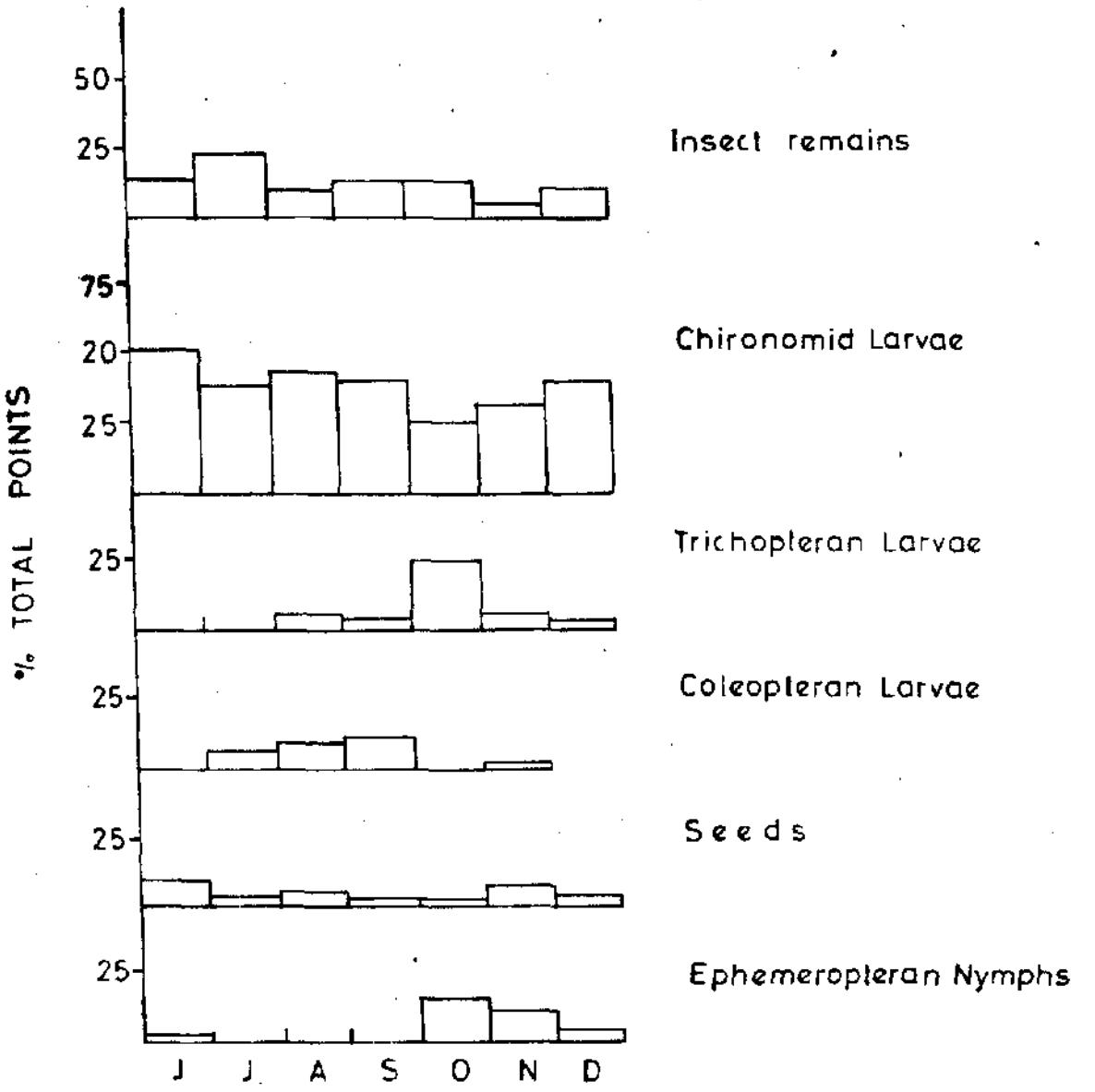



Fig. 14 (Marcusenius senegalensis.)
Monthly variation in composition of diet

in the month of September. The month of January was when the seeds showed highest importance in the stomach contents of the fish.

Table 4. Percentage composition and relative importance of dietary items in the stomachs / of Hyperopisus bebe.

| Food Items | % Frequency of Occurrence | % Total Points |
|---|---|---|
| Insect remains | 30.0 | 4.2 |
| Adult Insects | | |
| Coleoptera | 4.4 | 0.8 |
| Hemiptera | 1.1 | 0.5 |
| Immature Insects | | |
| Ephemeroptera Nymph | 10.0 | 2.2 |
| Dragonfly Nymph | 5.6 | 0.8 |
| Megaloptera Larvae | 1.1 | 0.1 |
| Trichoptera Larvae | 2.2 | 0.6 |
| Coleoptera Larvae | 3.3 | 0.2 |
| Lepidoptera Larvae | 4.4 | 1.4 |
| Diptera Larvae + Pupae | | |
| Chironomid Larvae | 25.6 | 3.8 |
| Chironomid Pupae | 2.2 | 0.1 |
| Chaoborus Larvae | 1.1 | 0.5 |
| Heleidae Larvae | 2.2 | 0.1 |
| TOTAL INSECTA | | 15.3 |
| Fish eggs | 12.2 | 1.3 |
| TOTAL FISH | | 1.3 |

| Food Items | % Frequency of Occurrence | % Total Points |
|---|---|---|
| Ostracods | 46.7 | 10.6 |
| Clam shrimps | 6.7 | 0.7 |
| TOTAL CRUSTACEA | | 11.3 |
| Hydracarina | 7.8 | 0.4 |
| TOTAL ARACHNIDA | | 0.4 |
| Gastropoda | 51.1 | 17.1 |
| Lamellibranchia | 13.3 | 7.0 |
| TOTAL MOLLUSCA | | 24.1 |
| Algae | 2.2 | 0.2 |
| Plant remains | 2.2 | 0.7 |
| Seeds | 76.7 | 45.6 |
| TOTAL PLANT ORIGIN | | 46.5 |
| OTHERS | | 1.1 |

III.A.3. FOOD AND FEEDING HABITS OF HYPEROPISUS BEBE.

a. The food items selected.

Table 4 lists the food items found in H. bebe. Seeds (especially Graminae) played a dominant role in the diet of this species. Next in importance are the molluscs. The last two groups that followed in importance are insects and crustaceans. The seeds which was dominant had a percentage total points of 45.6%, and occurred relatively regularly by having a percentage frequency of occurence of 76.7%. Among the molluscs, the gastropods were more common, followed by the lamellibranchs. Both of them formed a relatively major proportion of the food of this species. Among the crustaceans, ostracods played a major role in terms of relative importance, their small size notwithstanding. The percentage total points of ostracods was 10.6%. Among the insect group, chironomid larvae are the most common and next in importance are the Ephemeroptera nymphs. Both can be considered to be taken by a fair proportion of the fish, although their ultimate contribution to the total stomach contents was low. The food items of H. bebe indicates its omnivorous habit.

b. Monthly feeding intensity.

Fig. 15 shows the monthly feeding intensity. Around 70% of the fish were feeding at any time during the period of investigation. However, the lowest level of feeding was noticed in the month of June. The peak of the feeding intensity was

in the month of November. The overall pattern shows a gradual rise as from June to November with exception of September when there was a little decline. A steep fall in feeding intensity was noticed again in the month of December.

c. Monthly variations in the food items selected.

Fig. 16 shows that H. bebe consumed large proportion of seeds all through the period of investigation. The peak was in July. This coincided with the period of rainy season when the rivers and lakes are usually flooded. This is the period that majority of plants undergoes reproduction and produces a lot of seeds. In the month of October, the percentage points for seeds decreased considerably. It is in the same month, that the percentage points for the molluscs rose to its peak. This was the period when a high number of t the younger fishes appeared. These younger ones tended to feed more on the molluscs than seeds, and this must have contributed to the decline. In the months of November and December, the percentage points of seed increased again while that of the molluscs decreased. There was a gradual increase in the proportion of ostracods utilized by the fish as from July to December. Although, H. bebe is omnivorous, it seems to prefer seeds to animal items.

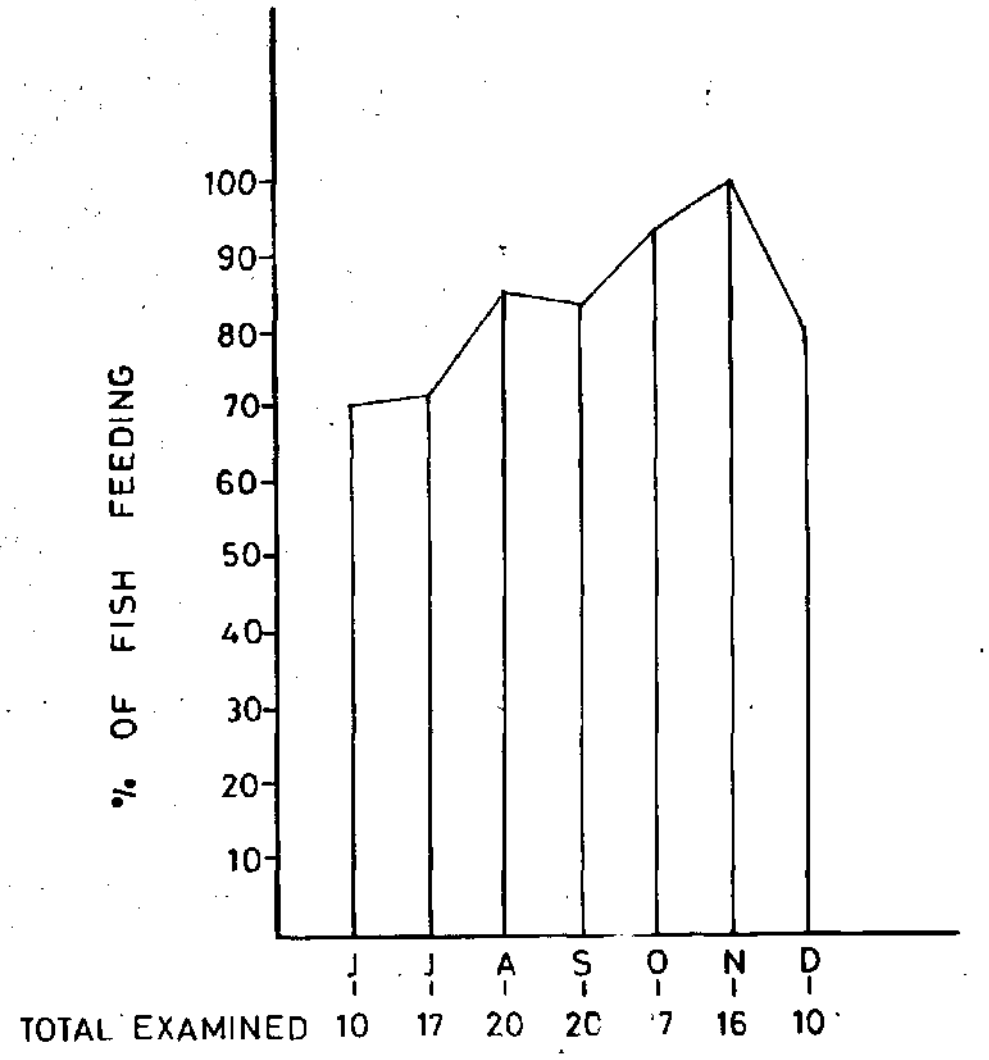



Fig. 15 (Hyperopis s bebe)
Monthly feeding intensity pattern

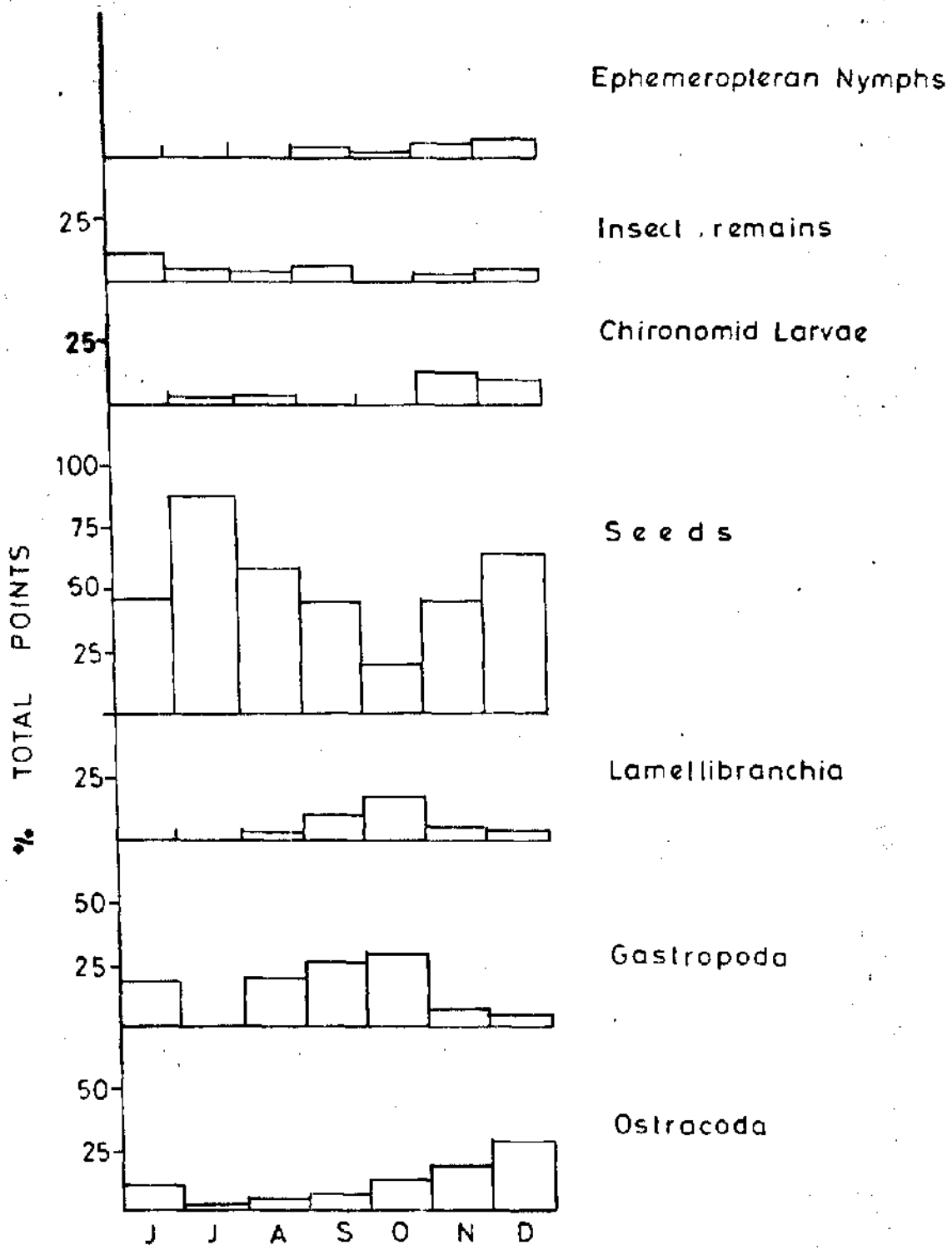



Fig. 16 (Hyperopisus bebe)
Monthly variation in diet composition

Table 5. Percentage composition and relative importance of dietary items in the stomachs of Mormyrops deliciosus.

| Food Items | % Frequency of Occurrence | % Total Points |
|---|---|---|
| Insect remains | 69.8 | 11.5 |
| Adult Insects | | |
| Coleoptera | 11.6 | 2.0 |
| Hemiptera | 2.3 | 0.6 |
| Immature Insects | | |
| Ephemeroptera Nymph | 4.7 | 0.6 |
| Dragonfly Nymph | 27.9 | 8.3 |
| Damselfly Nymph | 23.3 | 7.3 |
| Hemiptera Nymph | 4.7 | 0.5 |
| Trichoptera Larvae | 16.3 | 1.9 |
| Coleoptera Larvae | 18.6 | 5.3 |
| Diptera Larvae + Pupae | | |
| Chironomid Larvae | 11.6 | 0.9 |
| Chaoborus Pupae | 7.0 | 0.9 |
| TOTAL INSECTA | | 39.8 |
| Fish remains (including whole fish) | 55.8 | 43.2 |
| TOTAL FISH | | 43.2 |
| Decapod (Prawns) | 9.3 | 5.0 |
| TOTAL CRUSTACEA | | 5.0 |

| Food Items | % Frequency of Occurrence | % Total Points |
|---|---|---|
| Sand Pebbles | 4.7 | 0.4 |
| TOTAL BOTTOM DEPOSITS | | 0.4 |
| Plant remains | 23.3 | 3.9 |
| Seeds | 27.9 | 4.6 |
| TOTAL PLANT ORIGIN | | 8.5 |
| OTHERS | | 3.1 |

III.A.4. FOOD AND FEEDING HABITS OF MORMYROPS DELICIOSUS

a. The food items selected.

The composition and relative importance of the dietary items found in the stomachs of M. deliciosus are as seen in Table 5.

Fish and insects formed the major food items while the crustaceans and plant material were of secondary importance. The fish prey, although not very distinct, resemble the Tilapia sp. Fish occurred in 55.8% of the stomachs examined, and the total percentage points was up to 43.2%. Insects scored 39.8% by points and a closer look, shows that dragonfly nymphs, damselfly nymphs and coleoptera larvae were the preferred insect food items. Out of the whole mormyrid fishes found in Zaria area, M. deliciosus showed a unique feature by taking least chironomid larvae. The dragonfly nymphs occurred in about 27.9% of stomach samples and contributed up to 8.3% by points. The damselfly nymphs occurred in 23.3% and the percentage total points was 7.3%. Coleoptera larvae played a relatively smaller role by scoring 5.3% by points. Plant materials were usually in form of seeds, although fragments of other forms (plant remains) were also present. The seeds had 27.9% by frequency of occurrence and 4.6% by points. The Juveniles of M. deliciosus were more insectivorous than the adults which were principally piscivorous.

b. The monthly feeding intensity.

The feeding intensity pattern as shown in Fig. 17, indicates

that all the fishes were feeding in the months of June, July and August. The low feeding intensity in November and December is surprising because this was the period we expect to find a lot of the fingerlings of the fish prey. On the whole, the feeding intensity throughout the period of investigation was relatively high in that no time was the intensity below 50%.

c. Monthly variations in the food items selected.

Fig. 18 shows that the fish remains was significant throughout period of investigation. It was found to score up to 60% of the stomach contents in the months of July and October. The quantity of fish remains found in the stomach contents was much lower ( $\leq$ 31%) in the months of November and December. These months of November and December were the period that contributions of the prawns were high.

It may be that the prawns were abundant at this period. dragonfly nymphs and damselfly nymphs were not taken in the months of June and July. There was a gradual decrease in the percentage points of both items as from August to December except in the month of October when the damselfly nymph was not found in its diet. Coleopteran larvae were most significant in the stomach contents in June and totally absent as from October to December.

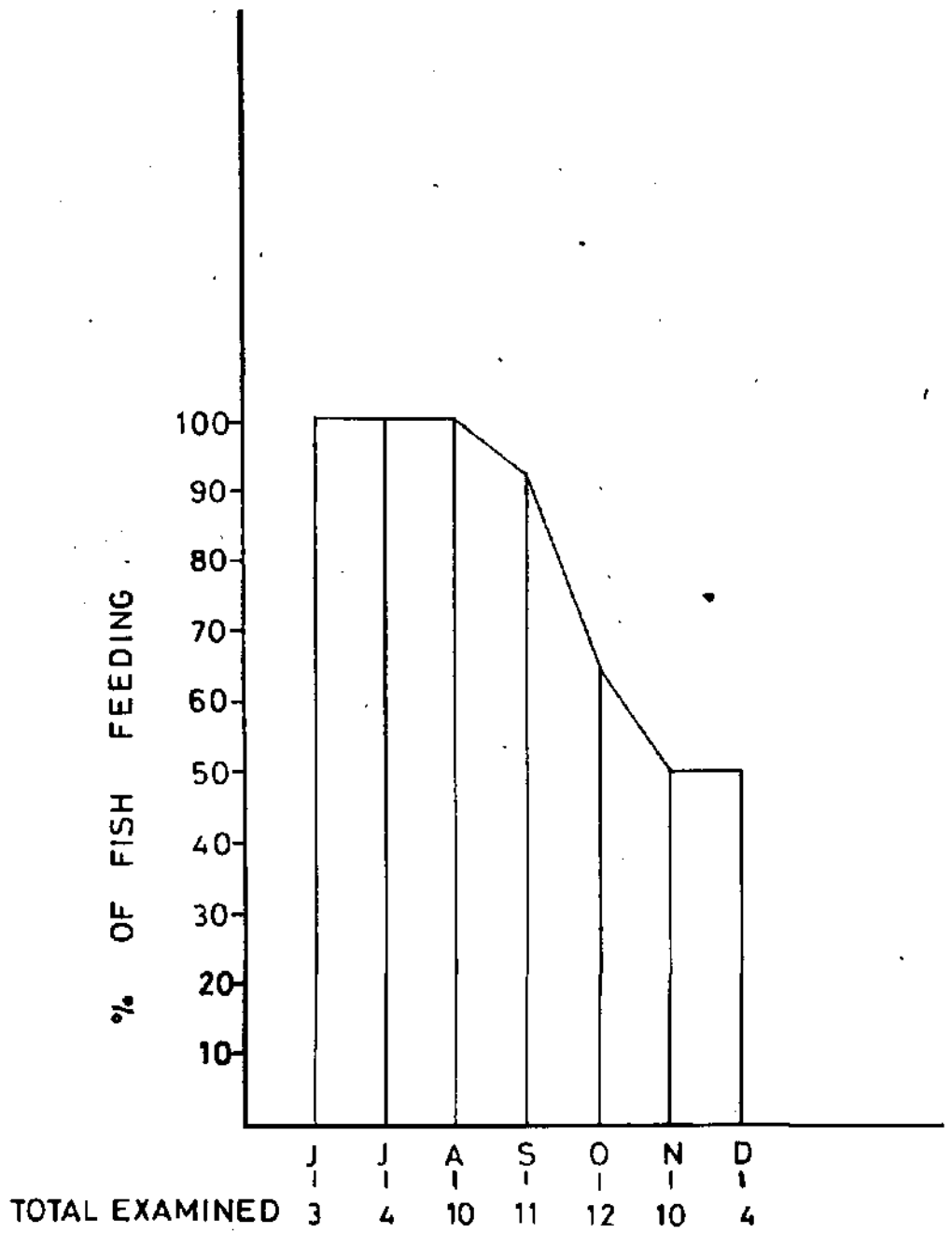



Fig. 17 (Mormyrops deliciosus.)
Monthly feeding intensity pattern

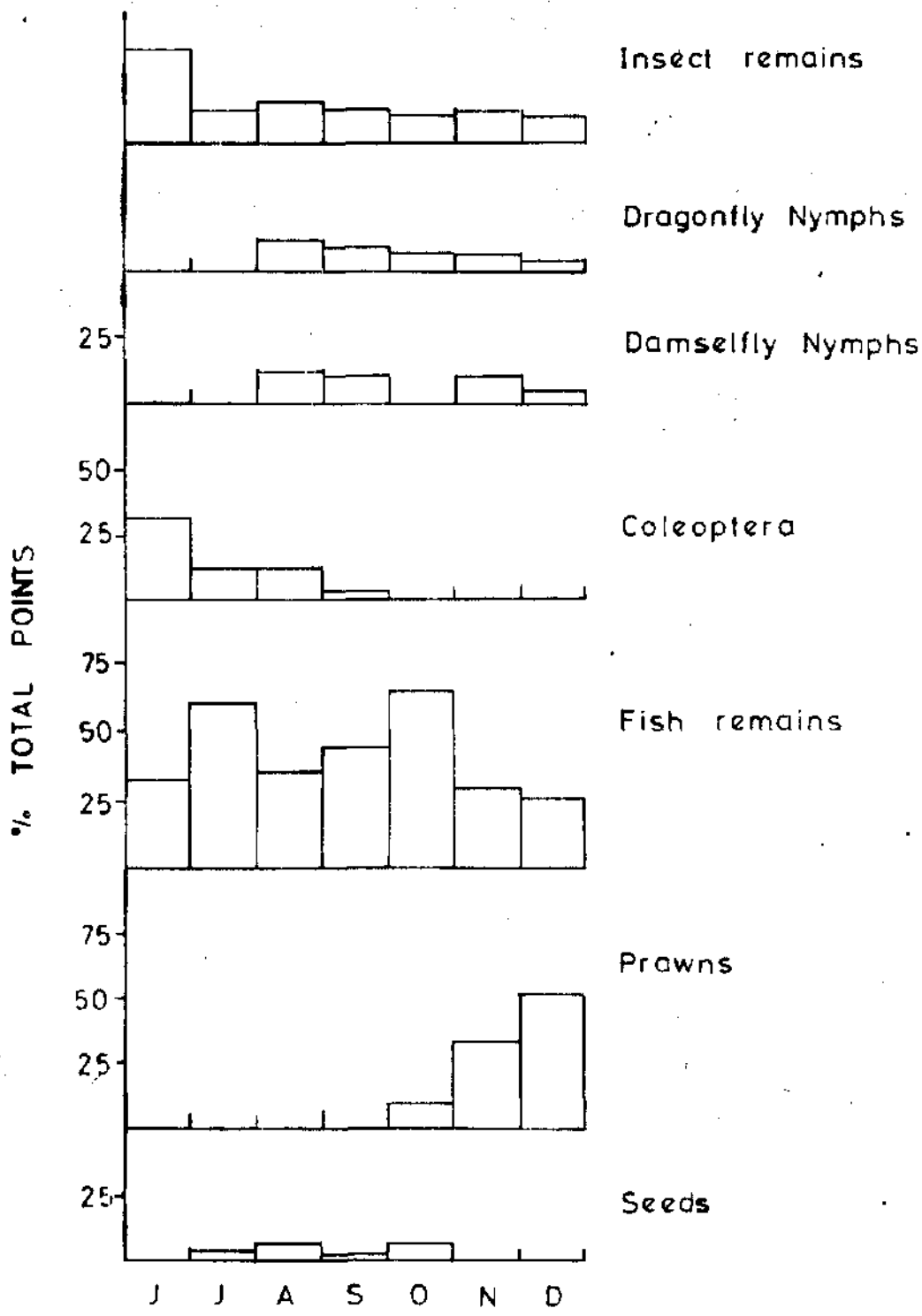



Fig. 18 (Mormyrops deliciosus
Monthly variation in diet composition

Table 6. Percentage composition and relative importance of dietary items in the stomachs of Mormyrus rume.

| Food Items | % Frequency of Occurrence | % Total Points |
|---|---|---|
| Insect remains | 46.7 | 11.9 |
| Adult Insects | | |
| Coleoptera | 3.3 | 0.5 |
| Immature Insects | | |
| Ephemeroptera Nymph | 11.7 | 4.9 |
| Dragonfly Nymph | 16.7 | 4.8 |
| Trichoptera Larvae | 53.3 | 26.3 |
| Coleoptera Larvae | 8.3 | 1.4 |
| Diptera Larvae + Pupae | | |
| Chironomid Larvae | 71.7 | 24.6 |
| Chironomid Pupae | 8.3 | 1.0 |
| Chaoborus Larvae | 16.7 | 2.5 |
| Chaoborus Pupae | 3.3 | 0.2 |
| Heleidae Larvae | 45.0 | 7.8 |
| Anthomyiidae Pupae | 1.7 | 0.1 |
| TOTAL INSECTA | | 86.0 |
| Ostracods | 1.7 | 0.1 |
| Clam shrimps | 3.3 | 0.8 |
| TOTAL CRUSTACEA | | 0.9 |

| Food Items | % Frequency of Occurrence | % Total Points |
|---|---|---|
| Water-spider | 1.7 | 0.2 |
| TOTAL ARACHNIDA | | 0.2 |
| Gastropoda | 3.3 | 0.3 |
| TOTAL MOLLUSCA | | 0.3 |
| Oligochaetes | 8.3 | 3.8 |
| TOTAL ANNELIDA | | 3.8 |
| Sand and pebbles | 11.7 | 2.2 |
| Detritus | 15.0 | 2.2 |
| TOTAL BOTTOM DEPOSITS | | 4.4 |
| Plant remains | 11.7 | 0.9 |
| Seeds | 21.7 | 2.4 |
| TOTAL PLANT ORIGIN | | 3.3 |
| OTHERS | | 1.1 |

III.4.5. THE FOOD AND FEEDING HABITS OF MORMYRUS RUME.

a. The food items selected.

