THE BIOLOGY OF A MORMYRID FISH

MORMYRUS KANNUME (FORSKAL, 1776)

IN A TROPICAL MAN-MADE LAKE

LAKE KAMBURU

BY

Charles H.O. Oduol (BSC. Hons)

THESIS SUBMITTED IN PARTIAL FULFILMENT
FOR THE DEGREE OF MASTER OF SCIENCE OF
THE UNIVERSITY OF NAIROBI

-1986-

The work presented in this thesis is the result of my own investigations and has neither been accepted nor is being submitted for the award of any other degree.

Signature................Date. 28-2-86..

Charles H.O. Oduol

Candidate

Signature................Date. 28-2-86

Dr. Stephen Dadzie

Supervisor

Senior Lecturer

Zoology Department

University of Nairobi

P.O.Box 30197

NAIROBI.

CONTENTS

A B S T R A C T

Four years after inundation, changes in some limnological parameters of the new man-made lake, lake Kamburu, have taken place. Higher mean values were obtained from the lake for: transparency-43.25 cm; surface water temperature - 23.5^{o} C; p^{H}-8.4 and conductivity-184 μmhos. Comparable values from the river were: transparency - 22.1 cm; temperature - 21.5^{o}C; p^{H} - 7.6 and conductivity - 109 μmhos. On the other hand, oxygen concenteration was lower in the lake (4.8 mg/l) than in the river (7.4 mg/l).

Analysis of the monthly changes in the condition of Mormyrus kannume indicated a generally high condition factor and the length-weight relationship revealed that growth of the fish is isometric. The length-frequency distribution showed monthly flu.ctuations in modes.

Studies of food and feeding habits revealed that M. kannume is an insectivorous feeder and both immature and mature fish feed mainly on the larval stages of aquatic insects throughout the year. In order of importance the following were recorded: Chironomus spp., Tanytarsus spp., detritus and Baetis spp.

The species is a bottom feeder and its long, tube-like snout is well adapted for bottom feeding. It is nocturnal in its feeding behaviour.

The reproductive patterns studied through analyses of annual cyclical changes in the gonadal weight and maturity stages revealed that M. kannume spawns throughout the year with peaks in spawning activities in November/December and April/May.

The minimum size at maturity was 24.0 cm SL in females and 24.8 cm SL in males. Spawning takes place in the riverine environments. The ratio of males to females in the population was 1:1 throughout the year except in the months of September 1978, October 1978, December 1978 and August 1978 when there was a preponderance of males over females in the ratio of 1.6:1, 1.4:1, 1.6:1 and 1.6:1 respectively and in January 1979 when a reverse ratio of 1:2 in favour of females was observed.

Fecundity is low and it ranges from 406 eggs in a 22.85cm female to 3466 eggs in fish measuring 42.5cm with a mean of 1600 eggs, and it increased with length ($r = 0.82$ $P < 0.001$) and weight ($r=0.85$ $P < 0.001$) of the females. Egg size ranged from 1.9mm to 2.9mm with a mean of 2.4mm. The size of the eggs did not seem to bear any relationship to the number of eggs spawned ($r = 0.01$; $P < 0.9$).

INTRODUCTION

In developing countries, man-made lakes are seen as great economic achievements. Such lakes provide sufficient reservoirs for water for water for generation of hydroelectric power. The water is also used for irrigation. Thirdly, the lake which is formed as a result of the construction of an impoundment across a river, is seen as a source of great hope in fisheries development for the supply of essential protein in the crusade against malnutrition.

While the provision of hydroelectric power and water for irrigation are direct and undisputed benefits of man-made lakes, the latter i.e increase in fish production, depends on a number of factors, the most important being the ability to manage positively the fishery, taking into consideration the new aquatic regime that will be established. In the context of fisheries, therefore, creation of man-made lakes may either be beneficial or detrimental depending on whether the orginally riverine fish species would be able to adapt and establish themselves in their new lacustrine environment or not. Management techniques are therefore called for in the development of the fisheries.

One of the most