This species fed predominantly on immature insects as shown in Table 6. The insects formed 86% of the food by points. The most important immature insect was trichopteran larvae which was found in 53.3% of the stomachs examined and scored 26.3% by points. Chironomid larvae were the next insect item of importance. Ephemeropteran nymphs, dragon-fly nymphs and Heleidae larvae also occurred relatively regularly in the diet. M. rume consumed considerable amount of oligochaetes, which contributed a percentage total points of 3.8%. The presence of the sand and pebbles to an appreciable extent (2.2% by points) was noticed in M. rume. This noticeable proportion of sand and pebbles may be due to accidental intake of the "cases" of trichopteran larvae. The sand and pebbles were found to be the major materials which most trichopteran larvae species e.g. Hydropsyche sp. utilizes in building their cases (Pennak, 1978). Sometimes these cases of trichopteran larvae occurred distinctly in the stomachs of this fish and an application of a little pressure normally dislodges the case exposing a lot of sand grains and pebbles. Table 6, shows that M. rume is principally insectivorous.

b. Monthly feeding intensity.

The feeding pattern as seen in Fig. 19 depicts a generally high feeding intensity throughout the period of investigation The least was noticed in the month of July when 58% of the fishes

examined, showed food items in their stomachs. July to November, showed a gradual rise in feeding intensity. The peak was in the month of November when 86% of the fish examined, had food items in their stomachs. There was a fall in feeding intensity by December.

c. Monthly variations in the food items selected.

The monthly percentage total points of the food items, are shown in Fig. 20. Although Table 6, showed that trichopteran larvae were most important food items of the fish, it appears from Fig. 20, that it was completely absent in the month of July. The Chironomid larvae which rated second in importance in Table 6, was regular all through the months of investigations. In the months of investigation monthly percentage total point for trichopteran larvae was 58%. This peak coincided with the peak score for the sand and pebbles. From the months of August to November, the monthly percentage total points of trichopteran larvae and sand and pebbles followed the same trend. In the months of November and December, when the percentage total points of trichopteran larvae decreased considerably, was the period that the chironomid larvae in particular and ephemeropteran nymphs increased in importance. In the month of June, when the trichopteran larvae in the stomach content decreased to a minimum, was the period that Heleidae larvae gained its maximum importance and declined sharply by the next month.

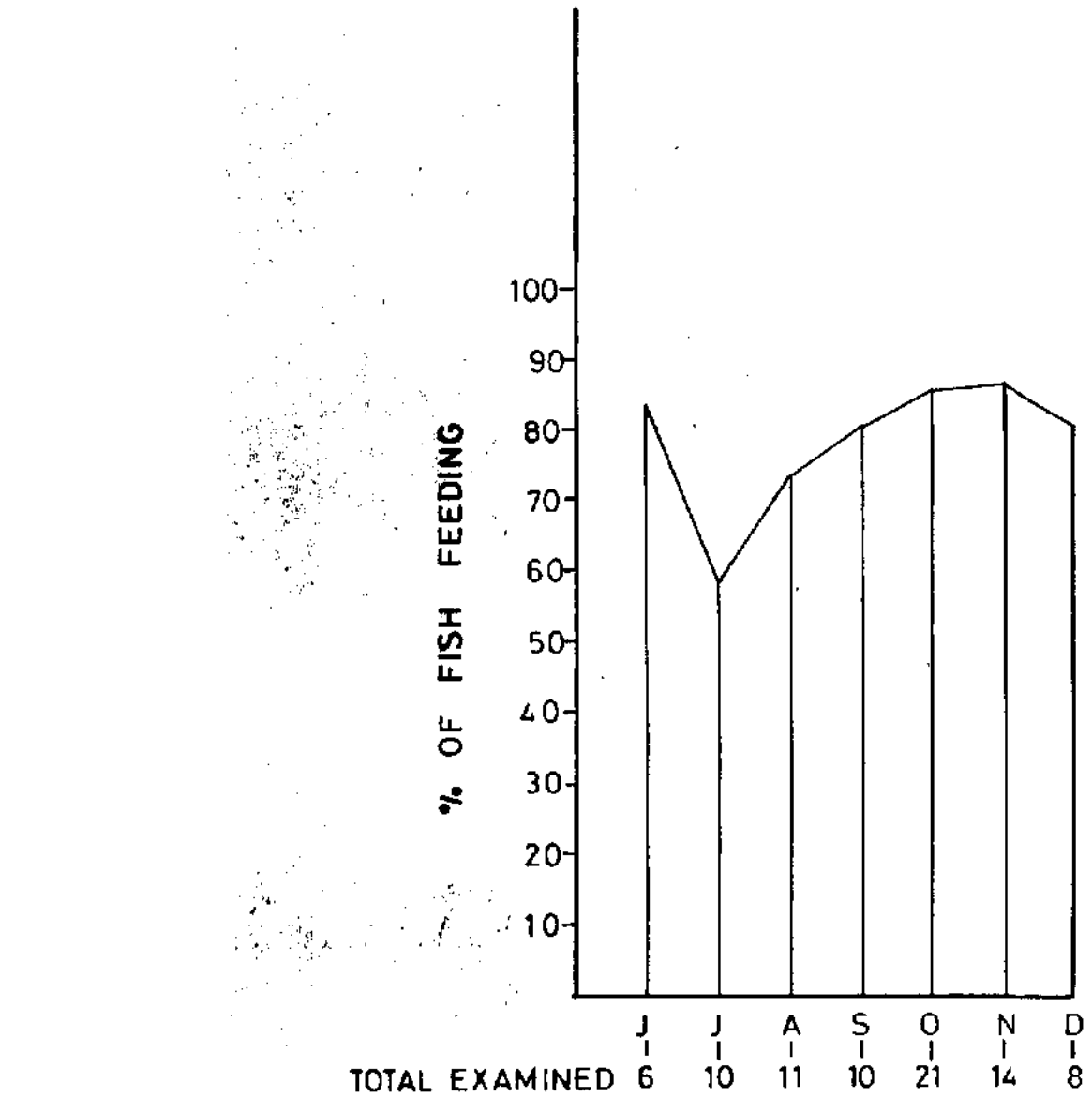



Fig. 19 (Mormyrus rume.)
Monthly feeding intensity pattern

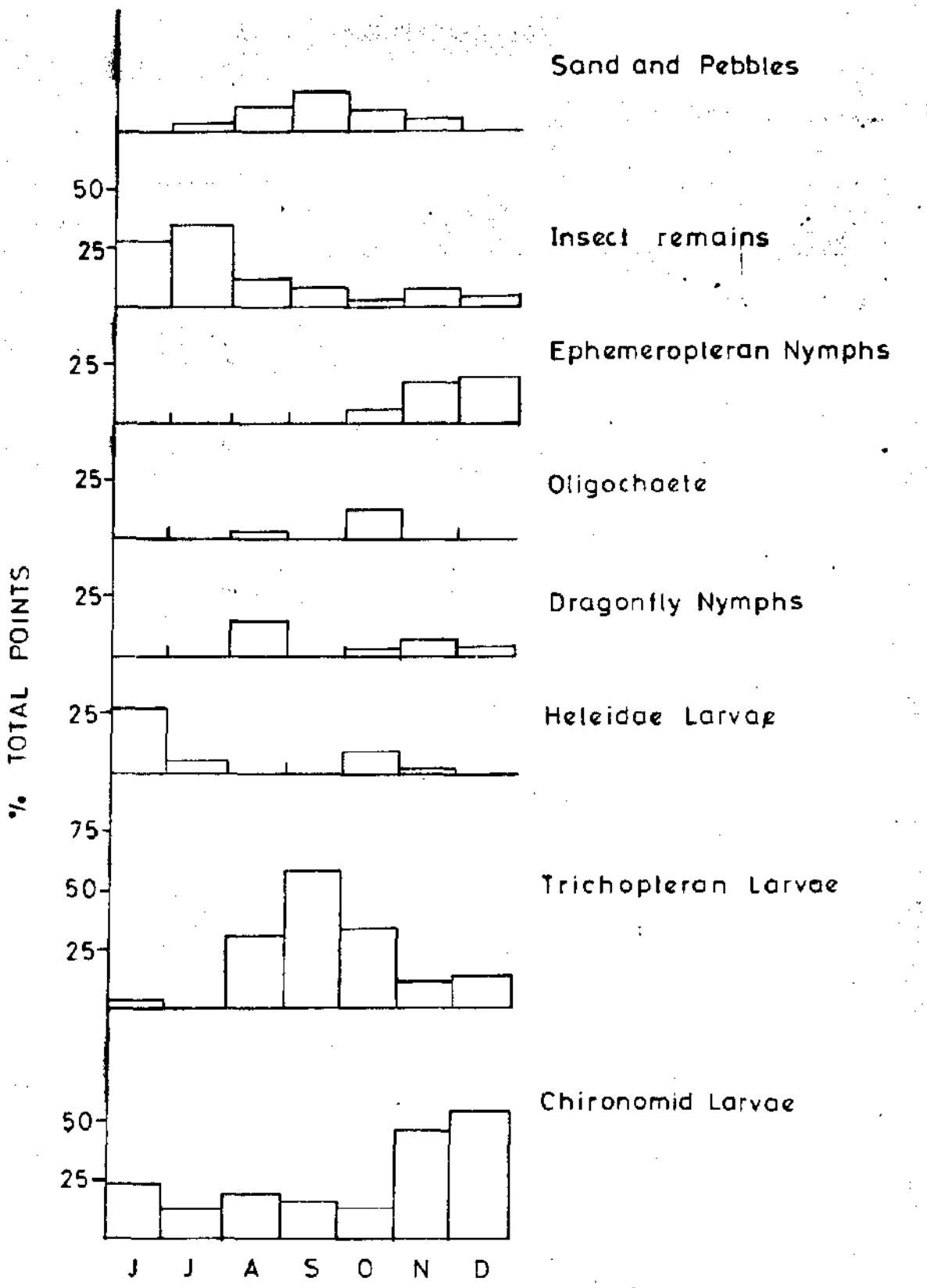



Fig. 20 (Mormyrus rume)
Monthly variation in diet composition

Table 7. Percentage composition and relative importance of dietary items in the stomachs of *Petrocephalus bovei*.

| Food Items | % Frequency of Occurrence | % Total Points |
|---|---|---|
| Inscet remains | 71.1 | 24.4 |
| Adult Insects | | |
| Coleoptera | 10.5 | 2.7 |
| Hemiptera | 2.6 | 0.3 |
| Immature Insects | | |
| Ephemeroptera Nymph | 5.3 | 2.4 |
| Dragonfly Nymph | 31.6 | 12.4 |
| Hemiptera Nymph | 23.7 | 5.4 |
| Damselfly Nymph | 7.9 | 3.2 |
| Megaloptera larvae | 2.6 | 0.4 |
| Trichoptera larvae | 34.2 | 15.8 |
| Diptera Larvae + Pupae | | |
| Chironomid Larvae | 65.8 | 16.5 |
| Chaoborus Larvae | 21.1 | 7.5 |
| Heleidae Larvae | 5.3 | 0.3 |
| TOTAL INSECTA | | 91.3 |
| Clam shrimp | 2.6 | 0.2 |
| Copepod (cyclops) | 15.8 | 2.8 |
| TOTAL CRUSTACEA | | 3.0 |

| Food Items | % Frequency of Occurrence | % Total Points |
|---|---|---|
| Hydracarina | 5.3 | 0.4 |
| TOTAL ARACHNIDA | | 0.4 |
| Lamellibranchia | 2.6 | 0.1 |
| TOTAL MALLUSCA | | 0.1 |
| Oligochaetes | 5.3 | 1.3 |
| TOTAL ANNELIDA | | 1.3 |
| Seeds | 18.4 | 2.9 |
| TOTAL PLANT ORIGIN | | 2.9 |
| OTHERS | | 1.0 |

III.A.6. THE FOOD AND FEEDING HABITS OF PETROCEPHALUS BOVEI .

a. The food items selected.

Table 7, shows that this fish fed mainly on insects. Chironomid larvae and trichopteran larvae comprised the major insect food items consumed. The percentage total points for chironomid larvae was 16.5% and trichoptera was 15.8%. The dragonfly nymphs were consumed to a considerable extent by P. bovei, and they occurred in 31.6% of the stomachs with food, with a 12.4% score in percentage total points. Next in importance, are chaoborus larvae and hemipteran nymphs. The chaoborus larvae scored 7.5% while hemipteran nymphs scored 5.4% by points. Other insects like damselfly nymphs, ephemeropteran nymphs and adult coleopterans were noticed in the stomachs. Insects which had percentage total points of 91.3%, thus constitute the main source of food for P. bovei. This shows that this was principally insectivorous. Cyclops were also found in this fish It occurred in about 15.8% of the stomachs examined. Although it scored 2.8% by points because of its relatively small size, this was the highest score when compared with other mormyrids. Similarly, seeds made a small contribution by scoring 2.9% by points, and occurred in 18.4% of the fishes examined.

b. Monthly feeding intensity.

Fig. 21, shows that feeding intensity was at its peak in the month of September. The feeding intensity was lowest

in the month of June. Fig. 21 indicates that the feeding intensity for the months of July and August was almost the same. No specimen was examined for the months of October and December. In November 83% of them were feeding, although the number examined during this month was low. On the average the feeding intensity of P. bovei was relatively high.

c. Monthly variations in the food item selected.

Fig. 22 shows that chironomid larvae were the most regular food item taken by P. bovei. Although, table 7 showed Trichoptera to score relatively high points, it was not found regularly in the stomach samples. Chironomid larvae were consumed more in June. In the month of July, when the chironomid larvae just had 5% of the stomach contents, chaoborus larvae and insect remains rose to their peak. Another conspicuous decline of chironomid larvae was noticed in the month of September and this coincided with the period that the trichopteran larvae monthly percentage points was 40%. No stomach was examined in the months of October and December. Hemipteran nymphs and adults were consumed more in June and gradually declined. Dragonfly nymphs were found in the months of July, August and November. Damselfly nymphs were conspicuous only in September when it contributed up to 22% of the stomach contents. Similarly, cyclops had a remarkable monthly percentage total points in November when it had up to 20%.

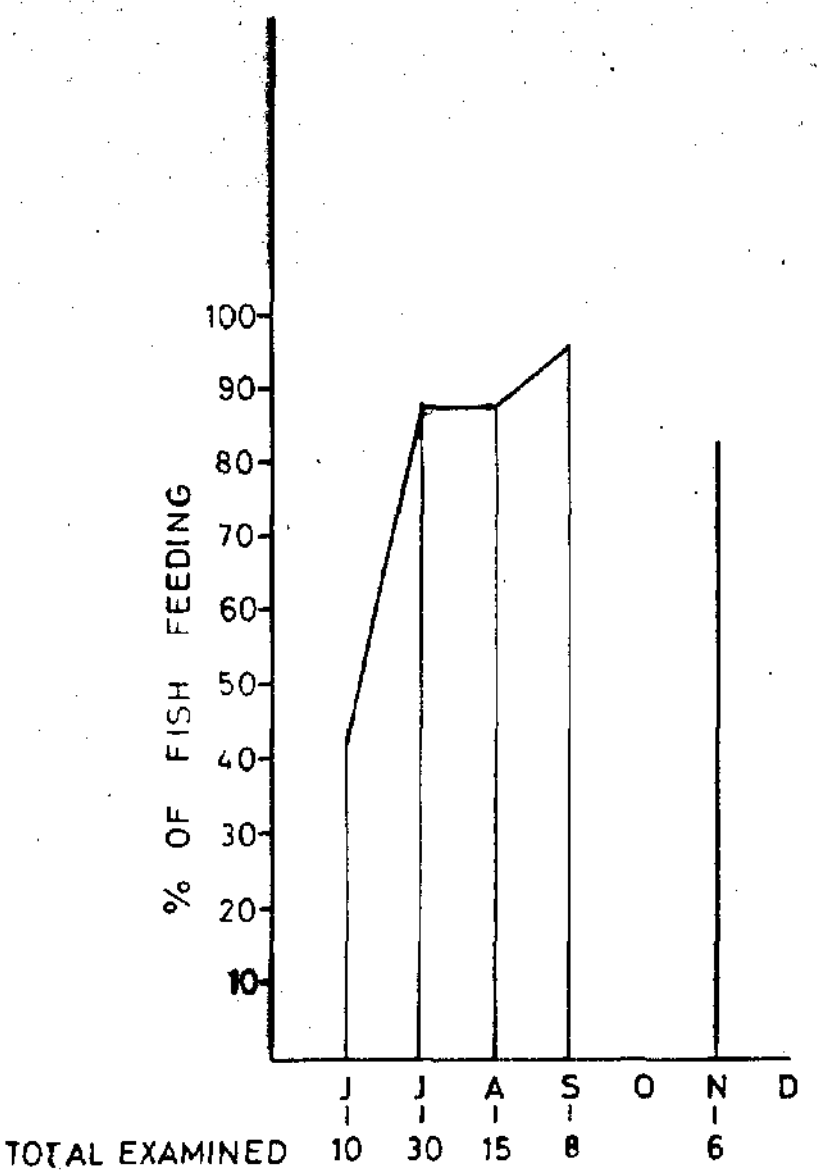



Fig. 21 (Petrocephalus bovei)
Monthly feeding intensity pattern

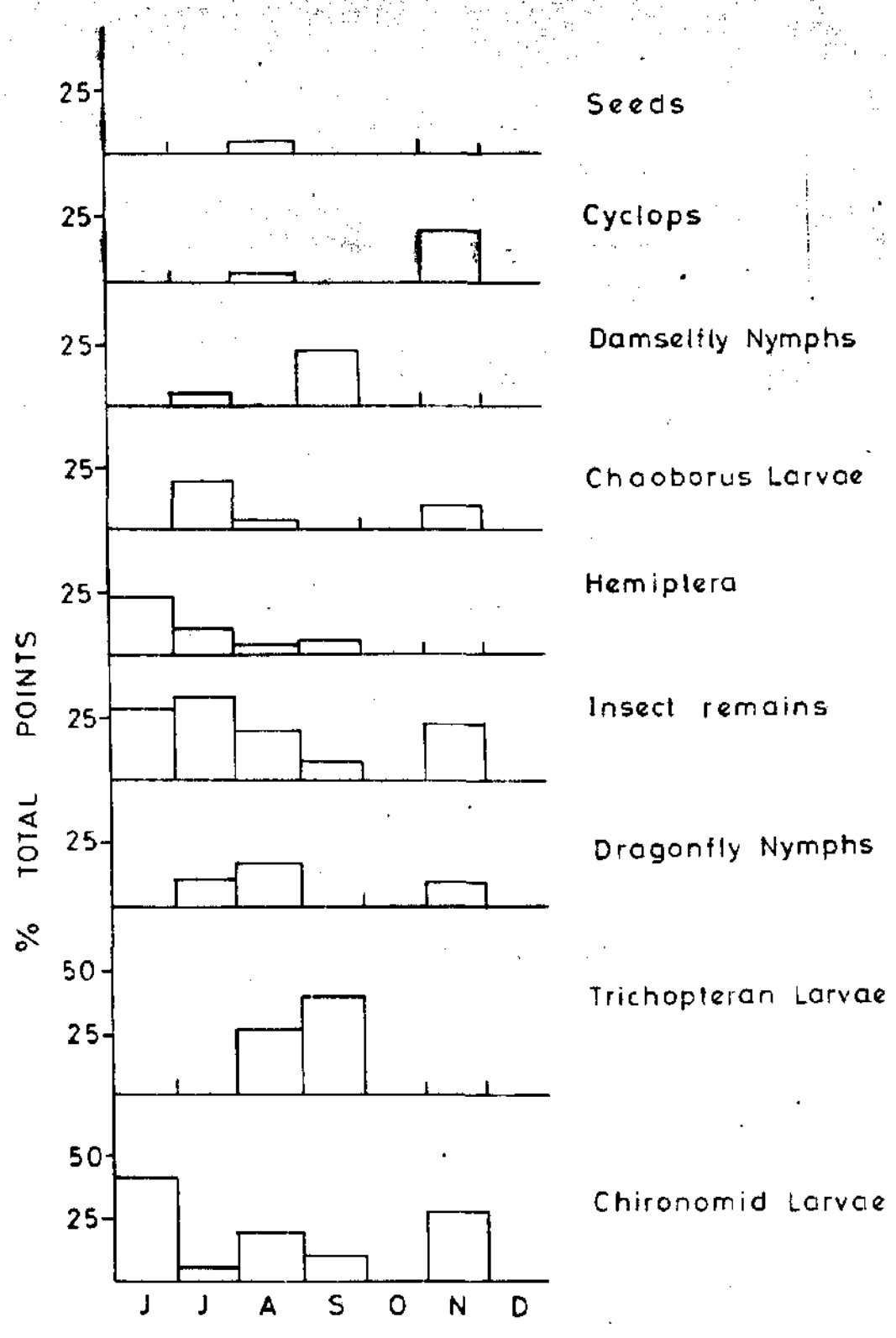



Fig. 22 (Petrocephalus bovei)
Monthly variation in diet composition

Table 8. Percentage composition and relative importance of dietary items in the stomachs of Hippopotamyrus pictus.

| Food Items | % Frequency of Occurrence | % Total Points |
|---|---|---|
| Insect remains | 65.4 | 14.6 |
| Adults Insects | | |
| Coleoptera | 7.7 | 0.4 |
| Immature Insects | | |
| Ephemeroptera Nymph | 50.0 | 25.0 |
| Dragonfly Nymph | 7.7 | 1.6 |
| Damselfly Nymph | 11.5 | 0.8 |
| Megaloptera Larvae | 3,9 | 0.8 |
| Trichoptera Larvae | 65.4 | 35.1 |
| Diptera Larvae + Pupae | | |
| Chironomid Larvae | 61.5 | 13.4 |
| Chironomid Pupae | 7.7 | 0.4 |
| Heleidae Larvae | 15.4 | 2.2 |
| TOTAL INSECTA | | 94.3 |
| Ostracods | 3.9 | 0.1 |
| Clam shrimps | 3.9 | 0.3 |
| TOTAL CRUSTACEA | | 0.4 |
| Seeds | 23.1 | 4.2 |
| TOTAL PLANT ORIGIN | | 4.2 |
| OTHERS | | 1.1 |

III.A.7. THE FOOD AND FEEDING HABITS OF HIPPOPOTAMYRUS PICTUS.

a. The food items selected.

The composition and relative importance of the dietary items found in the stomachs of H. pictus is as seen in Table 3. The table, shows that H. pictus fed exclusively on immature insects. Insects scored up to 94.3% of total points and this goes to confirm that the fish is principally insectivorous. Trichopteran larvae, ephemeropteran nymphs and chironomid larvae were the most important dietary items. The most important insect was the trichopteran larvae, which occurred in about 65.4% of samples examined with 35.1% points. The ephemeropteran nymphs which were next in importance occurred in about 50% and with a 25% points. The chironomid larvae occurred in 61.5% and formed 13.4% by points. Other insects like dragonfly nymphs, heleidae larvae, damselfly nymphs, megalopteran larvae and coleopteran adult occurred but were unimportant components of the food items. There was a considerable percentage of seeds in the stomach contents of this species. Seeds occurred in up to 23.1% and scored 4.2% by points. Other dietary items like Ostracods and Clam shrimps were relatively not important.

b. Monthly feeding intensity.

Fig. 23 suggests a constantly outstanding high rate of feeding intensity throughout the period of investigation (>30%). On the whole, H. pictus was observed to have the

highest feeding intensity when compared with other mormyrids investigated. The feeding intensity was 100% for months of June, July and August before it declined in September to 86%. By October, it rose to 100% and maintained it in November before declining to 80% in December.

c. Monthly variations in the food items selected.

Fig. 24 depicts the monthly variations in the food items. Selected during the period of investigation. Chironomid larvae were always present in their stomachs throughout the period. In any case, the percentage point contribution for most months were low when compared with trichopteran larvae and ephemeropteran nymphs. Trichoptera seemed to be prominent during the rainy season. It gradually declined up till October, before it increased in the months of November and December. Ephemeropteran nymphs seemed to have constituted about 62% of the stomach contents in October. The histogram for ephemeropteran nymphs and trichopteran larvae reflects the impression that when one is increasing, the other is decreasing and vice versa for the months of August to December. This alternation between the percentage of trichopteran larvae and ephemeropteran nymphs presumably reflects changes in their availability. Seeds made its highest contribution in July, when both ephemeropteran nymphs and trichopteran larvae were absent,

III.A.8. FOOD AND FEEDING HABITS OF REMAINING MORMYRID SPECIES.

Two other species of mormyrid were recorded during the

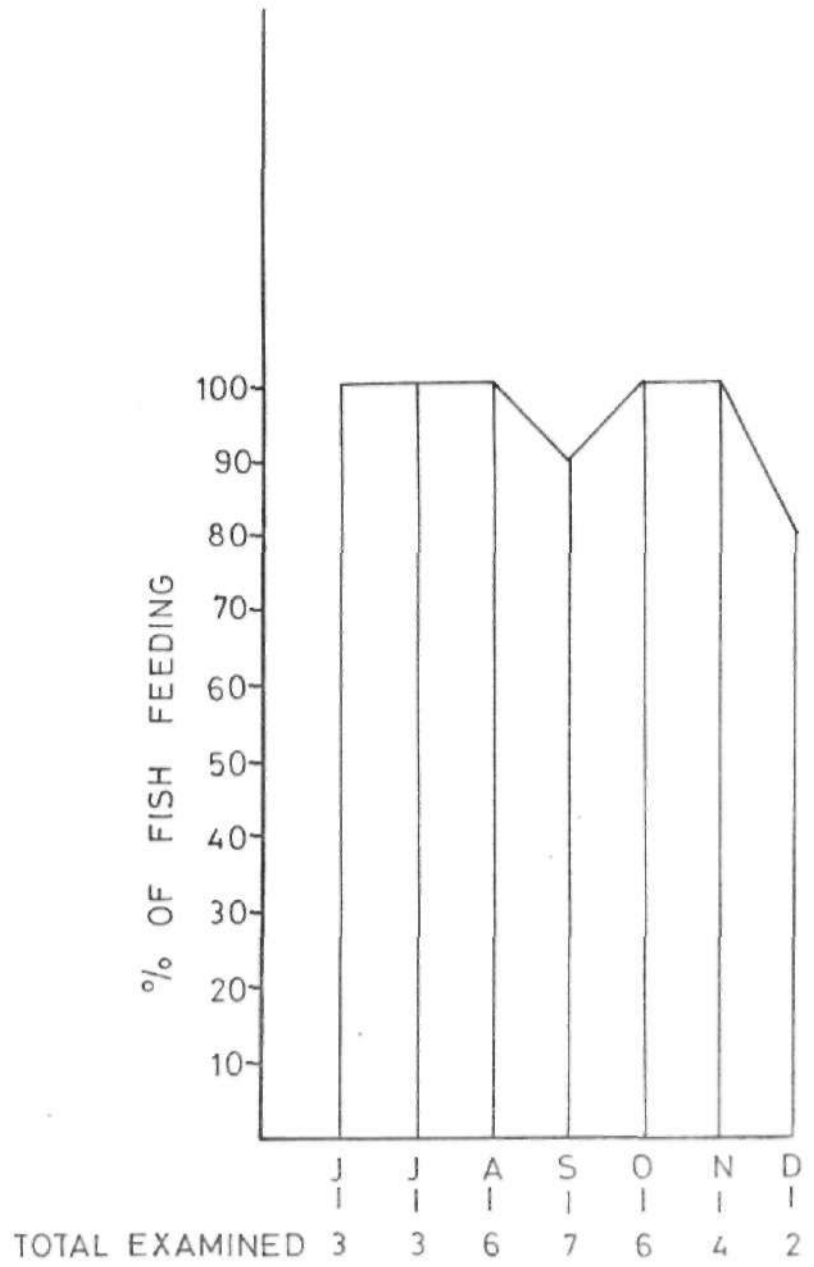



Fig. 23 (Hippopotamyrus pictus.)
Monthly feeding intensity pattern

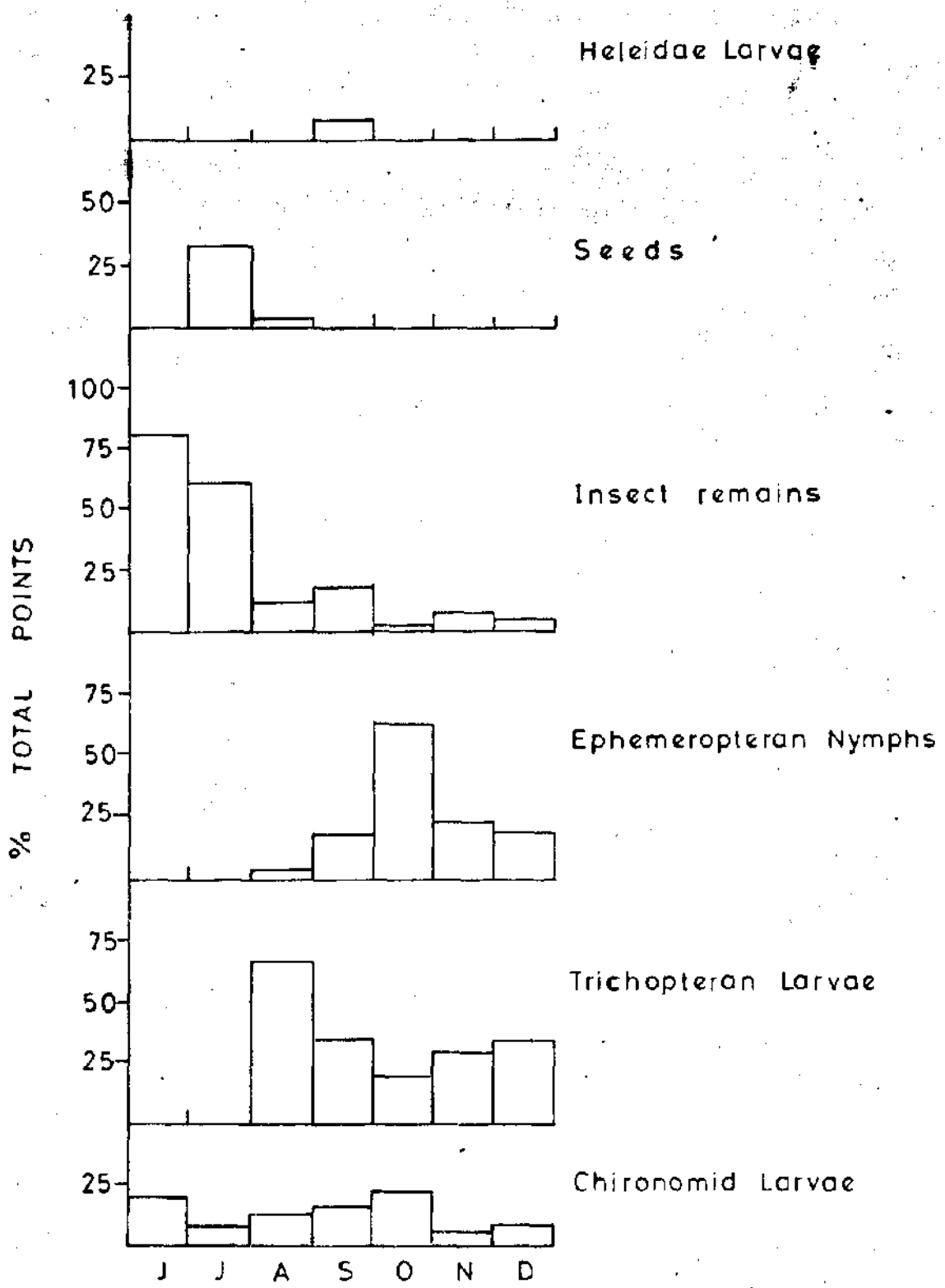



Fig. 24 (Hippopotamyrus pictus.)
Monthly variation in diet composition

present work. Only seven specimens of Pollimyrus isidori (Cuvier and Valenciennes) and six specimens of Hippopotamyrus psittacus (Boulenger) were collected during the period of investigation. Both numbers are small for any meaningful quantitative stomach analysis. Examination of the stomach contents reveald a predominance of chironomids in both species. Very small animal food items like cyclops, ostracods and hydracarina appeared to be important in the feeding habit of P. isidori. This might be related to the small nature of this species. Trichopteran larvae seemed to be another insect prey favoured by H. psittacus, although items like seeds and Anthomyiidae pupae were found in their stomachs.

Table 9. Percentage composition and relative importance of dietary items in the stomachs / of Auchenoglanis occidentalis.

| Food Items | % Frequency of Occurrence. | % Total Points |
|---|---|---|
| Insect remains | 43.9 | 5.9 |
| Adult Insects | | |
| Coleoptera | 4.5 | 0.3 |
| Hymenoptera | 6.1 | 2.5 |
| Immature Insects | | |
| Ephemeroptera Nymph | 9.1 | 1.6 |
| Dragonfly Nymph | 7.6 | 3.4 |
| Damselfly Nymph | 1.5 | 0.2 |
| Hemiptera Nymph | 6.1 | 0.9 |
| Trichoptera Larvae | 15.2 | 2.5 |
| Coleoptera Larvae | 27.3 | 3.5 |
| Diptera Larvae + Pupae | | |
| Chironomid Larvae | 89.4 | 39.0 |
| Chironomid Pupae | 31.8 | 5.5 |
| Chaoborus Larvae | 6.1 | 0.4 |
| Chaoborus Pupae | 4.6 | 0.7 |
| Heleidae Larvae | 27.3 | 3.4 |
| Tabanidae Larvae | 1.5 | 0.7 |
| Syrphidae Larvae | 1.5 | 0.6 |
| Anthomyiidae Larvae | 1.5 | 0.1 |

| Food Items | % Frequency of Occurrence | % Total Points |
|---|---|---|
| Anthomyiidae Pupae | 3.0 | 1.3 |
| Tipulidae Larvae | 1.5 | 0.2 |
| TOTAL INSECTA | | 72.7 |
| Fish scales | 9.1 | 1.6 |
| TOTAL FISH | | 1.6 |
| Ostracods | 15.2 | 2.4 |
| Clam shrimps | 19.7 | 4.5 |
| Copepod (Cyclops) | 6.1 | 0.6 |
| TOTAL CRUSTACEA | | 7.5 |
| Gastropoda | 4.6 | 0.6 |
| Lamellibranchia | 3.0 | 2.3 |
| TOTAL MOLLUSCA | | 2.9 |
| Oligochaetes | 7.6 | 10.9 |
| TOTAL ANNELIDA | | 10.9 |
| Sand and pebbles | 12.1 | 1.8 |
| TOTAL BOTTOM DEPOSITS | | 1.8 |
| Plant remains | 3.0 | 0.6 |
| Seeds | 10.6 | 1.3 |
| TOTAL PLANT ORIGIN | | 1.9 |
| OTHERS | | 0.7 |

## III.A.9. THE FOOD AND FEEDING HABITS OF AUCHENOGLANIS OCCIDENTALIS.

### a. The food items selected.

Table 9 lists the individual food items identified from stomachs of A. occidentalis. The insects formed the major food items while crustaceans and oligochaetes were of secondary importance. The remaining food items were of minor importance. An examination of the individual food items projects chironomid larvae and pupae to be the most important among insect food items. The chironomid larvae occurred in more than 89% of the stomachs examined and scored a total point of 39%. The chironomid pupae were present in more than 31% of the stomachs examined and had more than 5% by points. This fish relatively took a reasonable quantity of hymenoptera (Crematogaster sp.). This food item scored 2.5% by points. This terrestrial insect must have been accidentally carried by the flood to the rivers. Trichopteran larvae, coleopteran larvae and dragonfly nymphs can also be considered to have been taken by a fair proportion of the fish, although the volume contributed to the total stomach content was relatively low.

The oligochaetes were not often encountered in the stomachs, but it appeared to predominate in few stomachs of the fish that it occurred. This was why it had a percentage frequency of occurrence of about 7% with a percentage total points of 10.9%.

Clam shrimps and ostracods were not frequently observed. They scored 4.5% and 2.4% total points respectively. Lamellibranchs had total points of 2.3%, and occurred mostly as empty shells.

b. Monthly feeding intensity.

Fig. 25 shows the feeding intensity pattern. A peak was noticed in November. The minimal feeding intensity was noticed in the month of July. Fig. 25 indicates that the feeding intensity increased from July to September. It declined in October but not to compare with the decline in July. It increased in November before another decline in December.

c. Monthly variations in the food items selected.

Fig. 26 shows the monthly variations in the food items selected during the period of investigation. Chironomid larvae were fed upon throughout the months under investigation. The peak was seen in August. The least impact was noticed in the months of June and October. It is interesting to note that the month the chironomid larvae had the peak value was when most other food items contributed little or nothing to the stomach content. Clam shrimp and coleopterans were important in the month of June. This coincided with the month that chironomid larvae was less important. Dragonfly nymphs and ostracods were both important in the month of December, while lamellibranchs were important in the month of November.

Generally, it may be that these variations were caused by abundance and availability of the dietary items.

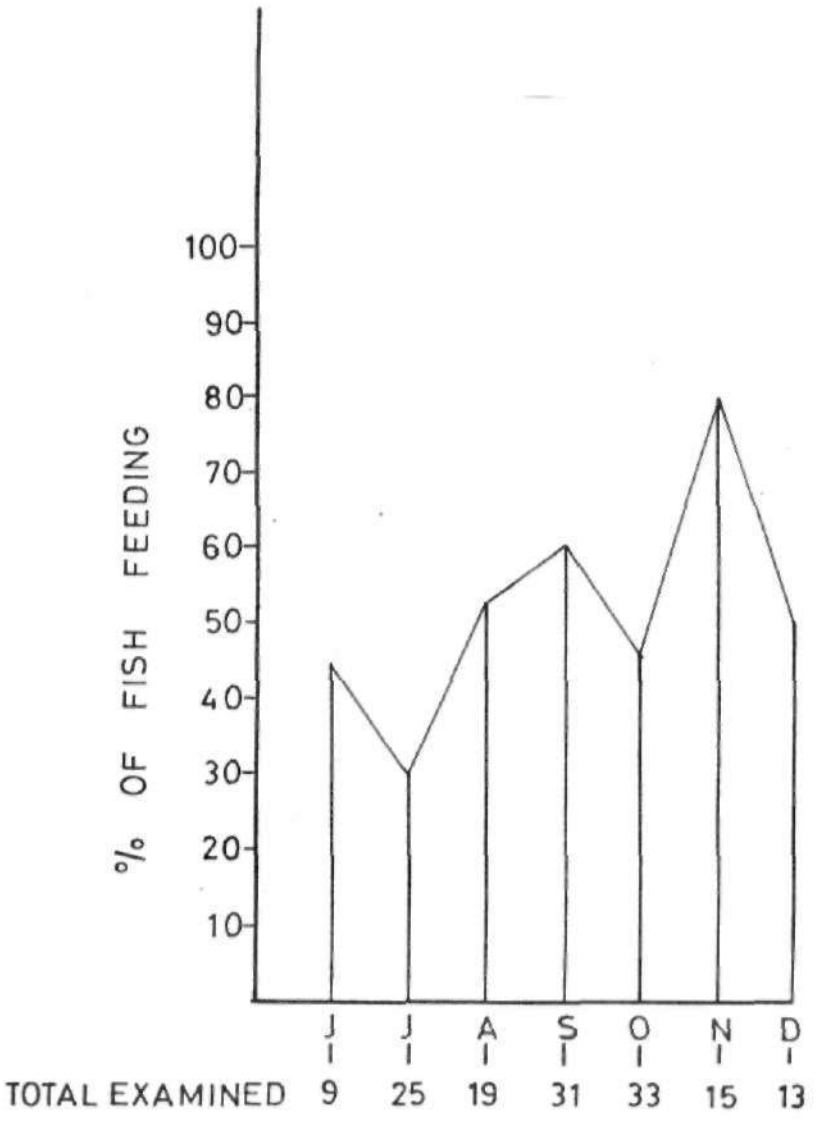



Fig. 25 (Auchenoglanis occidentalis)
Monthly feeding intensity pattern

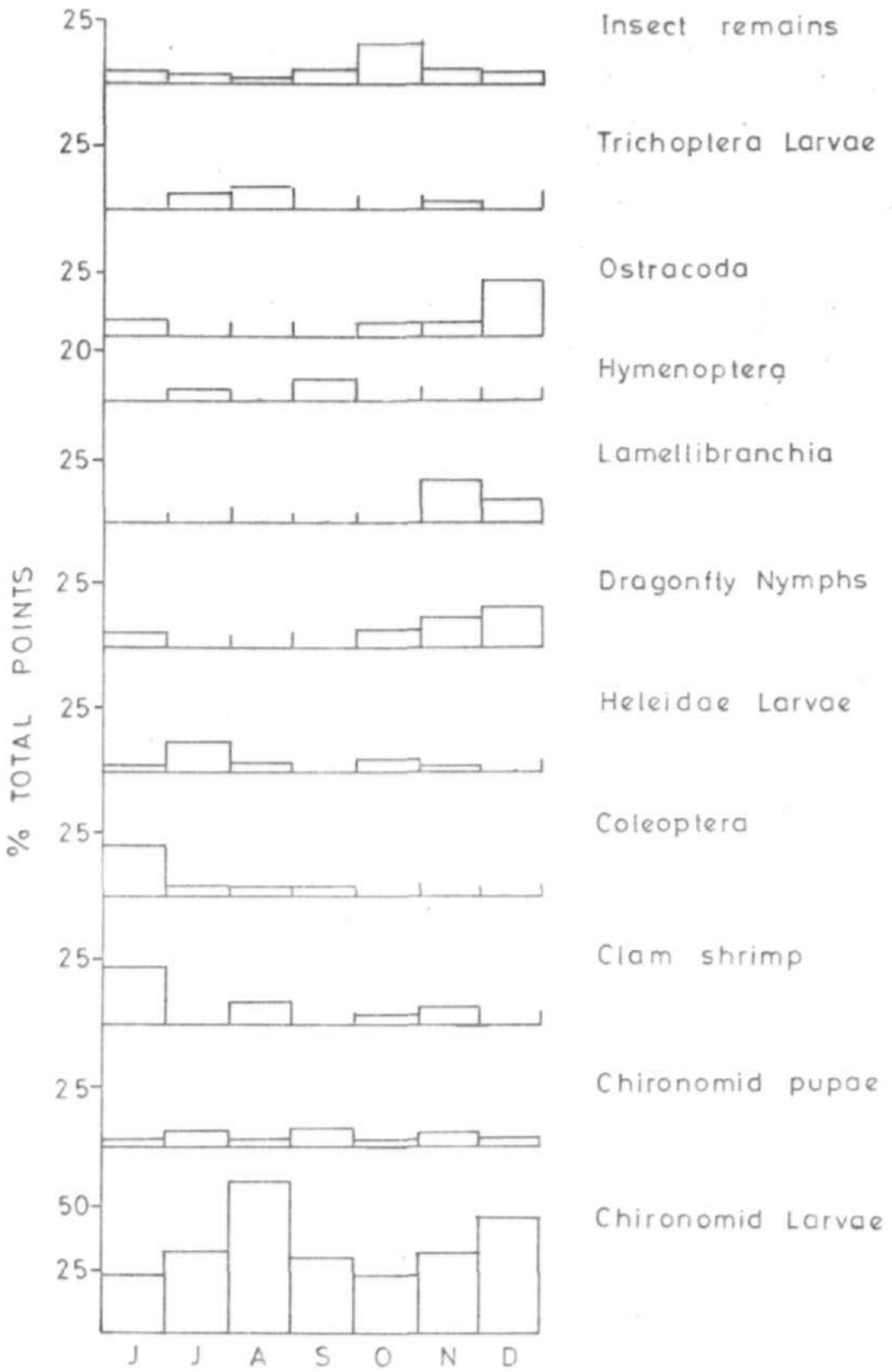



Fig. 26 (Auchenoglanis occidentalis)
Monthly variation in diet composition

Table 10. Percentage composition and relative importance of dietary items in the stomachs of Bagrus docmac.

| Food Items | % Frequency of Occurrence | % Total Points |
|---|---|---|
| Insect remains | 37.3 | 9.4 |
| Adult Insects | | |
| Coleoptera | 9.8 | 2.0 |
| Immature Insects | | |
| Ephemeroptera Nymph | 3.9 | 1.1 |
| Dragonfly Nymph | 5.9 | 2.5 |
| Damselfly Nymph | 2.0 | 1.0 |
| Hemiptera Nymph | 2.0 | 0.2 |
| Trichoptera Larvae | 27.5 | 5.9 |
| Diptera Larvae + Pupae | | |
| Chironomid Larvae | 5.9 | 0.6 |
| Chironomid Pupae | 2.0 | 0.3 |
| Chaoborus Larvae | 2.0 | 0.4 |
| TOTAL INSECTA | | 23.4 |
| Fish scales | 5.9 | 1.7 |
| Fish remains (including whole fish) | 70.6 | 64.9 |
| TOTAL FISH | | 66.6 |
| Clamp shrimp | 2.0 | 0.3 |
| Copepod (cyclops) | 2.0 | 0.2 |
| Decapod (Prawns) | 11.8 | 3.2 |

| Food Items | % Frequency of Occurrance | % Total Points |
|---|---|---|
| TOTAL CRUSTACEA | | 3.7 |
| Sand and Pebbles | 17.7 | 1.7 |
| TOTAL BOTTOM DEPOSITS | | 1.7 |
| Plant remains | 11.8 | 3.5 |
| Seeds | 5.9 | 0.5 |
| TOTAL PLANT ORIGIN | | 4.0 |
| OTHERS | | 0.6 |

III.A.10. THE FOOD AND FEEDING HABITS OF BAGRUS DOCMAC

a. The food items selected.

Table 10 shows the different food items found in stomachs of B. docmac. Fish remains formed the major bulk of food items consumed by B. docmac. The fish remains formed 64.9% by points of total stomach contents and occurred in more than 70% of the fishes examined.

Invertebrates particularly insects, contributed to the diets also. Insects as a whole scored 23.4% by points. The adults of B. docmac were principally piscivorous, but individuals with standard length less than 14cm, fed mainly on insects and to a slight extent on fish. Trichopteran larvae were most important. Dragonfly nymphs, ephemeropteran nymphs and adult coleopterans made little contribution to the dietary items. The rest of the insects were of major importance. The prawns were important in the diet of all sizes of B. docmac. The two fish genera, identified as preys of B. docmac were Tilapia sp. and Synodontis sp. Some plant remains were also found from the stomach contents, but the contibution was relatively low.

b. Monthly feeding intensity.

The monthly feeding intensity as shown in Fig. 27, portrays that B. docmac had a high rate of feeding intensity all through the period of investigation ( $>57\%$). A relatively low intensity was observed in the months of July and October. The peak of the feeding intensity was in the

months of December and November. In the months of June and July, the available fish for analysis was low therefore the data obtained might not be reliable.

c. Monthly variations in the food items selected.

Fig. 28 shows that fish remains occurred regularly in the stomachs almost throughout the period of investigation, except in August when there was a remarkable decline. This period was the only month that dragonfly nymphs were present in the stomach contents. There was a little drop in fish consumed in December. This coincided with the month that prawns were predominant in the stomach contents. It may be that the prawns became abundant at this time of the investigation. Trichlpteran larvae was always in the stomach contents throughout the period of investigation, but their contribution in each month was low.

III.A.11. THE FOOD AND FEEDING HABITS OF CHRYSICHTHYS NIGRODIGITATUS

One other bagrid species recorded during this study was chrysichthys nigrodigitatus (Lacepede). Only two specimens were found during the period of investigation. The stomachs of these two specimens were empty.

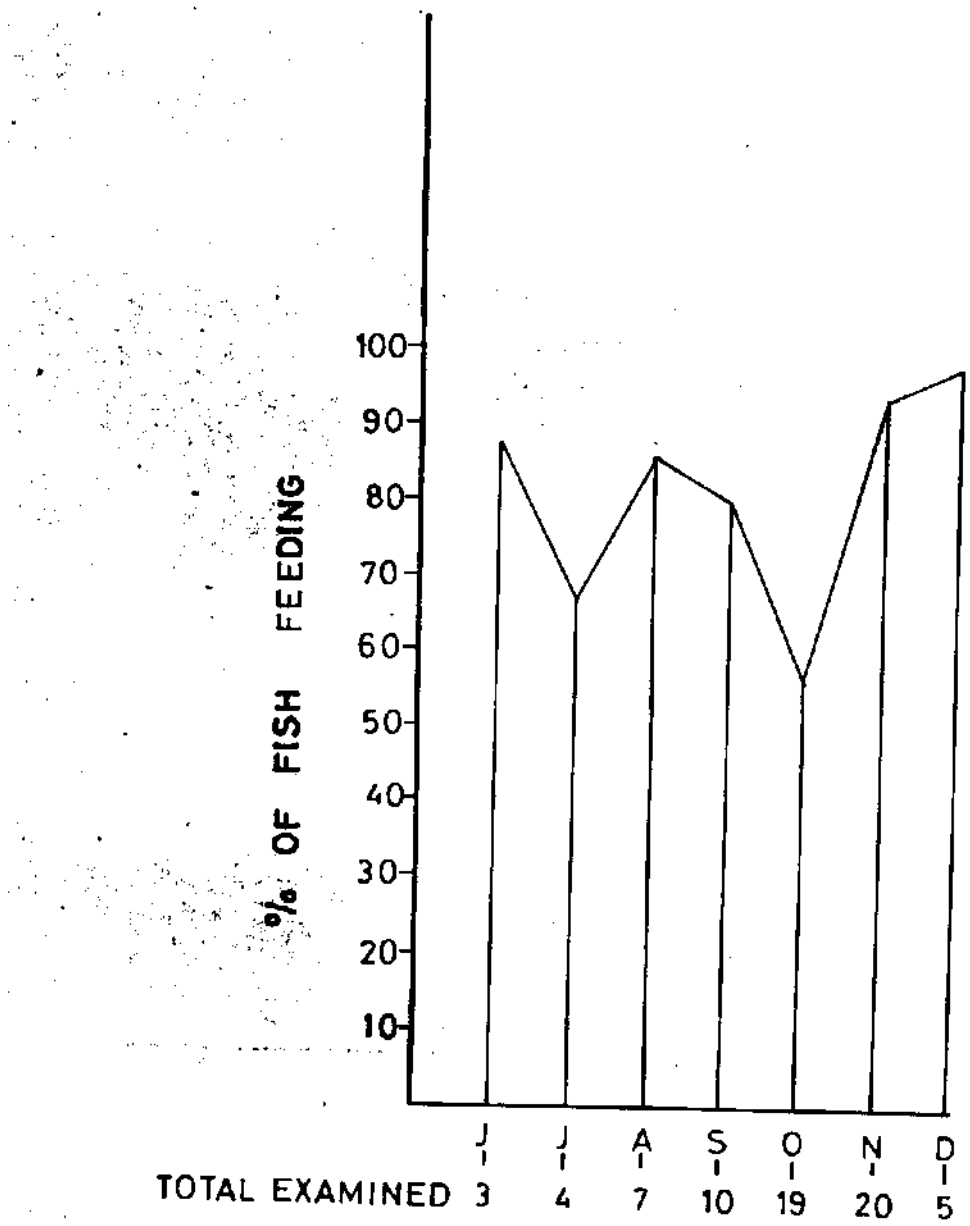



Fig. 27 (Bagrus docmac.)
Monthly feeding intensity pattern

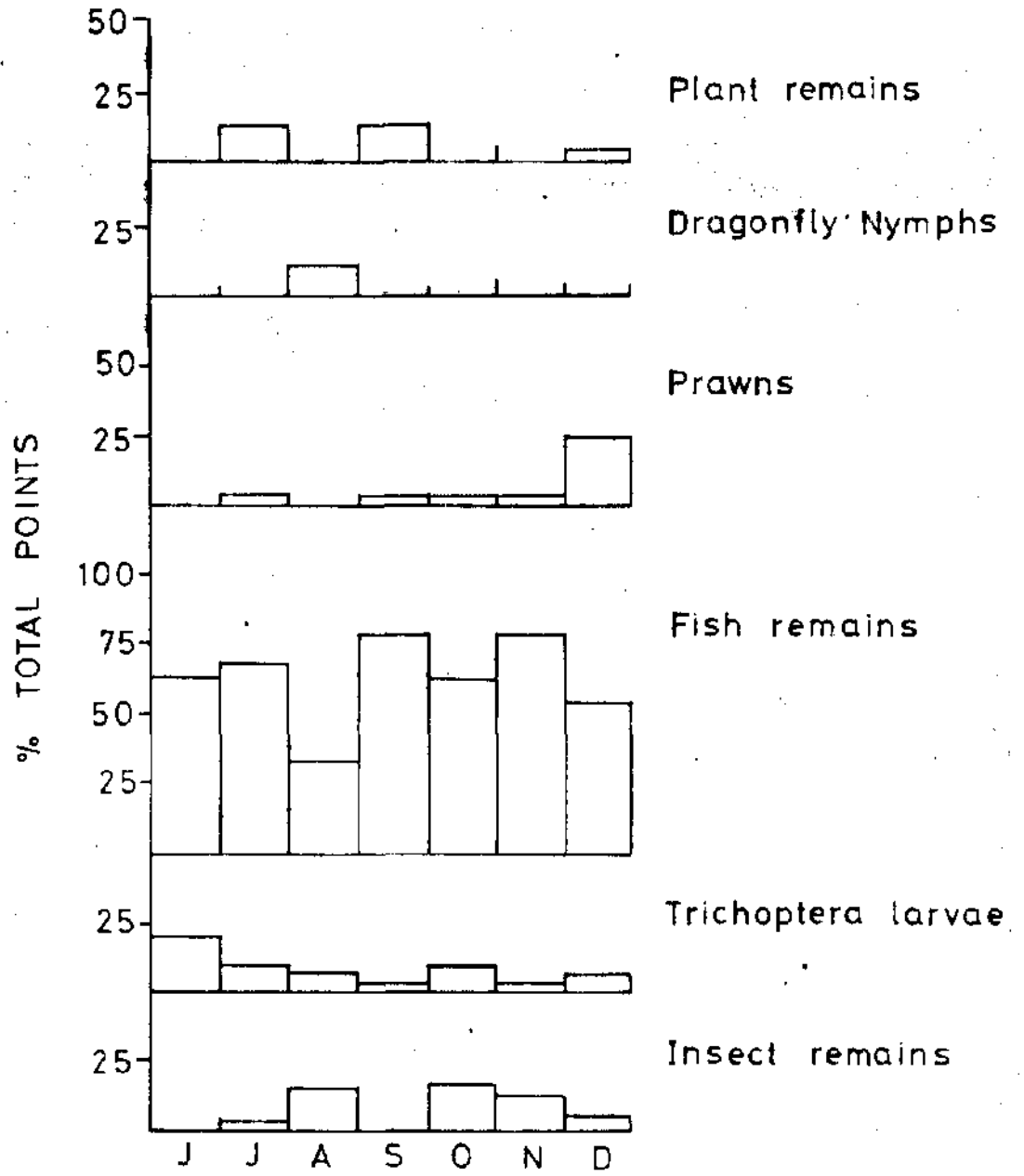



Fig. 28 (Bagrus docmac.)
Monthly variation in diet composition

Table 11. Percentage composition and relative importance of dietary items in the stomachs / of Synodontis schall

| Food Items | % Frequency of Occurrence | % Total Points |
|---|---|---|
| Insect remains | 42.7 | 9.0 |
| Adult Insects | | |
| Coleoptera | 8.4 | 1.3 |
| Hemiptera | 1.5 | 0.2 |
| Hymenoptera | 3.1 | 2.1 |
| Immature Insects | | |
| Ephemeroptera Nymph | 13.7 | 7.5 |
| Dragonfly Nymph | 2.3 | 0.7 |
| Damselfly Nymph | 3.1 | 0.4 |
| Hemiptera Nymph | 10.7 | 1.2 |
| Megaloptera Larvae | 0.8 | 0.1 |
| Trichoptera Larvae | 16.0 | 3.5 |
| Coleoptera Larvae | 9.9 | 0.8 |
| Diptera Larvae + Pupae | | |
| Chironomid Larvae | 55.7 | 12.1 |
| Chironomid Pupae | 12.2 | 1.8 |
| Chaoborus Larvae | 0.8 | 0.1 |
| Chaoborus Pupae | 0.8 | 0.1 |
| Heleidae Larvae | 2.3 | 0.1 |
| Syrphidae Larvae | 2.3 | 0.3 |
| Anthomyiidae Pupae | 1.5 | 0.4 |

| Food Items | % Frequency of Occurrence | % Total Points |
|---|---|---|
| TOTAL INSECTA | | 41.7 |
| Fish eggs | 2.3 | 0.5 |
| Fish scales | 7.6 | 4.4 |
| TOTAL FISH | | 4.9 |
| Ostracods | 30.5 | 3.1 |
| Clam shrimps | 5.3 | 0.6 |
| Cladocera | 0.8 | 0.1 |
| Copepod (cyclops) | 6.9 | 0.4 |
| TOTAL CRUSTACEA | | 4.2 |
| Hydracarina | 2.3 | 0.1 |
| TOTAL ARACHNIDA | | 0.1 |
| Gastropoda | 9.9 | 3.0 |
| Lamellibranchia | 4.6 | 1.0 |
| TOTAL MOLLUSCA | | 4.0 |
| Oligochaetes | 0.8 | 1.1 |
| TOTAL ANNELIDA | | 1.1 |
| Sand and Pebbles | 3.1 | 0.3 |
| TOTAL BOTTOM DEPOSITS | | 0.3 |
| Algae | 24.4 | 13.8 |
| Plant remains | 23.7 | 5.0 |
| Seeds | 49.6 | 24.4 |
| TOTAL PLANT ORIGIN | | 43.2 |
| OTHERS | | 0.5 |

III.A.12. THE FOOD AND FEEDING HABITS OF SYNODONTIS SCHALL.

a. The food items selected.

Table II shows the list of the food items found in the stomach of S. schall.

Plant materials and insects were the two major sources of food for S. schall. Chironomid larvae were the most important food item for S. schall among the insects. It scored 12.1% by points. Ephemeropteran nymphs were second in importance. Trichopteran larvae could be considered to have an appreciable contribution. It scored 3.5% by points. Other insect food items made a minor contribution. Among materials of plant origin, the seeds made a remarkable contribution to the diets of S. schall. It was of primary importance and scored 24.4% by points. Algae was also, an important food item. It scored 13.8% of total points. Unidentified plant remains contributed about 5%. Among the crustaceans, the ostracods was the only important food item. Fish scales and gastropods also made some minor contributions to the diets. In conclusion, S. schall can be considered to be ominivorous.

b. Monthly feeding intensity.

Fig. 29 shows the trends in the monthly feeding intensity during the period of investigation. In the month of July, the feeding intensity declined to a minimum. There was a continuous increase in feeding intensity as from the month of August to October. It gradually declined

again in the months of November and December. This is expected in dry season when there are reduction in food materials available for the fish.

c. Monthly variations in the food items selected.

Fig. 30 shows the monthly variation for different food items selected throughout the period of study. Seeds occurred in the stomachs for most of the months except in June. Seeds scored up to 52% in monthly total point by September. The chironomid larvae were always present in the stomach contents throughout the period of investigation. Ephemeropteran nymphs and fish scales were absent in the stomach contents for four months and only appeared in the months of October to December . Insect remains occurred throughout the period of investigation, while plant remains were absent in the month of September.

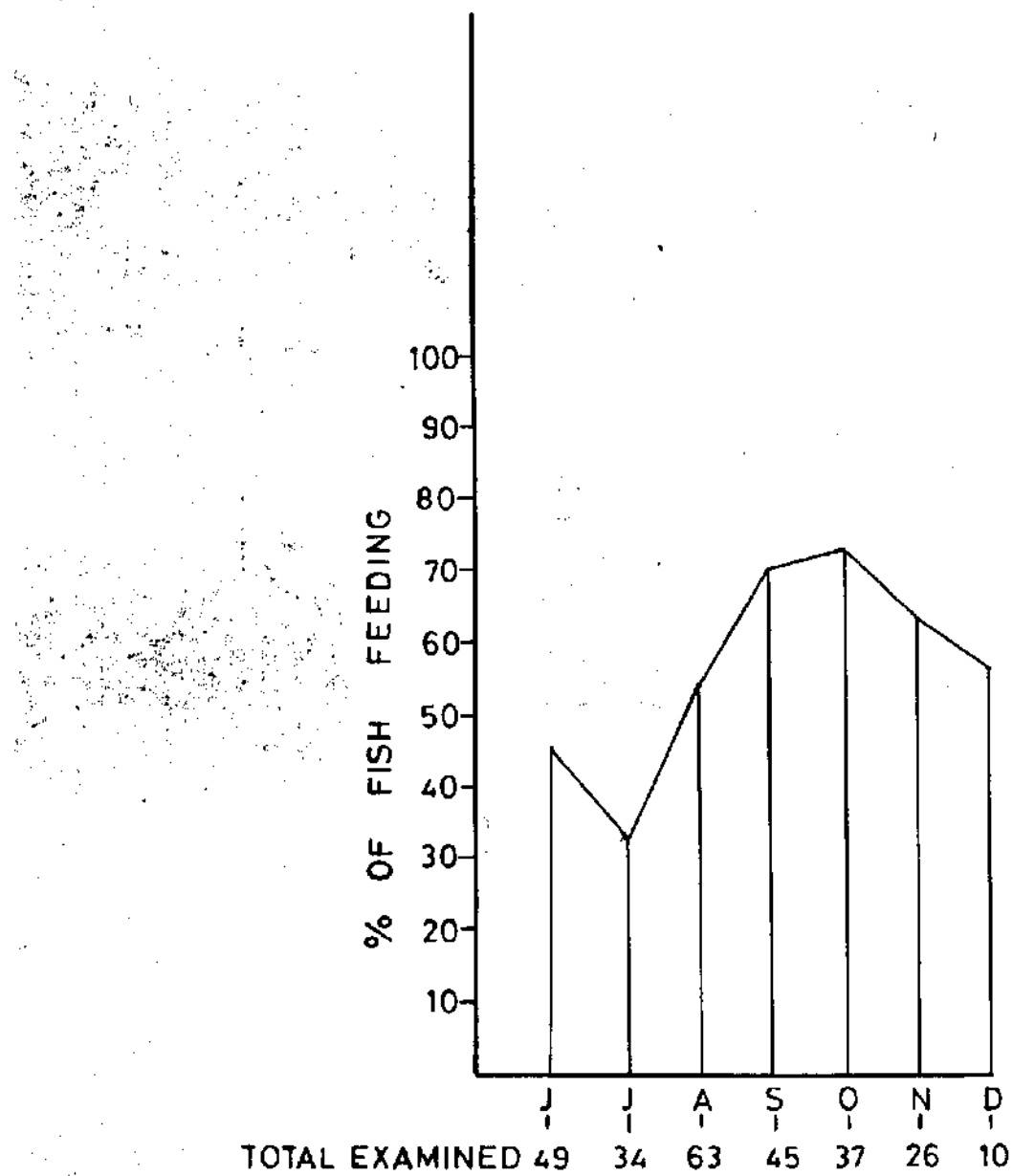



Fig. 29 (Synodontis schall.)
Monthly feeding intensity pattern

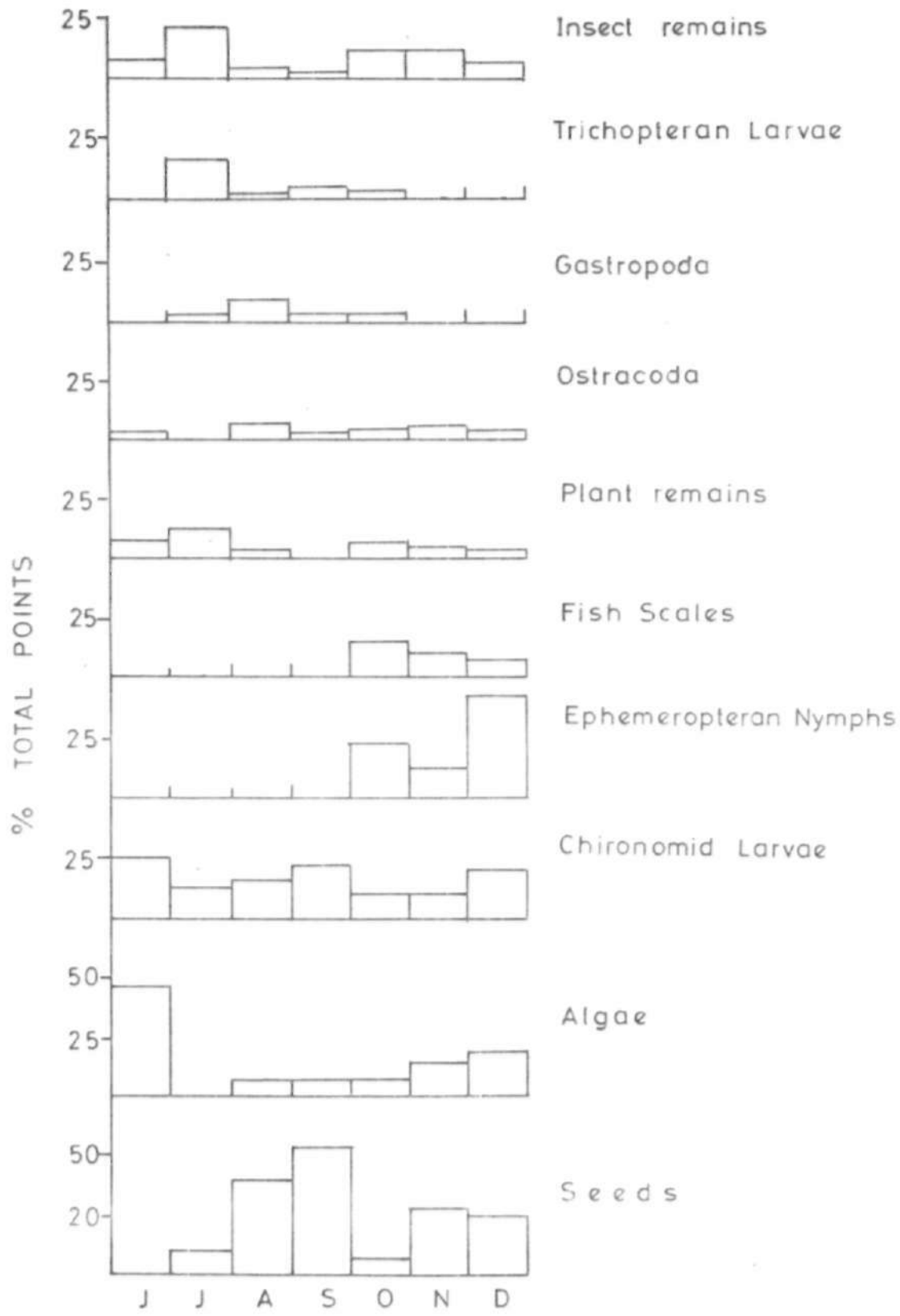



Fig. 30 (Synodontis schall)
Monthly variation in diet composition

III.B. LENGTH-WEIGHT RELATIONSHIP.

The length-weight relationships were calculated using electronic calculator. The formular described by Le Cren (1951), was used for the calculation:-

$$W = aL^b \quad - - - - - - - - - - - - - - (1)$$

Where W = weight of fish (g)

L = standard length of fish (cm)

a = constant

b = an exponent

The constant a and exponent b were emperically determined, after a logarithmic transformation of all the data. The expression (1), can then be represented as:-

$$\text{Log } W = \log a + b \log L \quad - - - - - - - - - - - - (2)$$

Graphs of log weight (dependent variable) on log length (independent variable) were drawn as shown in Figs. 31 to 44. The best straight line was fitted using least squares regression analysis. Notation and formula in calculations for fitting a linear regression equation using method of least squares is as shown in the appendix I.

Pearson Product-Moment method for calculating correlation coefficient was used in calculating the correlation coefficient. The symbol for the correlation coefficient is (r), while the formula is =

$$r = \frac{(\Sigma liwi - CFlw)}{\sqrt{(\Sigma li^2 - CFl)(\Sigma Wi^2 - CFw)}}$$

Test statistic $t = r\,(n-2)/(1-r2)$

Degrees of freedom d.f. = n-2

(see appendix I, for explanation of symbols)

The results of the regression are as seen on table 12. The correlation coefficient was very high (.83 - .99) in all the species. The correlation between the lengths and weights were found to be highly significant (P = 0.01 - 0.001). The regression coefficient "b" in all the species were found to fall between 2.33 and 3.60. The available specimens for Pollimyrus isidori, Hippopotamyrus psittacus and Chrysichthys nigrodigitatus during the period of investigation, were very small for any reliable calculation to be carried out. The available specimens for Petrocephalus bovei was quite substantial, but the narrow range in lengths and weights of the samples made the calculation of length weight relationship give a result that deviated from the normal 2 to 4 'b' value range

Table 12. Length - weight regression analysis and correlation coefficient of fishes of Mormyridae, Bagridae and Mochokidae in Zaria area.

| Families | Species | Sex | No. of fish | log a | b | Standard error of 'b' | Correlation Coefficient. |
|---|---|---|---|---|---|---|---|
| Mormyridae | Mormyrops deliciosus | Female | 30 | -2.51 | -3.25 | 0.06 | 0.99 |
| | " " | Male | 23 | -1.10 | 2.33 | 0.22 | 0.95 |
| | Hyperopisus bebe | Female | 65 | -3.00 | 3.60 | 0.18 | 0.99 |
| | " " | Male | 33 | -2.28 | 3.08 | 0.13 | 0.98 |
| | Mormyrus rume | Female | 44 | -2.25 | 3.14 | 0.09 | 0.99 |
| | " " | Male | 28 | -2.11 | 3.02 | 0.12 | 0.99 |
| | Marcusenius senegalensis | Female | 110 | -1.18 | 2.42 | 0.12 | 0.99 |
| | " " | Male | 5 | -1.95 | 3.00 | 0.14 | 0.99 |
| | Hippopotamyrus pictus | Female | 27 | -1.74 | 2.92 | 0.12 | 0.97 |
| | Petrocephalus bovei | Female | 78 | -5.48 | 7 | - | - |
| Bagridae | Auchenoglanis occidentalis | Female | 75 | -1.53 | 2.88 | 0.13 | 0.97 |
| | " " | Male | 49 | -1.18 | 2.61 | 0.10 | 0.98 |
| | Bagrus docmac | Female | 38 | -1.87 | 3.06 | 0.09 | 0.99 |
| | " " | Male | 31 | -1.86 | 3.06 | 0.14 | 0.98 |
| Mochokidae | Synodontis schall | Female | 150 | -1.70 | 3.11 | 0.39 | 0.83 |
| | " " | Male | 111 | -1.79 | 3.17 | 0.15 | 0.99 |

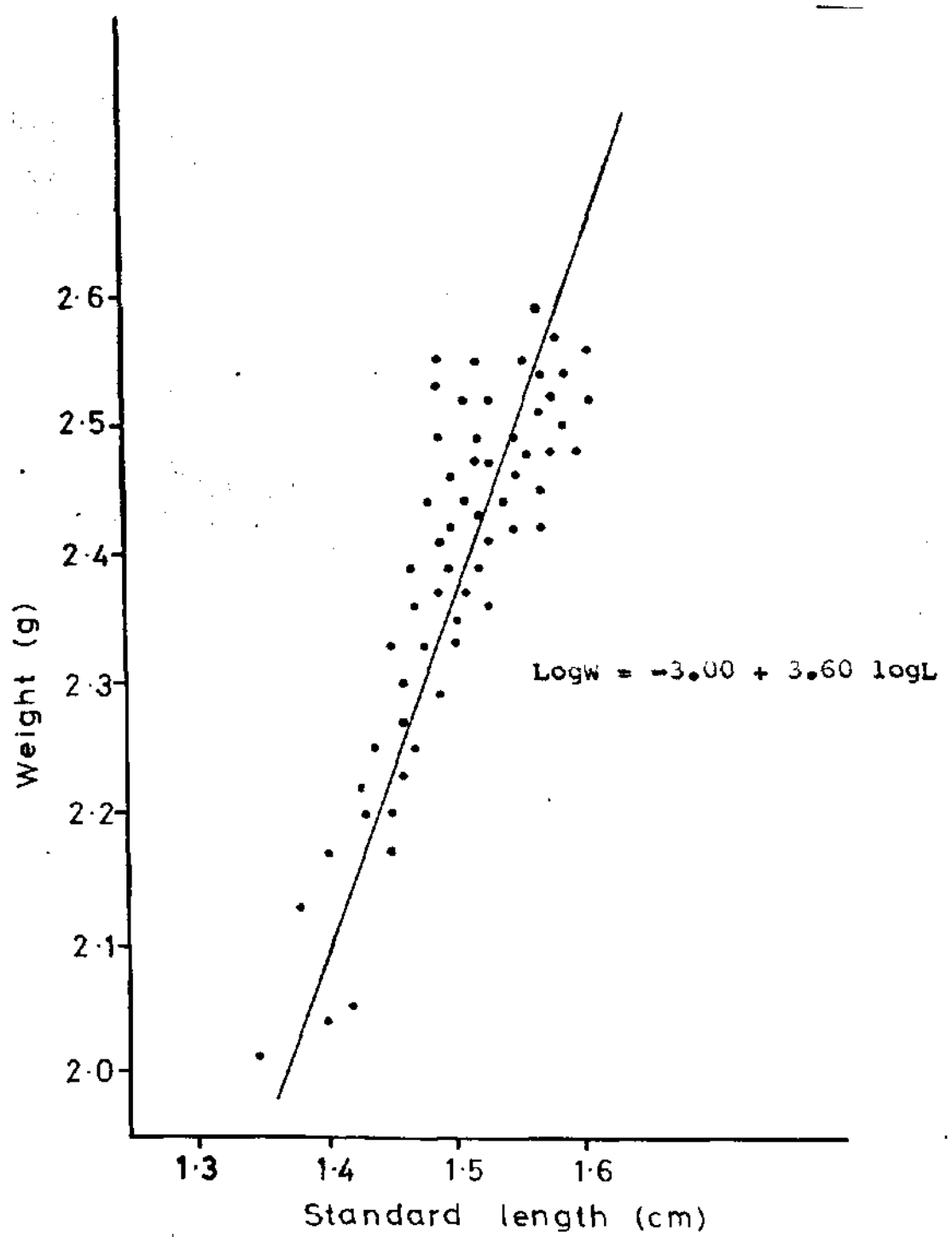



Fig. 31 Length/Weight relationship (log-log) of female Hyperopisus bebe

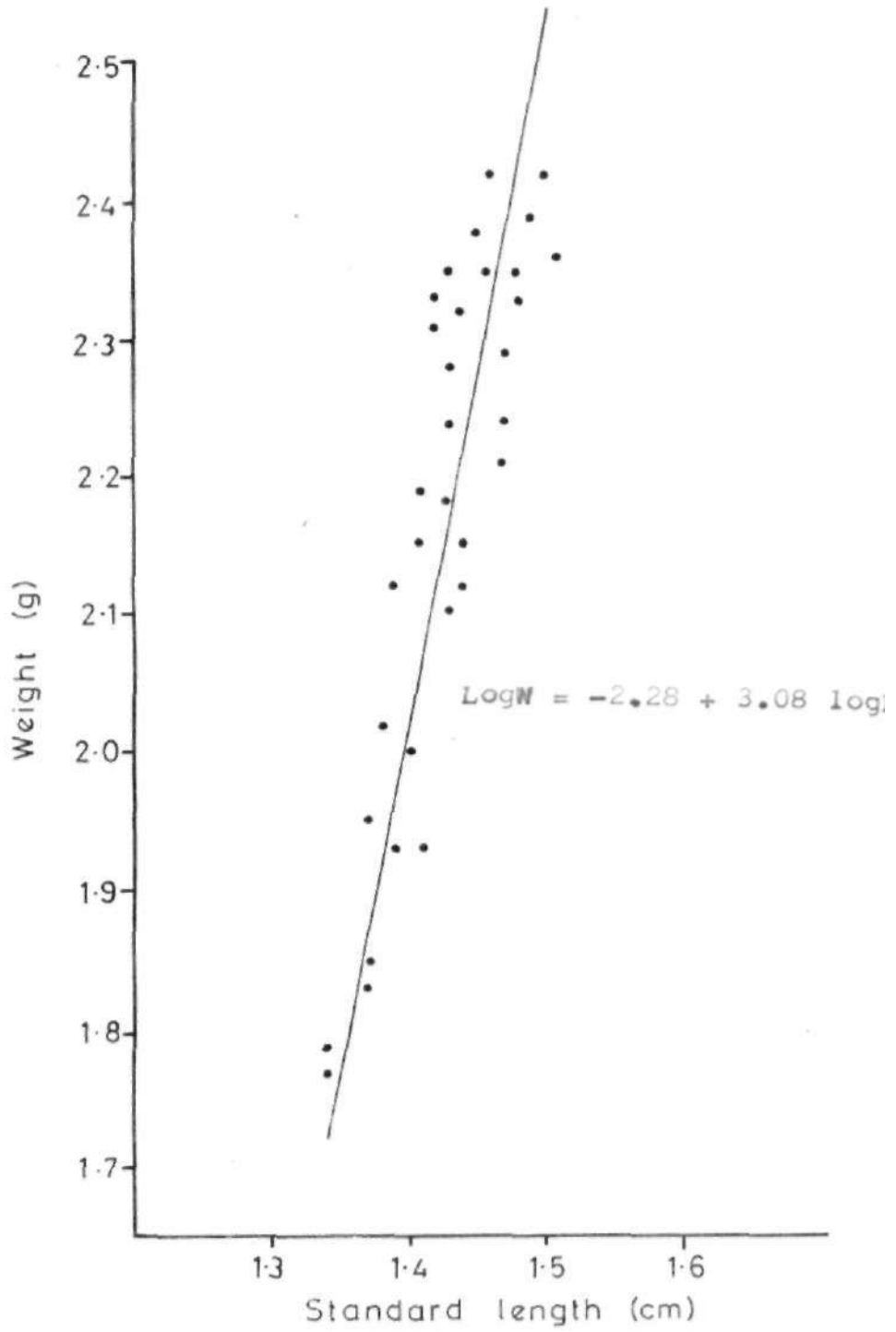



Fig. 32 Length/Weight relationship (log-lo
of male Hyperopisus bebe

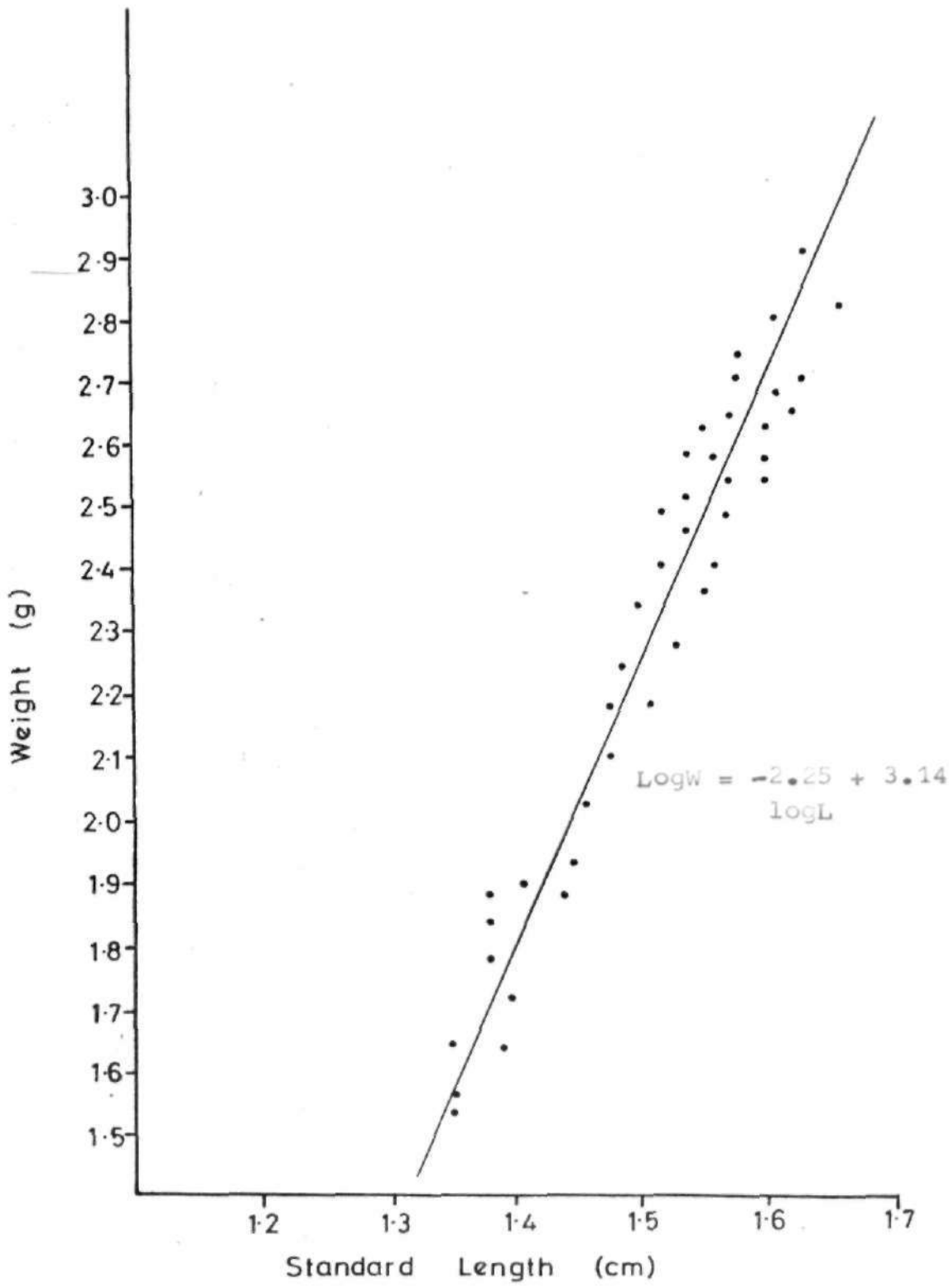



Fig. 33 Length/Weight relationship (log-log) of female Mormyrus rume

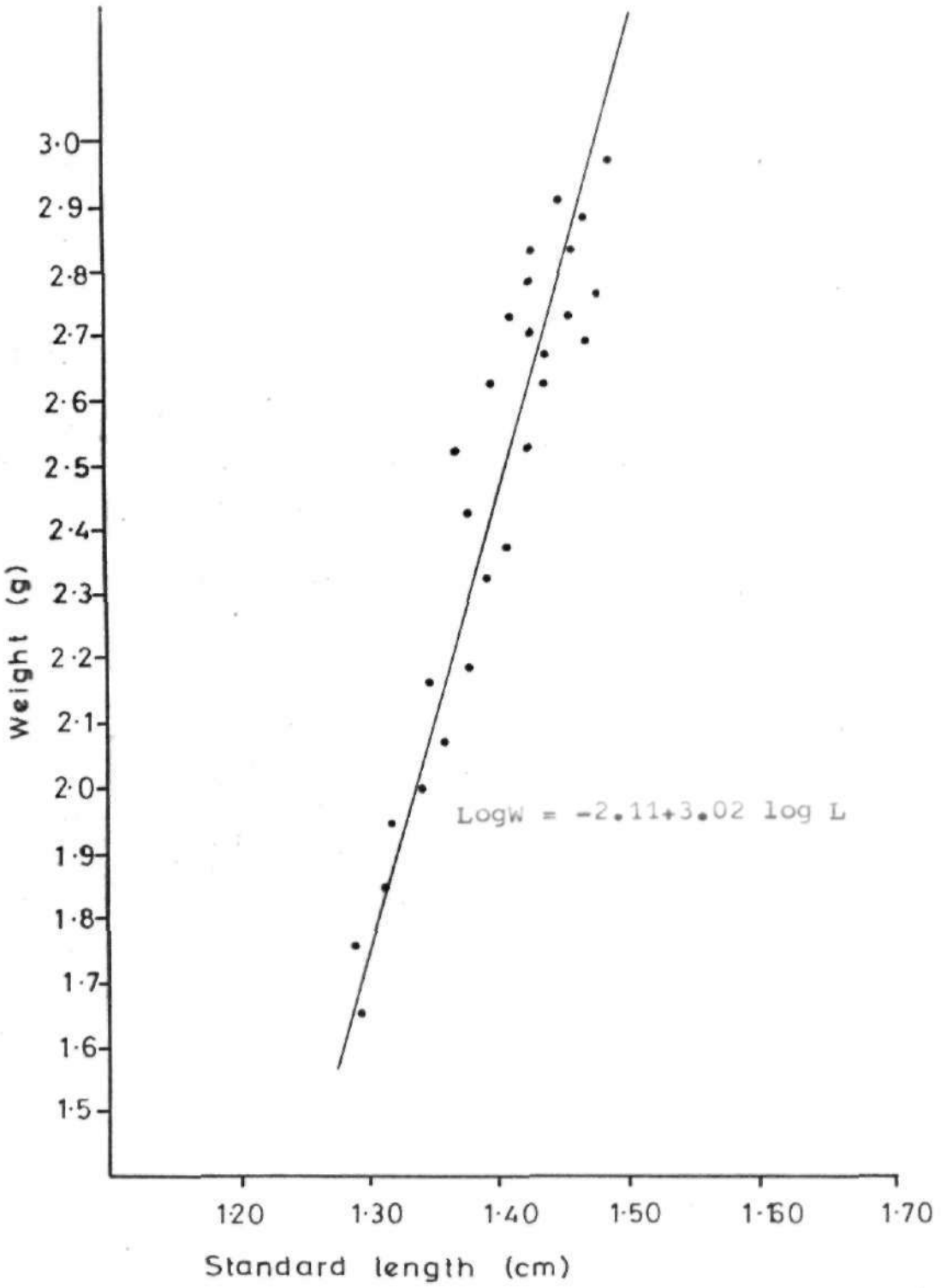



Fig. 34 Length/Weight relationship (log-log) of male Mormyrus rume

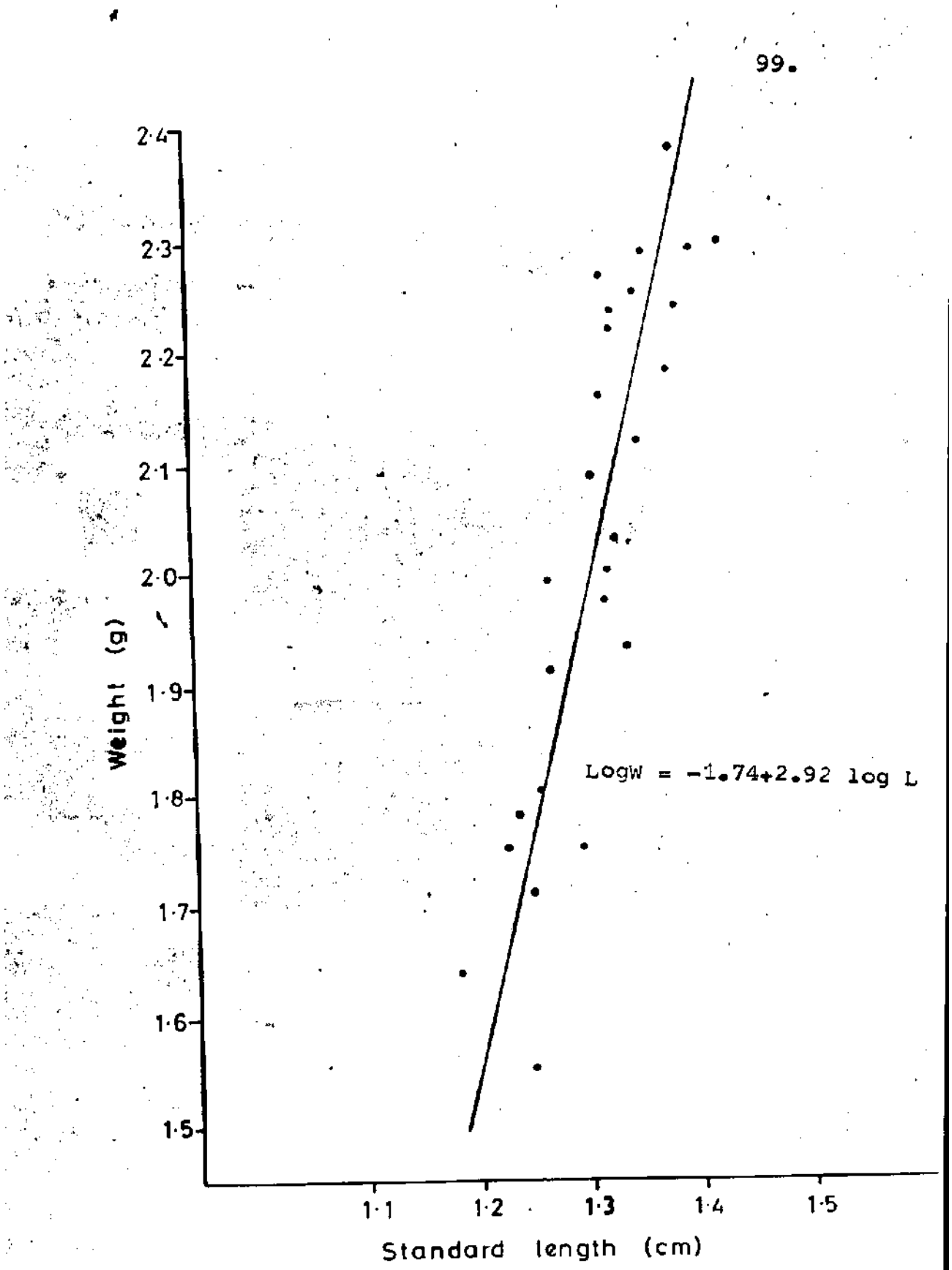



Fig. 35 Length/Weight relationship (log-log) of female Hippopotmyrus pictus

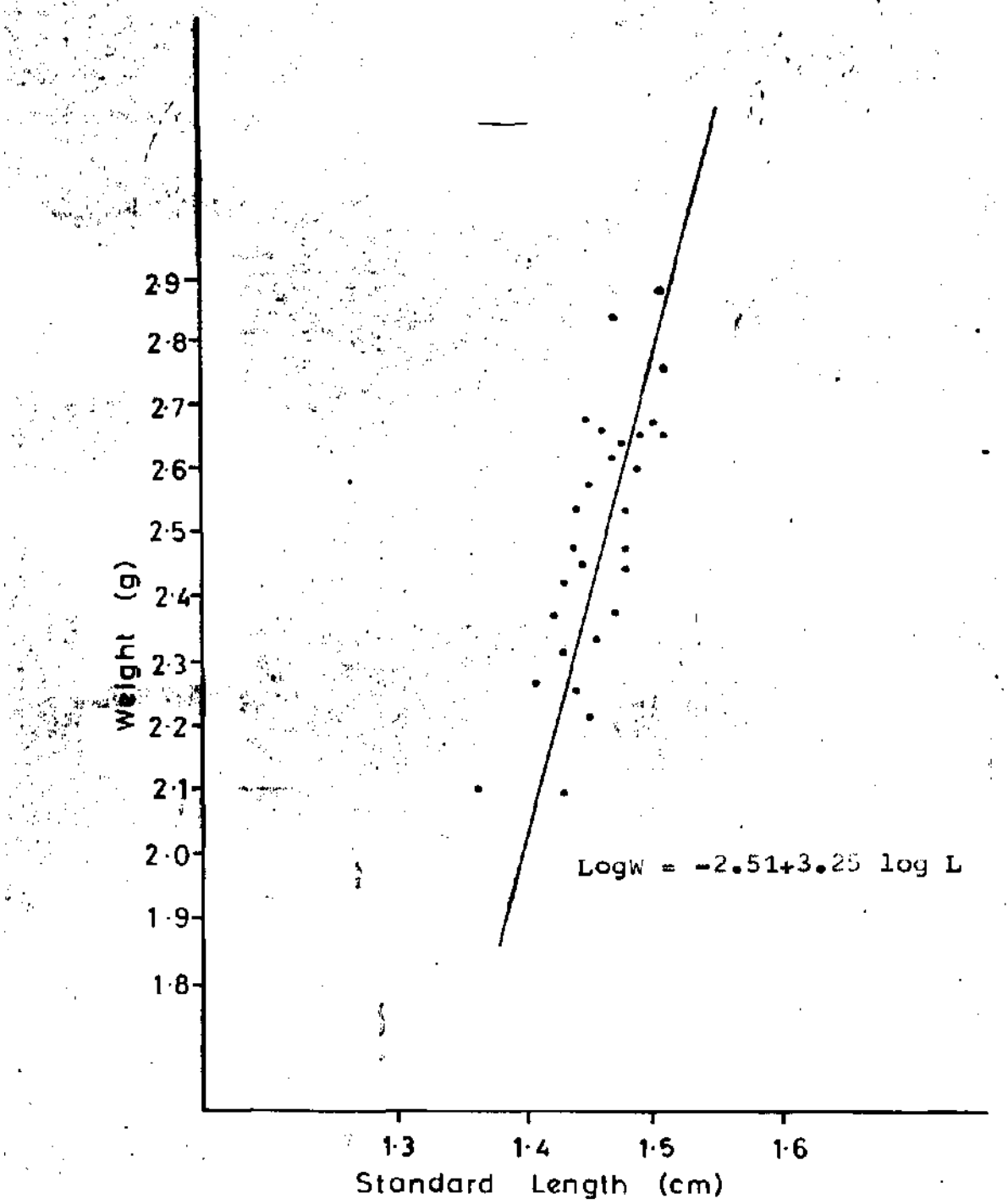



Fig. 36 Length/Weight relationship (log-log) of female Mormyrops deliciosus

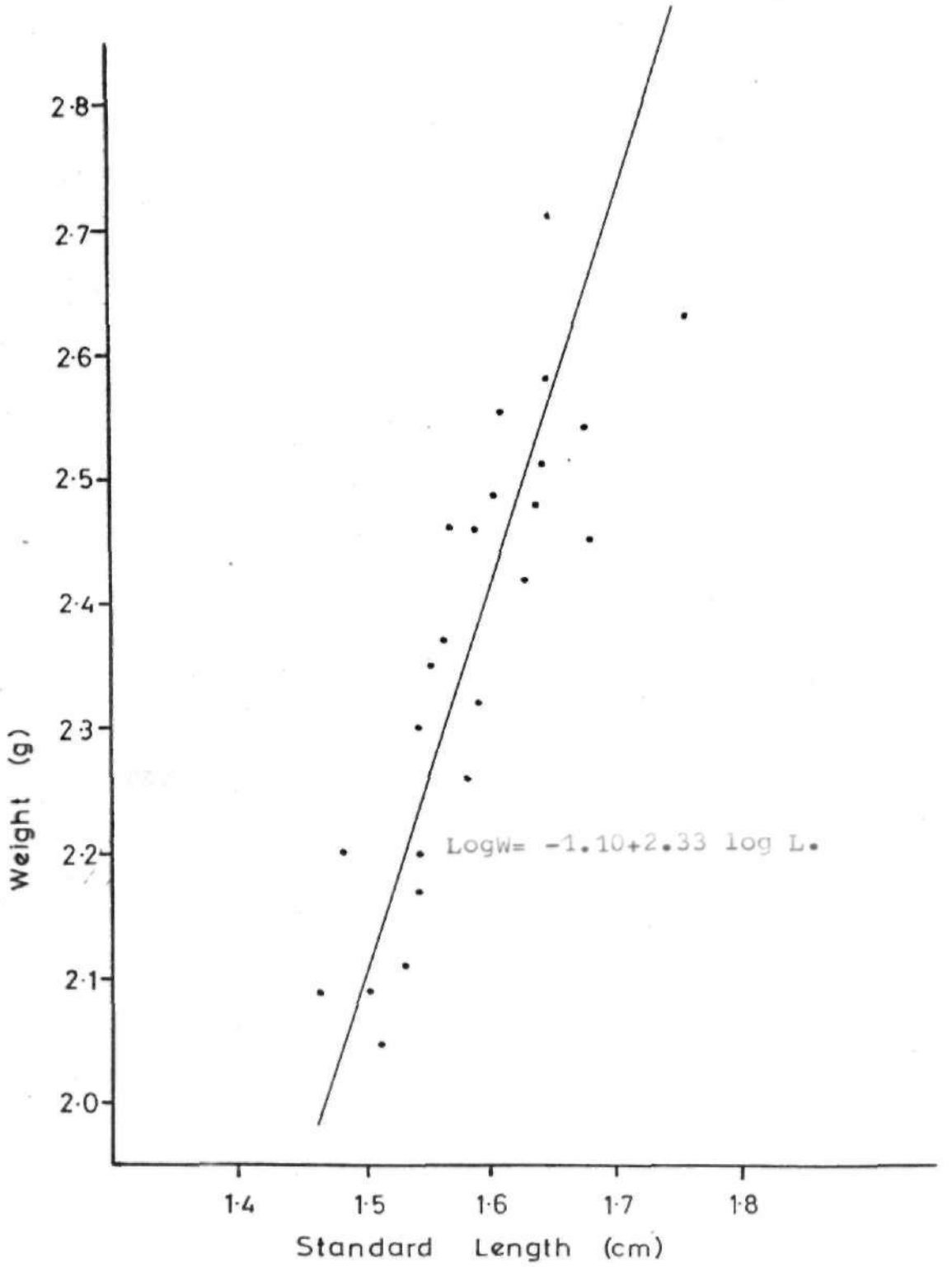



Fig. 37 Length/Weight relationship (log-log) of male Mormyrops deliciosus

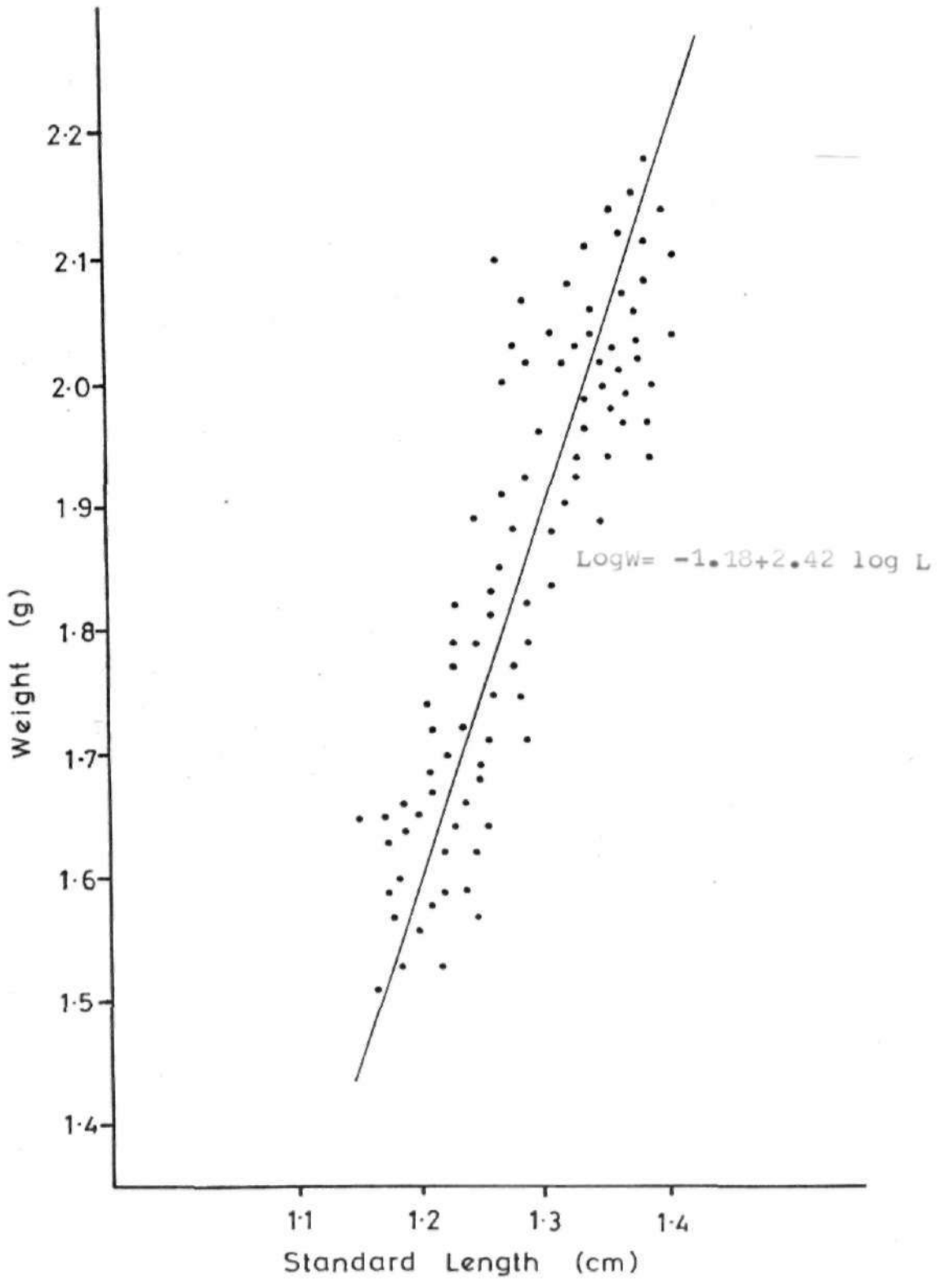



Fig. 38 Length/Weight relationship (log-log) of female Marcusenius senegalensis

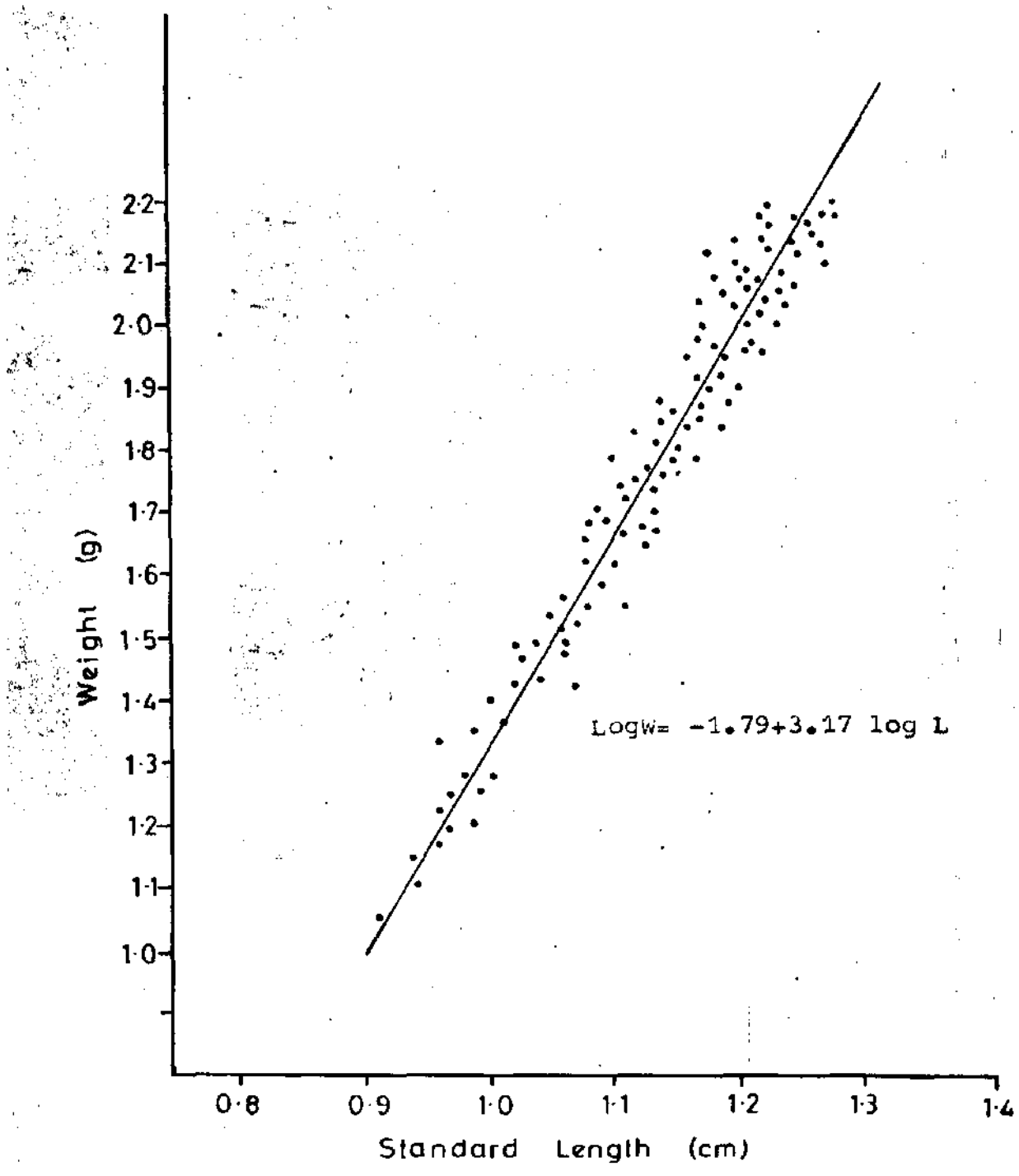



Fig. 39 Length/Weight relationship (log-log) of male Synodontis schall

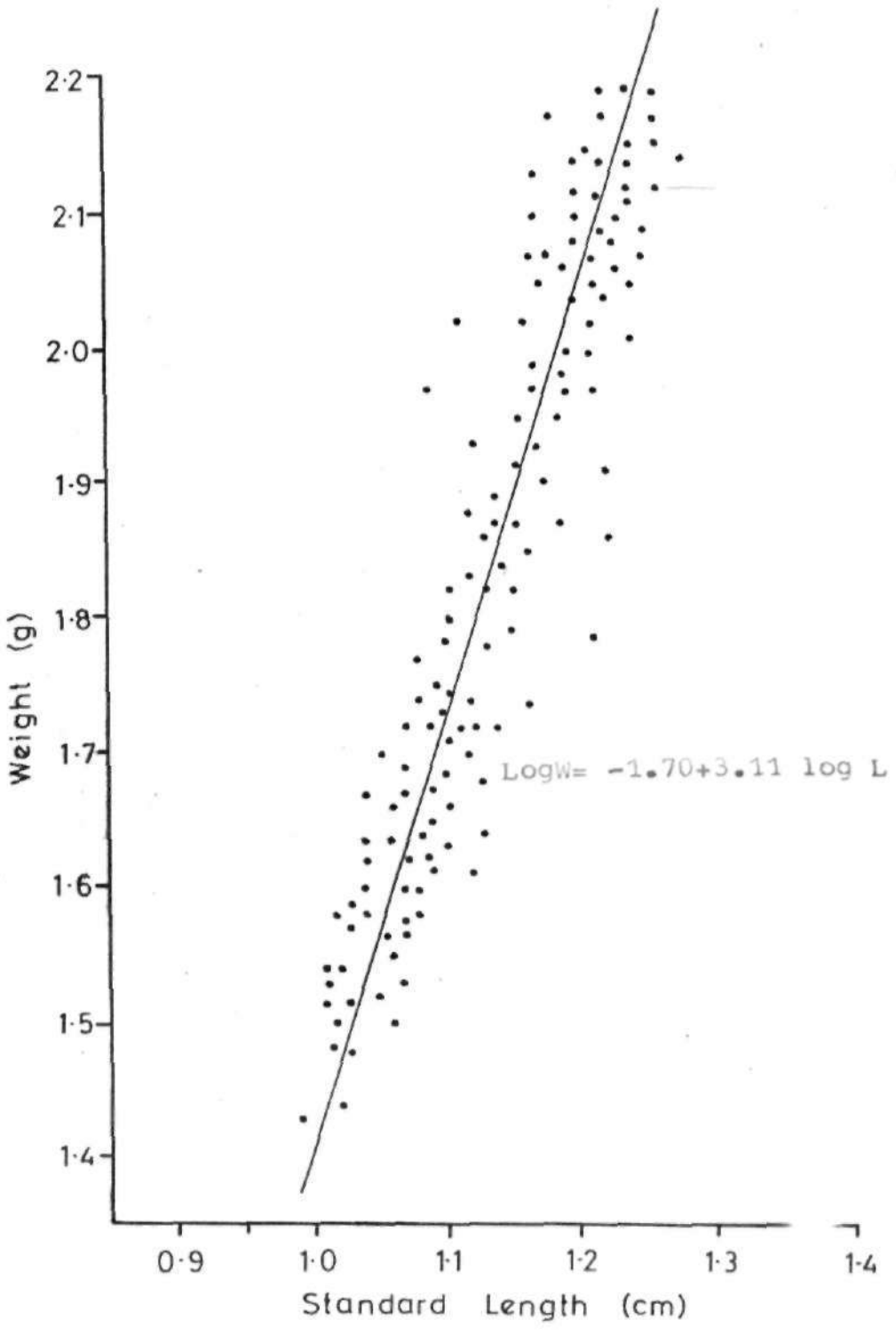



Fig. 40 Length/Weight relationship (log-log) of female Synodontis schall

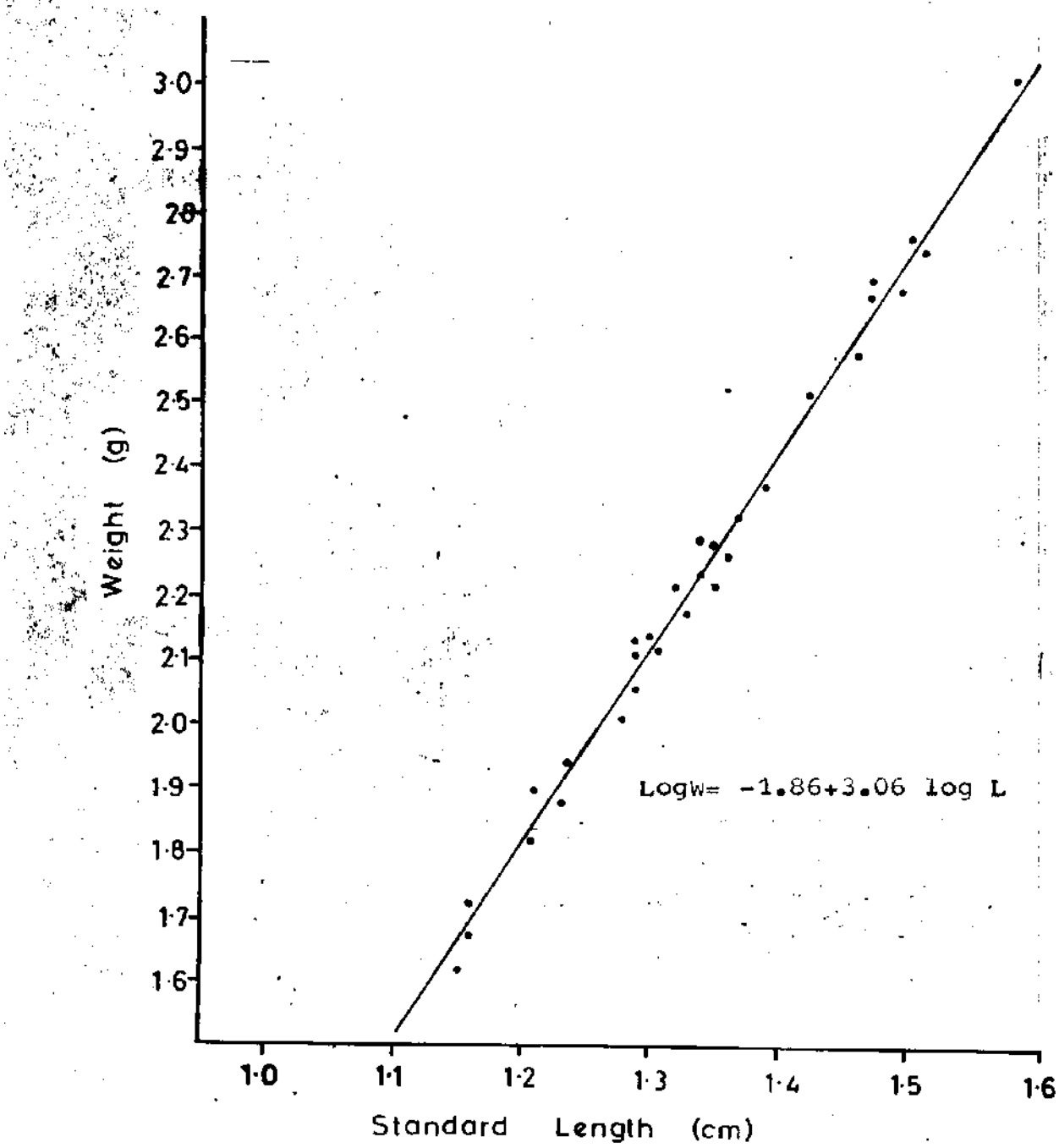



Fig. 41 Length/Weight relationship (log-log) of male Bagrus docmac

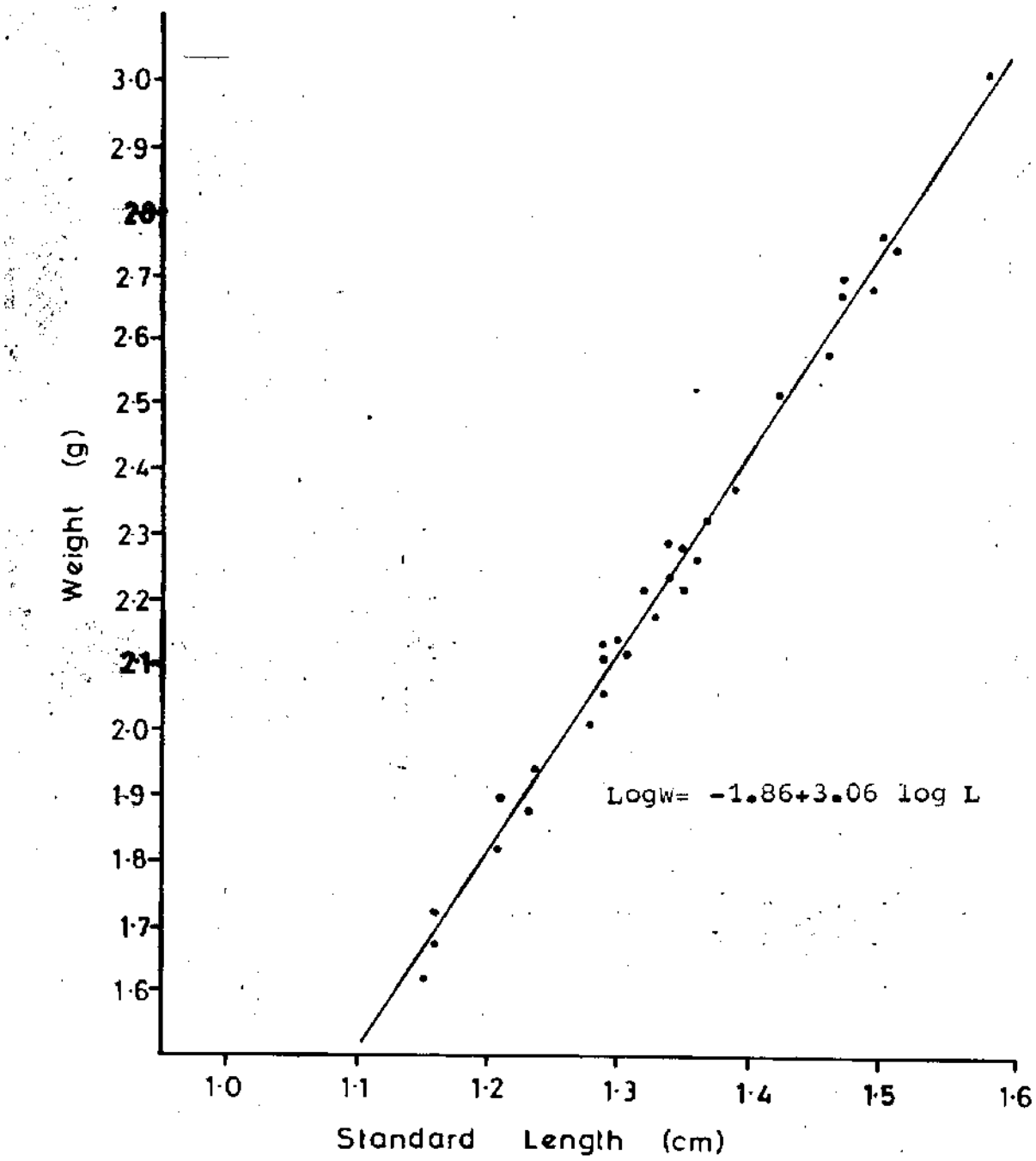



Fig. 41 Length/Weight relationship (log-log) of male Bagrus docmac

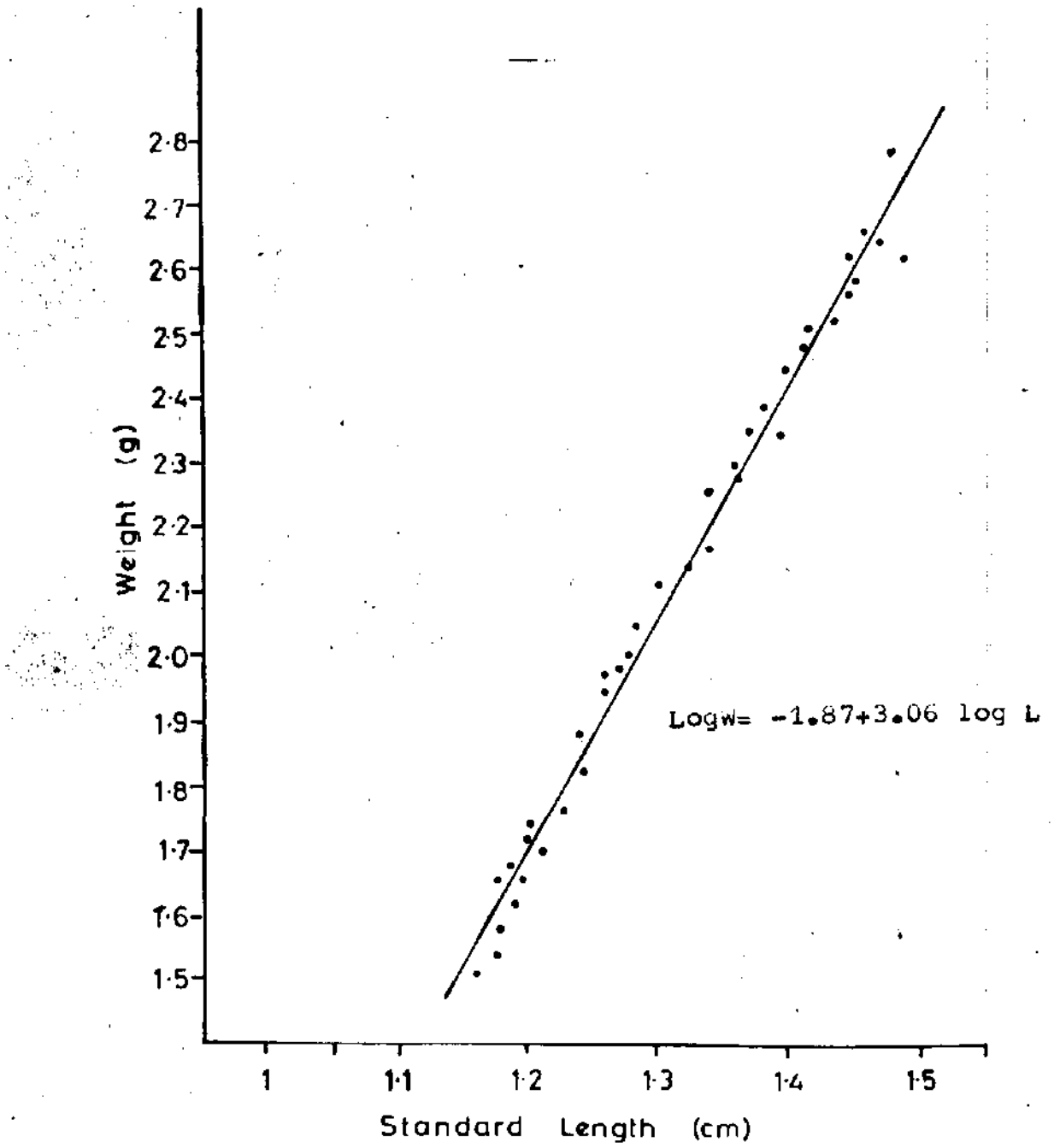



Fig. 42 Length / Weight relationship (log-log) of female Bagrus docmac

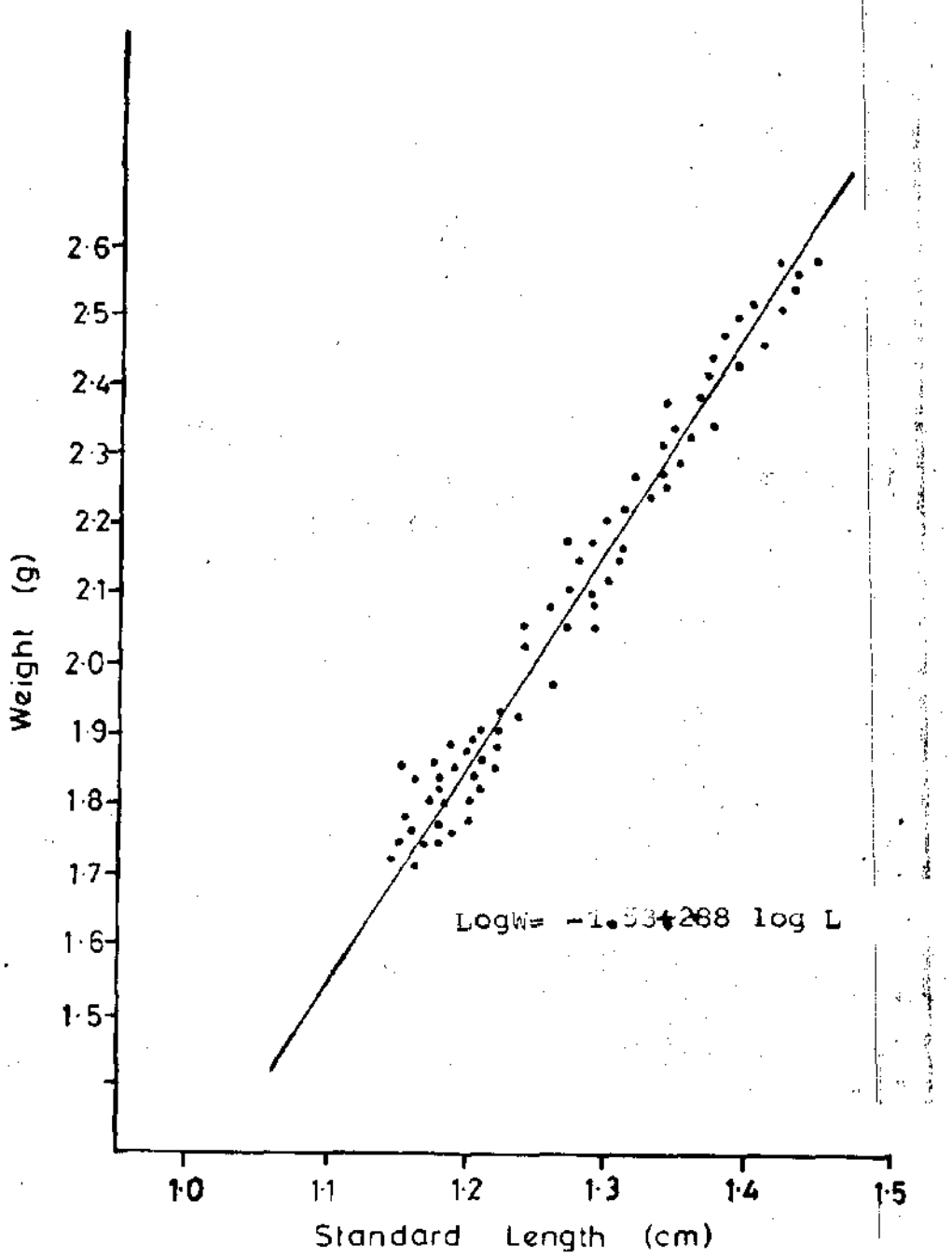



Fig. 43 Length/Weight relationship (log-log) of female Auchenoglanis occidentalis

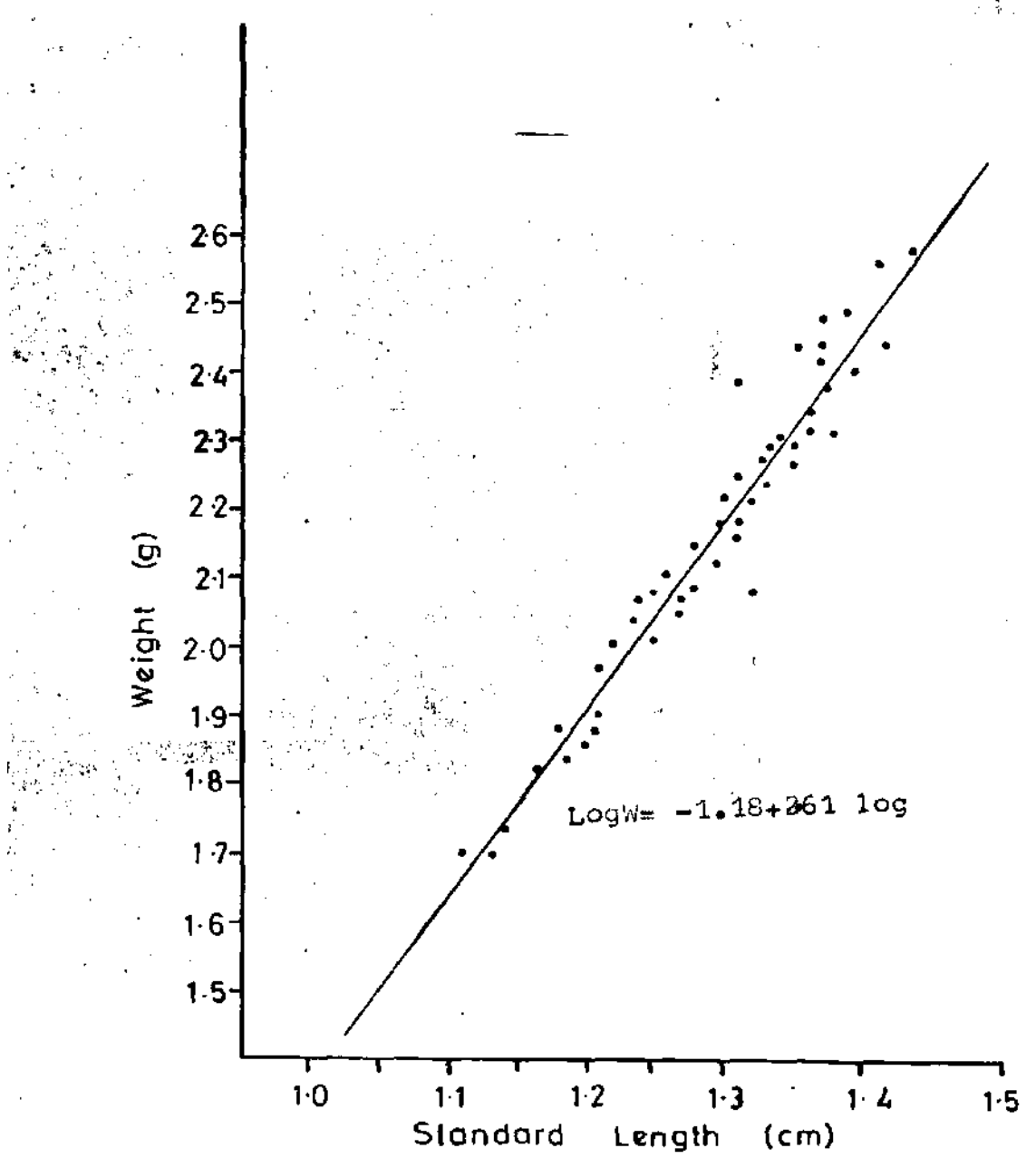



Fig. 44 Length/Weight relationship (log-log) of male Auchenoglanis occidentalis

## III.C. SEX RATIO, REPRODUCTIVE CYCLE AND FECUNDITY.

### III.C.1 SEX RATIO.

Table 13, shows the sex ratio of the species found in the three families under investigation. In the mormyrid species, there were fewer males than females. This preponderance of female over male was most emphasized in *Petrocephalus bovei*. The very small size of this species could be a limiting factor in the identification of the male sex. The sex ratio for the species like *H. psittatus* and *P. isidori*, may not be very reliable as the observable number of specimens were small.

In the Bagridae, only two specimens of *C. nigrodigitatus* were available and both were males. 67 specimens of *B. docmac* had recognizable gonad. Of these, 37 were females and 30 males. This gives a sex ratio of 1 male to 1.2 female. In *A. auchenoglanis*, 124 specimens showed a sex ratio of 1 male to 1.5 female.

*Synodontis schall* a mochokid, had observable gonad in 260 specimens. This sizable population, gave a sex ratio of 1 male to 1.4 female.

Table 13. Sex ratio of Mormyridae, Bagridae and Mochokidae species in Zaria area.

| Family | Species | Total number with recognizable gonads | Number of Male | Number of Female | Sex ratio M : F |
|---|---|---|---|---|---|
| Mormyridae | Mormyrops deliciosus | 53 | 23 | 30 | 1 : 1.3 |
| | Hyperopisus bebe | 98 | 33 | 65 | 1 : 2 |
| | Mormyrus rume | 72 | 28 | 44 | 1 : 1.6 |
| | Marcusenius senegalensis | 115 | 5 | 110 | 1 : 22 |
| | Hippopotamyrus pictus | 27 | 0 | 27 | 0 : 27 |
| | Hippopotamyrus psittacus | 3 | 0 | 3 | 0 : 3 |
| | Petrocephalus bovei | 78 | 0 | 70 | 0 : 78 |
| | Pollimyrus isidori | 5 | 0 | 5 | 0 : 5 |
| Bagridae | Auchenoglanis occidentalis | 124 | 49 | 75 | 1 : 1.5 |
| | Bagrus docmac | 67 | 30 | 37 | 1 : 1.2 |
| | Chrysichthys nigrodigitatus | 2 | 2 | 0 | 2 : 0 |
| Mochokidae | Synodontis schall | 261 | 110 | 150 | 1 : 1.4 |

III.C.2. REPRODUCTIVE CYCLE

a. Reproductive cycle in mormyrids.

Out of the eight species of this family, five were found to have matured gonads (stage iv) during the period of investigation. These were P. bovei, H. pictus, M. rume, M. senegalensis and H. bebe.

Table 14, shows that 28 female specimens of P. bovei with fully matured gonads were found from the month of June to August. Although, fishes with running gonad (stage v) were not seen, fishes with spent gonad (stage vi) were noticed in November. This seems to show that this species spawned between the months of June and October.

Four female H. pictus (Table 15) were found with fully matured gonads between August and September. Some female fishes with spent gonads were observed in October and November. This gives a clue that this species may be spawning between August and November, although no fish with running gonad was identified.

Table 16 shows that four female specimens of M. rume were carrying fully matured gonads during the study. These fully matured gonads were found between the months of July and August. Only one spent gonad was noticed in the month of October. This species probably may be spawning between the months of July and October. No fully matured male gonad was noticed in this species, although four males with stage III gonads were found in August.

The specimens / of H. bebe observed with various maturity stages of gonads are as seen in Table 17. This table shows that females with fully matured gonads were found between June and September. In the months of August and September, three male specimens were found with matured gonads (stage III).

M. senegalensis had thirty females with fully matured gonads as shown on Table 18. These were noticed as from June to September. Although, no female gonad in running stage was observed, eight females with spent gonads were found in the months of September to November. In the month of September, two males with fully matured gonads were noticed in the samples.

Table 19, shows that no fully matured gonad of either sex was seen in M. deliciosus. In any case, female matured gonads were seen in the months of July, August and October. Females with spent gonads were seen in October and November. It appears, that this species may be spawning between the months of August and November.

b. Reproductive cycle in mochokid.

Table 20, shows the gonad maturity stages of S. schall. Thirty-six females with fully matured gonads were seen in the months of July to September. Twenty-six males with fully matured gonads were noticed at these particular months. The presence of six female specimens with running gonads in August and September, goes to confirm that this species spawned

between the months of July and September. The female spent gonads were seen as from September to December, while the male spent gonads were noticed in September and October.

c. Reproductive cycle in bagrids.

Two female A. occidentalis were found to have fully matured gonads as shown in table 21. Boths specimens were seen in the months of July and August respectively. Two males with fully matured gonads were noticed in both months. There were no running and spent gonads in the specimens.

Table 22, shows that no specimen of both sexes was found to have gonad of stages III to VI, in B. docmac. Almost all the specimens were in stage II. It was in the month of October, that three females specimens were noticed to be in stage I. This seems to show that this species must have spawns before this time.

Table 14. Monthly occurrence of different stages of gonad in specimens of Petrocephalus bovei.

| Months | Sex | I | II | III | IV | V | VI | Total examined |
|---|---|---|---|---|---|---|---|---|
| June | F | - | 6 | 2 | 2 | - | - | 10 |
| | M | - | - | - | - | - | - | 0 |
| July | F | - | 2 | 19 | 9 | - | - | 30 |
| | M | - | - | - | - | - | - | 0 |
| August | F | - | 3 | 1 | 17 | - | 4 | 24 |
| | M | - | - | - | - | - | - | 0 |
| September | F | - | 6 | - | - | - | 2 | 8 |
| | M | - | - | - | - | - | - | 0 |
| October | F | - | - | - | - | - | - | 0 |
| | M | - | - | - | - | - | - | 0 |
| November | F | - | - | - | - | - | 6 | 6 |
| | M | - | - | - | - | - | - | 0 |
| December | F | - | - | - | - | - | - | 0 |
| | M | - | - | - | - | - | - | 0 |

Table 15. Monthly occurrence of different stages of gonad in specimens of Hippopotamyrus pictus

| Months | Sex | I | II | III | IV | V | VI | Total examined |
|---|---|---|---|---|---|---|---|---|
| June | F | - | 2 | 1 | - | - | - | 3 |
| | M | - | - | - | - | - | - | 0 |
| July | F | - | 2 | - | - | - | - | 2 |
| | M | - | - | - | - | - | - | 0 |
| August | F | - | 2 | - | 3 | - | - | 5 |
| | M | - | - | - | - | - | - | 0 |
| September | F | - | 4 | - | 1 | - | - | 5 |
| | M | - | - | - | - | - | - | 0 |
| October | F | 1 | 3 | - | - | - | 2 | 6 |
| | M | - | - | - | - | - | - | 0 |
| November | F | - | 2 | - | - | - | 2 | 4 |
| | M | - | - | - | - | - | - | 0 |
| December | F | - | 2 | - | - | - | - | 2 |
| | M | - | - | - | - | - | - | 0 |

Table 15. Monthly occurrence of different stages of gonad in specimens of Mormyrus rume.

| Months | Sex | I | II | III | IV | V | VI | Total examined |
|---|---|---|---|---|---|---|---|---|
| June | F | - | 3 | - | - | - | - | 3 |
| | M | - | 2 | 1 | - | - | - | 3 |
| July | F | - | 2 | - | 3 | - | - | 5 |
| | M | - | 4 | 1 | - | - | - | 5 |
| August | F | - | 3 | - | 1 | - | - | 4 |
| | M | - | 2 | 4 | - | - | - | 6 |
| September | F | - | 5 | 2 | - | - | - | 7 |
| | M | - | - | - | - | - | - | 0 |
| October | F | 3 | 10 | - | - | - | 1 | 14 |
| | M | 1 | 3 | - | - | - | - | 4 |
| November | F | - | 7 | - | - | - | - | 7 |
| | M | - | 6 | - | - | - | - | 6 |
| December | F | - | 4 | - | - | - | - | 4 |
| | M | - | 4 | - | - | - | - | 4 |

Table 17. Monthly occurrence of different stages of gonad in specimens of Hyperopisus bebe.

| Months | Sex | I | II | III | IV | V | VI | Total examined |
|---|---|---|---|---|---|---|---|---|
| June | F | - | 4 | - | 1 | - | - | 5 |
| | M | - | 4 | 1 | - | - | - | 5 |
| July | F | - | 6 | 2 | 1 | - | - | 9 |
| | M | - | 5 | - | - | - | - | 5 |
| August | F | - | 5 | 2 | 3 | - | - | 10 |
| | M | - | 2 | 2 | - | - | - | 4 |
| September | F | 3 | 6 | 1 | 1 | - | - | 11 |
| | M | - | 2 | 1 | - | - | - | 3 |
| October | F | - | 15 | - | - | - | - | 15 |
| | M | - | 6 | - | - | - | - | 6 |
| November | F | - | 8 | - | - | - | - | 8 |
| | M | - | 9 | - | - | - | - | 9 |
| December | F | - | 6 | - | - | - | 1 | 7 |
| | M | - | 1 | - | - | - | - | 1 |

Table 18. Monthly occurrence of different stages of gonad in specimens of Marcusenius senegalensis.

| Months | Sex | I | II | III | IV | V | VI | Total examined |
|---|---|---|---|---|---|---|---|---|
| June | F | - | 5 | - | 4 | - | - | 9 |
| | M | - | - | - | - | - | - | 0 |
| July | F | - | 14 | 3 | 10 | - | - | 27 |
| | M | - | - | - | - | - | - | 0 |
| August | F | - | 8 | 2 | 5 | - | - | 15 |
| | M | - | - | - | - | - | - | 0 |
| September | F | - | 9 | 4 | 9 | - | 6 | 28 |
| | M | - | 1 | 1 | 2 | - | - | 3 |
| October | F | 2 | 16 | - | - | - | 2 | 20 |
| | M | - | - | - | - | - | - | 0 |
| November | F | - | 5 | - | - | - | 2 | 7 |
| | M | - | 1 | - | - | - | - | 1 |
| December | F | - | 4 | - | - | - | - | 4 |
| | M | - | 1 | - | - | - | - | 1 |

Table 19. Monthly occurrence of different stages of gonad in specimens of Mormyrops deliciosus

| Months | Sex | I | II | III | IV | V | VI | Total examined |
|---|---|---|---|---|---|---|---|---|
| June | F | - | 2 | - | - | - | - | 2 |
| | M | - | - | - | - | - | - | 0 |
| July | F | - | 3 | 1 | - | - | - | 4 |
| | M | - | 2 | - | - | - | - | 2 |
| August | F | - | 3 | 1 | - | - | - | 4 |
| | M | - | 5 | - | - | - | - | 5 |
| September | F | - | 4 | - | - | - | - | 4 |
| | M | - | 7 | - | - | - | - | 7 |
| October | F | - | 7 | 1 | - | - | 1 | 9 |
| | M | - | 2 | - | - | - | - | 2 |
| November | F | - | 4 | - | - | - | 1 | 5 |
| | M | - | 5 | - | - | - | - | 5 |
| December | F | - | 2 | - | - | - | - | 2 |
| | M | - | 2 | - | - | - | - | 2 |

Table 20. Monthly occurrence of different stages of gonad in specimens of Synodontis schall.

| Months | Sex | I | II | III | IV | V | VI | Total examined |
|---|---|---|---|---|---|---|---|---|
| June | F | - | 7 | 27 | - | - | - | 34 |
| | M | - | 8 | 7 | - | - | - | 15 |
| July | F | - | 1 | 14 | 14 | - | - | 29 |
| | M | - | - | 4 | 1 | - | - | 5 |
| August | F | - | 2 | 3 | 20 | 5 | - | 30 |
| | M | - | - | 10 | 23 | - | - | 33 |
| September | F | 1 | 9 | - | 2 | 1 | 14 | 27 |
| | M | - | 6 | 1 | 2 | - | 9 | 18 |
| October | F | [illegible] | 4 | - | - | - | 10 | 18 |
| | M | - | 11 | - | - | - | 7 | 18 |
| November | F | - | 6 | - | - | - | 3 | 9 |
| | M | - | 17 | - | - | - | - | 17 |
| December | F | - | 2 | - | - | - | 1 | 3 |
| | M | - | 4 | - | - | - | - | 4 |

Table 21. Monthly occurrence of different stages of gonad in specimens of Auchenoglanis occidentalis.

| Months | Sex | I | II | III | IV | V | VI | Total examined |
|---|---|---|---|---|---|---|---|---|
| June | F | - | 3 | 2 | - | - | - | 5 |
| | M | - | 1 | 1 | - | - | - | 2 |
| July | F | - | 3 | 7 | 1 | - | - | 11 |
| | M | - | 2 | 6 | 1 | - | - | 9 |
| August | F | - | 6 | - | 1 | - | - | 7 |
| | M | - | 6 | 5 | 1 | - | - | 12 |
| September | F | 1 | 19 | - | - | - | - | 20 |
| | M | - | 6 | - | - | - | - | 6 |
| October | F | 4 | 16 | - | - | - | - | 20 |
| | M | 2 | 6 | - | - | - | - | 8 |
| November | F | - | 8 | - | - | - | - | 8 |
| | M | - | 8 | - | - | - | - | 8 |
| December | F | - | 4 | - | - | - | - | 4 |
| | M | - | 4 | - | - | - | - | 4 |

Table 22. Monthly occurrence of different stages of gonad in species of Bagrus docmac.

| Months | Sex | I | II | III | IV | V | VI | Total examined |
|---|---|---|---|---|---|---|---|---|
| June | F | - | 2 | - | - | - | - | 2 |
| | M | - | 1 | - | - | - | - | 1 |
| July | F | - | 2 | - | - | - | - | 2 |
| | M | - | 2 | - | - | - | - | 2 |
| August | F | - | 4 | - | - | - | - | 4 |
| | M | - | 3 | - | - | - | - | 3 |
| September | F | - | 5 | - | - | - | - | 5 |
| | M | - | 5 | - | - | - | - | 5 |
| October | F | 3 | 10 | - | - | - | - | 13 |
| | M | - | 6 | - | - | - | - | 6 |
| November | F | - | 9 | - | - | - | - | 9 |
| | M | - | 10 | - | - | - | - | 10 |
| December | F | - | 2 | - | - | - | - | 2 |
| | M | - | 3 | - | - | - | - | 3 |

III.C.3. FECUNDITY

a. Fecundity of mormyrids.

Table 23, shows that the estimated fecundity for P. bovei, ranged from 886 to 2032 with a mean of 1529 ± 311. The number of eggs of P. bovei, was plotted against the standard length and weight of the fish (Fig.45). Typical results of fecundity investigation, have shown that it is approximately proportional to the cube of the length or linearly proportional to the weight of the fish (Bagenal, 1971). The graph of egg number against length, showed no exact relationship (Fig. 45), while that of egg number against weight gives impression of a linear relationship in the scatter diagram. Table 23, shows the mean fecundities of H. pictus M. rume and H. bebe to be 2036 ± 786, 2690 ± 843 and 4862 ± 2036 respectively. A graphical interpretation was not done for fecundity estimates of H. pictus, M. rume and H. bebe, because the available number of specimens carrying fully matured gonads for these species were very few.

A relatively sizeable number of specimens were found to be carrying fully matured ovary in M. senegalensis as shown in Table 23. It was therefore, possible to compare fecundity with length and weight of this species. The mean fecundity estimate for this species was found to be 4261 ± 2585. The arithmetic plot of fecundity of M. senegalensis against standard length as shown in Fig. 46, gives impression of a curve and fecundity against length suggests a linear association.

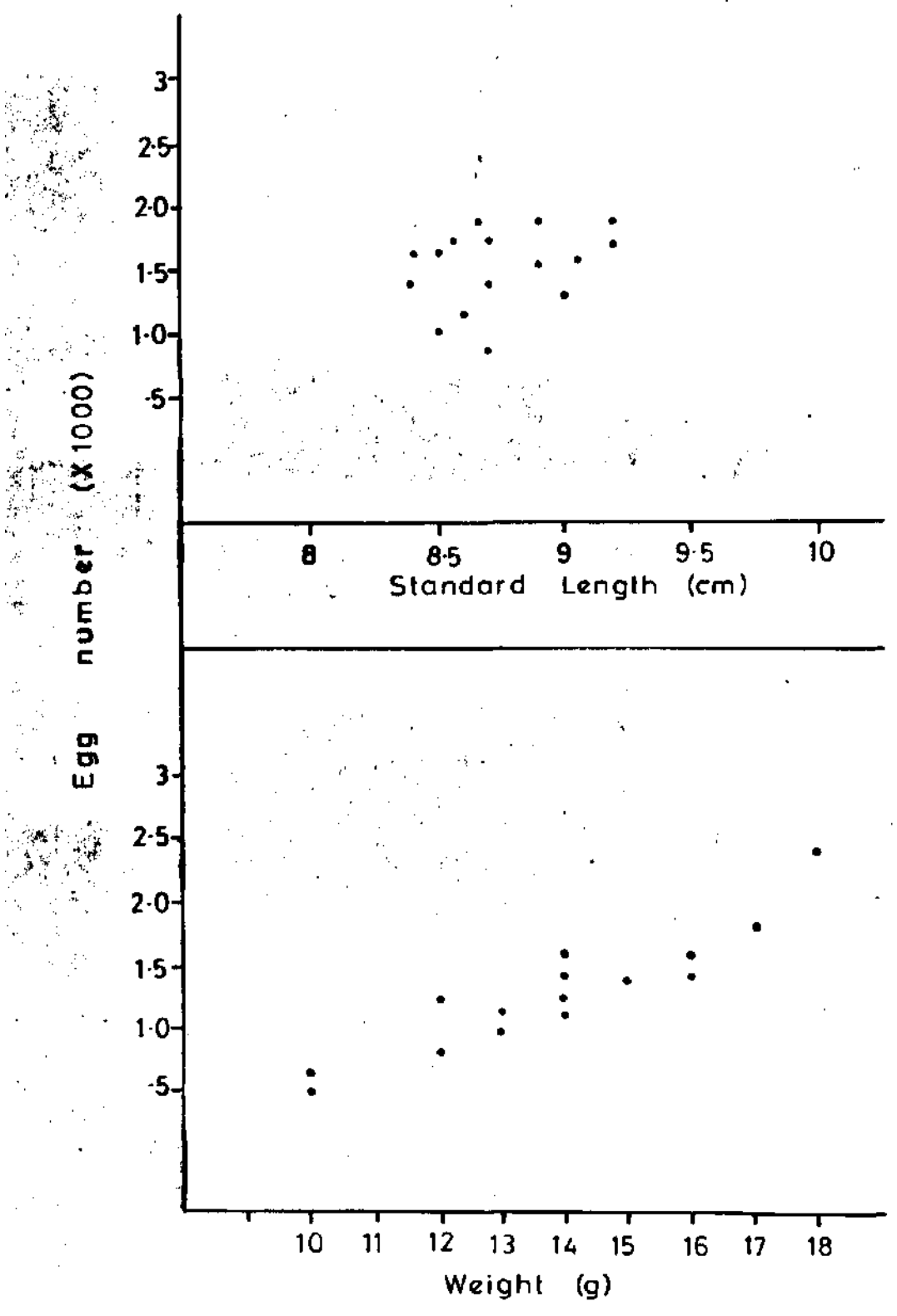



Fig. 45 Relationship of Fecundity estimate to weight and length of fish (Petrocephalus bovei)

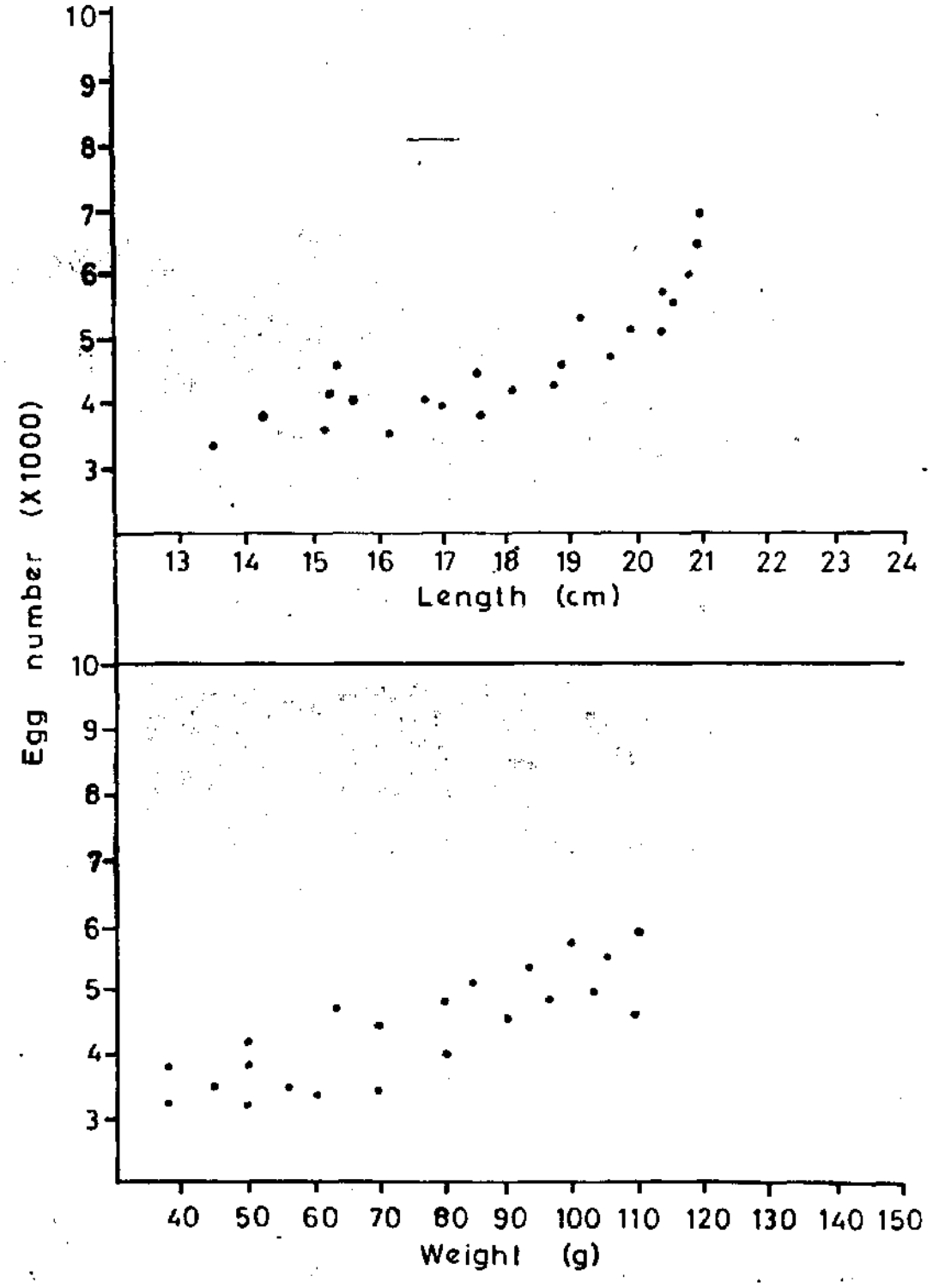



Fig. 46 Relationship of fecundity estimate to weight and length of fish (Marcusenius senegalensis.)

b. Fecundity of mochokid.

Table 23, shows the fecundity of Synodontis schall which ranges from 2,014 to 13262. Thirty specimens were available for fecundity estimation. A specimen of standard length 8.4cm carried 2014 eggs, while 13262 eggs was carried by fish of 18.2 standard length. The mean fecundity estimate for the thirty specimens was 6853 $\pm$ 2927. Fig. 47, represents the scatter diagram showing the relationship of fecundity with length and weight. In both graphs, it could be misleading to give it any particular relationship however, it appears to show an increase in fecundity with increase in length and weight.

c. Fecundity of a bagrid.

Only two specimens of A. auchenoglanis, were carrying fully matured ovary. As shown in Table 23, the fecundity of the two specimens were 1819 and 4195, which gives a mean estimate of 3007 $\pm$ 1188 eggs. A specimen of 23.0cm carried 1819 eggs, while a fish of 24.6 cm standard length contained 4195 eggs.

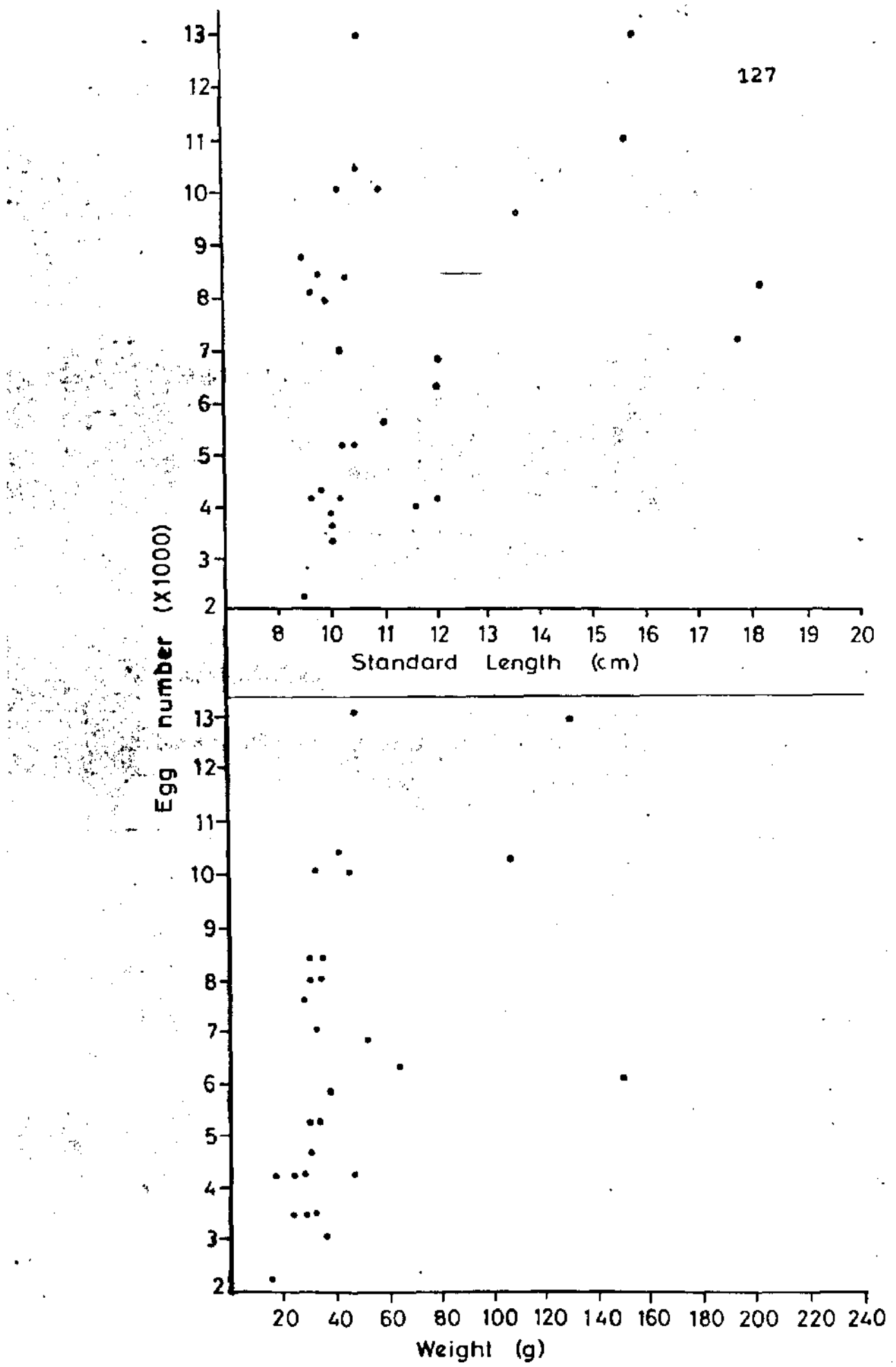



Fig. 47 Relationship of fecundity estimate to weight and length of fish (Synodontis schall)

Table 23. The fecundity of the species of Mormyridae, Bagridae and Mochokidae in Zaria area.

| Families | Species | Number examined | Standard length(cm) | Range of fecundity estimate | Mean of fecundity estimate | Standard deviation |
|---|---|---|---|---|---|---|
| Mormyridae | Petrocephalus bovei | 16 | 8.2-9.2 | 886-2032 | 1529 | 311 |
| | Hippopotamyrus pictus | 4 | 17.5-18.6 | 725-2787 | 2036 | 786 |
| | Mormyrus rume | 4 | 29.2-37.3 | 1434-3661 | 2690 | 843 |
| | Hyperopisus bebe | 4 | 32.4-33.1 | 2608-8169 | 4862 | 2036 |
| | Marcusenius senegalensis | 28 | 13.5-21.1 | 264-13124 | 4261 | 2585 |
| Mochokidae | Synodontis schall | 30 | 8.4-18.2 | 2014-13262 | 6853 | 2927 |
| Bagridae | Auchenoglanis occidentalis | 2 | 23.0-24.6 | 1819-4195 | 3007 | 1188 |

# CHAPTER FOUR
## DISCUSSION

The available food determines the faunal composition of freshwater body, where other necessary conditions are present. This food, will be consumed by the organism, to provide energy for all its metabolic functions. Fishes like other organisms, can be classified as carnivores, herbivores omnivores depending on the nature of the food they take.

Table 24, shows that a common bond, binding all the species under investigation is their omnivorous habits.

As noted by Blake (1976) in Lake Kainji and Corbet (1961) in Lake Victoria, it is possible to group mormyrids into three trophic classes:

(a) in species in which insect nymphs and larvae play major role - Hippopotamyrus pictus, Mormyrids rume, Marcusenius senegalensis and Petrocephalus bovei.

(b) Species in which plant materials (mainly seeds) and molluscs are important - Hyperopisus bebe.

(c) Species which are piscivorous at least as adults - Mormyrops deliciosus. Table 24, shows that Zaria mormyrid species, fall into these neat categories.

The table, indicates that H. pictus was an insectivorous mormyrid in Zaria area. There exists some divergencies in the insect dietary items preferred by the species of the first class, although there are sometimes overlaps. When

Table 24. Comparative analysis of the food items found in the stomachs of Bagrid, Mormyrid and Mochokid fishes in Zarie area.

| FISH SPECIES | FOOD ITEMS (% TOTAL POINTS) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | BOTTOM DEPOSITS | INSECTA | CRUSTACEA | ARACHNIDA | MOLLUSCA | ANNELIDA | PLANT ORIGIN | FISH |
| Petrocephalus bovei | - | 91.3 | 3.0 | 0.4 | 0.1 | 1.3 | 2.9 | - |
| Mormyrus rume | 4.4 | 86.0 | 0.9 | 0.2 | 0.3 | 3.8 | 3.3 | - |
| Mormyrops deliciosus | 0.4 | 39.8 | 5.0 | - | - | - | 8.5 | 43.2 |
| Hyperopisus bebe | - | 15.3 | 11.3 | 0.4 | 24.1 | - | 46.5 | 1.3 |
| Marcusenius senegalensis | 1.5 | 81.4 | 5.3 | 0.7 | - | 3.5 | 5.4 | 0.7 |
| Hippopotamyrus pictus | - | 94.3 | 0.4 | - | - | - | 4.2 | - |
| Bagrus docmac | 1.7 | 23.4 | 3.7 | - | - | - | 4.0 | 66.6 |
| Auchenoglanis occidentalis | 1.8 | 72.7 | 7.5 | - | 2.9 | 10.7 | 1.9 | 1.6 |
| Synodontis schall | 0.3 | 41.7 | 4.2 | 0.1 | 4.0 | 1.1 | 43.2 | 4.9 |

there are overlaps, in the principal insect dietary item, the secondary important insect items seem to vary. For example, H. pictus and M. rume principally consumed Trichoptera larvae, but insect of secondary importance for H. pictus were ephemeropteran nymphs and for M. rume were chironomid larvae. This idea of different species preferring different food items will reduce competition and make co-existence possible. The work of , Imevbore and Bakare (1970) in the Niger indicated a high reliance of these insectivores on chironomid larvae. These conform with my findings in Zaria area. The works of Blake (1976) in Lake Kainji and Petr (1968) in Lake Victoria contrasted with my findings, because the mormyrids of those water bodies relied heavily on Povilla nymphs (Ephemeroptera). This shows that there is a shift of reliance on chironomid larvae in the river to Povilla sp. in the Lake by these species. This is understandable because of the large number of Povilla sp. which colonized submerged trees of these lakes (Blake, 1976). M. senegalensis was noticed to be the most versatile in feeding habit, than any other mormyrid in Zaria area. This versatility must have been one of the causes of its abundance. The frequent appearance of clam shrimps (conchostraca) in stomachs of M. senegalensis in Zaria agreed with the findings of Blake, (1976) in Lake Kainji. M. rumme, consumed Heleidae larvae and oligochaete worms more than any other mormyrid. While M. rume in Zaria area depended mainly

on trichopteran larvae and chironomid larvae and to a much lesser extent on ephemeropteran nymphs, Petr (1968) observed in Volta region that this species depended more on chironomid larvae, followed by Povilla nymphs. It may be that the trichopteran larvae is non existent in this region or it is less abundant.

Other Mormyrus species like M. macrocephalus was noticed in Lake Victoria by Corbet (1961) to feed mainly on insects. This M. macrocephalus preferred ephemeropteran nymphs, but chironomid larvae and trichopteran larvae were of equal importance. A common aspect between studies in Lake Victoria and Zaria waters was that the Mormyrus species took mainly the hydrosychid caddisfly (Trichoptera). The reliance of H. pictus on Trichoptera larvae contrasts with the findings of Blake (1976) in his study in Lake Kainji. Blake (1976) showed that H. pictus fed mainly on Povilla adusta and Chironomidae. The absence of trichoptera larvae may be because hydropsychidae (Trichoptera) common in tropical waters prefer riverine environments than lakes (Mellanby, 1971). P. bovei is another insectivorous mormyrid species. The most preferred item is chironomid larvae, followed by Trichoptera larvae and finally dragonfly nymphs. This conforms with the work of Blake (1976) in Lake Kainji, who observed the stomach contents of P. bovei to be composed mainly of chironomid larvae and Povilla audsta. The study of food and feeding of small mormyrids in Lake Victoria by

Okedi (1971), showed that the fishes depended more on two items, viz. the larvae of Povilla and Chironomidae. He later observed the food of small mormyrids in Sio river and noticed that larvae of Povilla was of much less importance. This confirms my findings in the rivers of Zaria area. Okedi (1971), noticed that these small mormyrids took copepods and vegetable seeds in both the river and lake. This agrees with my findings in Zaria area where P. bovei was noticed to take the greatest proportion of copepods and some quantity of seeds.

Hyperopisus bebe was another very common mormyrid species noticed during the period of investigation in Zaria area. It appears, that the divergence of this species from the common insectivorous habit, has contributed to its success. The most important food item of H. bebe in Zaria area was seeds followed by Mollusca. This agreed to some extent with the findings of Blake (1976) in Lake Kainji. He observed that mainly molluscs, Povilla nymphs and some chironomids were consumed during the months of April, June and July when the water level was low. In the months of September to February, seeds became increasingly important reaching a peak in December. This later period in Lake Kainji was when water began to rise and flooded the lake margin exposing the seeds. In Zaria area, the seeds were most important in the months of June and July. This coincides with the period when rivers and lakes in Zaria area

are usually flooded. At this period, the vegetation becomes submerged exposing the seeds (particularly Graminae). By the month of October molluscs became increasingly important and this was accompanied by reduction in proportion of seeds taken. H. bebe consumed more ostracods than other mormyrids in Zaria area. Ostracods were found to be more important food item than chironomids. This does not agree with the findings of Blake (1976), who showed that chironomid larvae were more important than ostracods. This contrast may be due to local variations in the availability of the different food items.

M. deliciosus is distinctive in its feeding habits. It is the only mormyrid found to be piscivorous in Zaria area. Blake (1976) noticed similar feeding habit in Kainji lake. It was also found in Kainji by Blake (1976), that Povilla species was also important component. In Zaria, it was observed that Ephemeroptera was not important rather, Odonata nymphs and Coleoptera larvae were more important in its diet. A unique behaviour of M. deliciosus in the Zaria area and Lake Kainji was feeding on prawns. It is of interest to note that M. deliciosus in Zaria was found to feed on Cybister larvae (coleopteran) which feeds on fish fry (Pennak, 1978). During the investigation, it was noticed that juvenile M. deliciosus were predominantly insectivorous, while the adult ones, were found to be mainly piscivorous. Blake (1964) reported a change in the

diet of M. deliciosus as they matured. The juveniles were found to be insectivorous and adults piscivorus. Similar findings were reported from Volta by Petr (1968). This pattern was also observed in Kainji by Blake (1976). He observed that fishes in size range 18.0 - 27.0cm (S.L) were mainly insectivorous while those between 28.0cm - 62.0cm (S.L) range were mainly piscivorous.

Generally, it appears that most of the mormyrid species existing in Zaria waters, relied more on insects for their survival (Table 24). This reliance may be due to the abundance of this animal group in the aquatic environment of Zaria area.

In the bagrid family, one principal marked difference exists between the two common species found in Zaria area. Bagrus docmac was found to be principally piscivorous, while Auchenoglanis occidentalis depended mainly on insects. Some insects and prawns were of secondary importance to B. docmac. The works of Corbet (1961) in Lake Victoria and Worthington (1929) in Lakes Kyoga and Albert on the food of Bagrus docmac agrees with the present findings. They observed that adult fishes are principally piscivorous. Chilvers and Gee (1973) working in Lake Victoria confirmed the piscivorous habit of B. docmac. The work of Wellman (1948) in the Kaduna river also agrees with the present findings in Zaria area. Wellman (1948) found that B. docmac in River Kaduna fed entirely on Prawns, insects and

fish. It was noticed in Zaria waters, that B. docmac of standard length less than 14cm fed principally on insects and to a lesser extent on fish. Chilvers and Gee (1973) in their study found that B. docmac started piscivorous habit at about 10cm standard length with the transition from a principally invertebrate to a primarily piscivorous diet occuring at 15cm standard length. Corbet (1961) in a comprehensive survey of the food of non-cichlid fishes from the northern part of Lake Victoria, pointed out that B. docmac depended entirely on fish when above 15cm total length. These changes in the food composition in relation to size of B. docmac agrees with findings in Zaria area. These ontogenic changes in food types, have been observed by other workers studying with other species of fish. Olatunde (1978b) studying the schilbeid species in Lake Kainji found that there was an overall correlation between increasing amount of larger food items and increasing age and size in Eutropius niloticus. Mann (1976), also noted these relationship in chub. This study showed that the most important insect food item of B. docmac was trichopteran larvae, followed by anisopteran nymphs. This differs from the findings of Corbet (1961), where anisopteran nymphs were the most important invertebrate food item. The work of Chilvers and Gee (1973) in the same lake but different bottom types showed that Chaoborus and chironomids were the major invertebrate dietary items. The discrepancy in

the results may be due to the different habitats from which the respective specimens were collected. The identifiable fish preys of B. docmac in Zaria waters were Tilapia sp. and Synodontis sp. The findings of Corbet (1961), Chilvers and Gee (1973) in Lake Victoria showed that B. docmac fed piscivorously mainly on Haplochromis. The observation of Corbet (1961) in Lake Victoria in terms of prawn as a food item of B. docmac agrees with what was observed in Zaria area. In both cases, prawn was noticed not to be particularly preferred by any size range of B. docmac. It, however, formed an important food item for both the young and adult individuals.

The study of A. occidentalis in Zaria area, shows that it depended mainly on immature chironomids. Other invertebrate food items that were of less importance included Coleoptera (adult and larvae), dragonfly nymphs, ephemeropteran nymphs, ostracods, clam shrimps, copepods and oligochaetes. Bakare (1968) studied the food and feeding habits of non-cichlid fishes of River Niger in the Lake Kainji basin and found that A. occidentalis ate plankton, cladocerans, ostracods and insect larvae. Ajayi (1972), found in Kainji Lake that A. occidentalis fed on plant and animal detritus. Insect larvae and nymphs - mainly chironomids and some ephemeropterans as well as molluscs contributed to the diets in Lake Kainji (Ajayi 1972). All these findings in Lake Kainji disagreerwith this study in terms of

presence and relative abundance of food items. The disparity may be due to local variations.

Synodontis schall was observed to be an omnivore feeding principally on seeds, algae, chironomid larvae and ephemeropteran nymphs. The diets of Synodontis have been studied by sadon and El-Tayebi (1953), Daget (1954), Bishai and Gideiri (1965), Blache (1964), Petr (1967), Bakare (1968), Imevbore and Bakare (1970) and Willoughby (1974). Most of those studies were merely qualitative. Bishai and Gideiri (1965) and Willoughby (1974) gave an indication of the quantitative importance of different food items. Willoughby (1974) studying in Lake Kainji, confirmed that S. schall was omnivorous. He found out that S. schall ate plant matter, humus, algae, insect larvae and nymph, fish remains and seeds. His qualitative findings was almost in consonance with what was obtained in Zaria waters. Another area of agreement in both studies, was the fact that there was no significant differences in diet with size in S. schall, although Bishai and Gideiri (1965) noted this in their work on S. schall.

Generally, the oscillations in monthly feeding intensity and variations in dietary composition are caused by availability and abundance. The availability and abundance of the food items could be influenced by a lot of factors, both environmental and otherwise. For example, Macdonald (1956), noted that the lunar rythms of emergence of Chaoboridae and

Chironomidae in Lake Victoria affected the relative numbers of these organisms taken by Mormyrus kannume. Okedi (1971) noticed that the quantity of chironomids and Povilla nymphs which formed the chief food in the stomachs of the mormyrids studied appeared to be correlated with certain lunar phases. It then means that, when a particular food item is less abundant the fishes will change their diet to another food item that is more abundant. This will inevitably cause the monthly fluctuations in feeding intensity and variations in type of food taken.

During this study, some fish specimens were found to have empty stonachs. It may be that, the fishes have digested their food items before they were caught or that they might regurgitate their food items while struggling with the fishing gear.

The value of "b" in the length-weight relationship indicates, if the fish is growing isometrically or allometrically. The value of b, if close to 3, indicates that the fish is growing isometrically, but if below or above 3, shows the fish to grow allometrically (Tesch, 1968). Table 12, shows that males of Marcusenius senegalensis, males of Mormyrus rume, males and females of Bagrus docmac have "b" values close to 3 (3.00 - 3.06) indicating that these species exhibit isometric growth. All other values of "b" from this table showed allometric growth. This result shows that the isometric growth was more in the

males than the females. This could be caused, by the fact that, some of the female species were carrying different ovary stages which could affect the length-weight relationship.

Sex ratio for all the families under investigation showed that the females were more in population than the males. This high sex ratio in favour of the females was also observed by Murthur (1964), working with Hilsa ilisha; and Fagade (1979 working with Tilapia melanotheron. The result of sex ratio in Synodontis schall in Zaria area compare with the findings of Willoughby (1974) in Lake Kainji. The male/female ratio in Zaria area was 1:1.4 and that of Lake Kainji was 1:1.3.

All the species with fully matured ovary under investigation were noticed between the months of June and September during the rains. Bank et. al (1965), found in River Niger that C. nigrodigitatus, B. docmac and A. occidentalis had matured ovary during July to September floods. This may indicate that there is a relationship between the spawning behaviour of tropical fishes and the rainy season. The presence of different egg sizes in the fully matured ovaries of the species under investigation has been observed by other workers. Nawar (1959a), noted the presence of two egg sizes in H. bebe. Blake (1976), noted trimodial egg size distribution in H. pictus, M. senegalensis, Campylomormyrus tamandua, M. deliciosus and H. bebe. The presence of these egg size ranges may indicate different spawning periods or one protracted spawning period or even egg

resorption may occur rather than second spawning. Imevbore (1970), asserted that Synodontis spawn more than once. Table 23, shows that M. senegalensis was the most fecund when compared with other mormyrids found in Zaria. On the whole, S. schall was the most fecund among the species carrying fully matured gonad in the three fish families under investigation. This seems to corroborate its continued abundance in the market all through the period of investigation. The high fecundity of S. schall was observed by Willoughby (1974) in Lake Kainji. He noticed that all the members of the genus are very fecund. A plot of fecundity against length or weight showed a general increase in length and weight with increase in fecundity. In some species the highest fecundity was not seen in the biggest specimen. This was also observed by Fagade (1978) while studying Tilapia guineensis in the Lekki Lagoon.

## CONCLUSION

The title of this project suggests that some areas of the biology of these families, were not considered during the study e.g. age determination, distribution and abundance. This was as a result of time constraint. Some of the existing species in these families were not studied in detail as others e.g. Pollimyrus isidori, Hippopotamyrus psittacus and Chrysichthys nigrodigitatus. This was a result of insufficient number of specimens available within the period of study. These uncovered areas can be a useful research topic for any person interested in searching for more knowledge in these families. This study will be useful for any ichthyologist who wants to know the existing species of any of these families in Zaria area. The analysis of the stomach contents will be particularly important to aquaculturists who intend to breed any of the species studied. In this case, during the preparation of feed, the species dietary items will be considered. The species like B. docmac and M. deliciosus may not be very suitable for polyculture technique as they feed on the fishes.

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Appendix I. Notation and formular in calculations for fitting a linear regresion equation using method of least squares.

| STATISTIC | SYMBOL | FORMULA |
|---|---|---|
| $i^{th}$ observation on independent variable, l | li | |
| $i^{th}$ observation on dependent variable, w | wi | |
| Sample size | n | number of (li, wi) pairs |
| Means | $\bar{l}$, $\bar{w}$ | $\bar{l} = \Sigma li/n$, $\bar{w} = \Sigma wi/n$ |
| Correction factor for sum of squares, $\Sigma l^2 i$ | cfl | $cfl = (\Sigma li)^2/n$ |
| Correction factor for sum of squares, $\Sigma w^2 i$ | cfw | $cfw = (\Sigma wi)^2/n$ |
| Correction factor for sum products, $\Sigma liwi$ | cflw | $cflw = (\Sigma li)(\Sigma wi)/n$ |
| Slope coefficient (regression coefficient) | b | $b = \frac{\Sigma liwi - cflw}{(\Sigma l^2 i - cfl)}$ |
| Intercept | a | $a = \bar{w} - b\bar{l}$ |
| Regression equation | | $w = a + bl$ |
| Standard error of estimate | Sw.l | $Sw.l = \sqrt{\Sigma w^2 i - cfw - (\Sigma liwi - (flw)^2/C}$ |
| Standard error of b | Sb | $Sb = \frac{Sw.l}{\sqrt{(\Sigma l^2 i - cfl)}}$ |

Appendix 2. The fecundity of mormyrid, bagrid and mochokid species in Baria area.

1. Marcusenius senegalensis

| Standard length (cm) | Weight of fish (g) | Gonad weight (g) | Total weight of dried eggs (g) | Mean weight of three sub-samples of 200 eggs each | Fecundity estimate |
|---|---|---|---|---|---|
| 19.1 | 98 | 15.00 | 2.780 | .1025 | 5424 |
| 15.5 | 50 | 10.10 | 2.744 | .1235 | 4444 |
| 17.9 | 78 | 14.00 | 2.743 | .1055 | 5200 |
| 18.9 | 98 | 15.00 | 2.722 | .110 | 4949 |
| 19.9 | 122 | 27.10 | 9.879 | .150 | 13124 |
| 15.3 | 50 | 10.40 | 3.766 | .175 | 4304 |
| 17.2 | 68 | 09.80 | 3.536 | .134 | 5278 |
| 14.3 | 40 | 7.37 | 2.557 | .1305 | 3919 |
| 16.8 | 70 | 9.08 | 3.045 | .136 | 4478 |
| 20.8 | 110 | 19.49 | 7.364 | .173 | 8513 |
| 19.9 | 84 | 10.30 | 3.084 | .106 | 5815 |
| 19.2 | 96 | 10.90 | 3.594 | .151 | 4766 |
| 20.3 | 108 | 14.74 | 5.015 | .136 | 7375 |
| 15.2 | 54 | 9.90 | 3.604 | .133 | 5420 |
| 17.8 | 70 | 6.84 | 2.145 | .132 | 3250 |
| 18.3 | 80 | 11.30 | 3.682 | .130 | 5665 |
| 17.1 | 66 | 10.20 | 3.408 | .1255 | 5431 |
| 17.0 | 56 | 3.94 | 1.359 | .108 | 2517 |

Appendix 2 contd.

| Standard length (cm) | Weight of fish (g) | Gonad weight (g) | Total weight of dried eggs (g) | Mean weight of three sub-samples of 200 eggs each (g) | Fecundity estimate |
|---|---|---|---|---|---|
| 16.4 | 50 | 3.53 | .691 | .0465 | 2972 |
| 13.5 | 46 | 5.20 | 1.883 | .1065 | 3536 |
| 17.0 | 80 | 4.64 | 1.427 | .090 | 3171 |
| 19.8 | 106 | 4.60 | 1.416 | .080 | 3540 |
| 16.4 | 63 | 1.20 | .354 | .096 | 738 |
| 15.9 | 62 | 1.60 | .396 | .093 | 852 |
| 19.9 | 94 | 1.80 | .471 | .057 | 1653 |
| 21.1 | 136 | 1.70 | .270 | .041 | 1317 |
| 16.3 | 63 | 0.60 | .070 | .053 | 264 |
| 20.6 | 113 | 5.10 | 1.792 | .1205 | 2974 |
| | | 2. Hippotamyrus pictus | | | |
| 17.5 | 73 | 3.62 | 1.00 | .082 | 2439 |
| 18.0 | 80 | 3.33 | .800 | .074 | 2192 |
| 18.6 | 82 | 4.14 | 1.066 | .0765 | 2787 |
| 18.5 | 88 | 3.13 | .366 | .101 | 725 |
| | | 3. Petrocephalus bovei | | | |
| 9.2 | 17.5 | 3.23 | 1.067 | .105 | 2032 |

Appendix 2 contd.

3. *Petrocephalus bovei*

| Standard length (cm) | Weight of fish (g) | Gonad weight (g) | Total weight of dried eggs (g) | Mean weight of three sub-samples of 200 eggs each (g) | Fecundity estimate |
|---|---|---|---|---|---|
| 9.3 | 16.0 | 2.52 | .750 | .094 | 1596 |
| 8.9 | 14.0 | 2.01 | .519 | .0675 | 1538 |
| 8.5 | 15.0 | 2.00 | .595 | .071 | 1676 |
| 8.4 | 14.0 | 1.82 | .573 | .068 | 1685 |
| 8.2 | 12.0 | 1.92 | .500 | .070 | 1429 |
| 8.6 | 10.0 | 1.32 | .409 | .075 | 1091 |
| 8.7 | 13.0 | 2.20 | .636 | .091 | 1398 |
| 9.1 | 14.0 | 2.52 | .787 | .0975 | 1614 |
| 9.2 | 17.0 | 3.00 | .934 | .106 | 1762 |
| 8.7 | 14.0 | 3.32 | 1.045 | .1045 | 2000 |
| 8.6 | 14.0 | 2.00 | .557 | .065 | 1714 |
| 8.7 | 13.0 | 1.20 | .226 | .051 | 886 |
| 8.8 | 15.0 | 2.40 | .823 | .0995 | 1654 |
| 9.0 | 16.0 | 2.23 | .522 | .077 | 1356 |
| 8.5 | 12.0 | 1.41 | .407 | .079 | 1030 |

4. *Hyperopisus bebe*

| | | | | | |
|---|---|---|---|---|---|
| 32.4 | 320 | 14.74 | 4.534 | .111 | 8169 |
| 32.6 | 370 | 9.30 | 2.277 | .1045 | 4358 |
| 33.1 | 355 | 6.08 | 2.479 | .115 | 4311 |

Appendix 2 contd.

| Standard length (cm) | Weight of fish (g) | Gonad weight (g) | Total weight of dried eggs (g) | Mean weight of three sub-samples of 200 eggs each (g) | Fecundity estimate |
|---|---|---|---|---|---|
| | | 4. *Hyperopisus bebe* | | | |
| 32.9 | 265 | 5.15 | .828 | .0635 | 2608 |
| | | 5. *Mormyrus rume* | | | |
| 37.3 | 475 | 12.12 | 3.670 | .2005 | 3661 |
| 29.2 | 150 | 6.27 | 1.749 | .1425 | 2455 |
| 31.8 | 285 | 5.86 | 1.203 | .076 | 3208 |
| 29.2 | 192 | 3.80 | .882 | .123 | 1434 |
| | | 6. *Auchenoglanis occidentalis* | | | |
| 23.0 | 265 | 7.07 | 1.450 | .1595 | 1819 |
| 24.6 | 345 | 29.30 | 5.558 | .265 | 4195 |
| | | 7. *Synodontis schall* | | | |
| 8.4 | 19 | 4.64 | 1.46 | .145 | 2014 |
| 10.8 | 43 | 11.44 | 2.435 | .048 | 10146 |
| 10.3 | 42 | 12.10 | 2.785 | .042 | 13262 |
| 12.0 | 52 | 8.38 | 1.673 | .0525 | 6373 |
| 10.4 | 41 | 10.90 | 2.407 | .046 | 10461 |
| 9.7 | 30 | 7.90 | 2.018 | .048 | 8408 |
| 18.2 | 101 | 9.40 | 2.125 | .0515 | 8252 |

Appendix 2 contd.

7. *Synodontis schall*

| Standard length (cm) | Weight of fish (g) | Conad weight (g) | Total weight of dried eggs (g) | Mean weight of three sub-samples of 200 eggs each (g) | Fecundity estimate |
|---|---|---|---|---|---|
| 9.0 | 28 | 7.27 | 1.903 | .0495 | 7689 |
| 12.0 | 45 | 5.45 | 1.132 | .053 | 4272 |
| 9.9 | 31 | 6.87 | 1.837 | .0455 | 8075 |
| 10.5 | 36 | 5.00 | 1.212 | .0465 | 5213 |
| 16.5 | 130 | 17.60 | 4.362 | .067 | 13021 |
| 11.0 | 39 | 6.00 | 1.375 | .0475 | 5789 |
| 15.6 | 106 | 13.84 | 2.622 | .0505 | 10384 |
| 13.7 | 66 | 10.80 | 2.649 | .055 | 9633 |
| 17.7 | 147 | 13.00 | 1.095 | .0375 | 5840 |
| 10.7 | 33 | 5.14 | 1.177 | .045 | 5231 |
| 11.5 | 36 | 4.03 | .418 | .031 | 3103 |
| 12.0 | 48 | 6.26 | 1.344 | .0385 | 6982 |
| 10.1 | 34 | 6.26 | 1.474 | .042 | 7019 |
| 10.2 | 32 | 8.10 | 1.830 | .0435 | 8414 |
| 10.1 | 36 | 10.50 | 2.747 | .054 | 10174 |
| 10.0 | 30 | 3.13 | .661 | .075 | 3525 |
| 9.8 | 26 | 3.63 | .822 | .040 | 4110 |
| 10.0 | 32 | 3.23 | .556 | .031 | 3587 |
| 10.0 | 24 | 2.82 | .660 | .0385 | 3429 |
| 8.4 | 19.4 | 4.64 | 1.046 | .0495 | 4226 |
| 10.0 | 31 | 5.4 | 1.140 | .0485 | 4701 |
| 9.6 | 30 | 7.47 | 1.837 | .045 | 8164 |
| 10.2 | 27 | 3.43 | .747 | .0365 | 4093 |

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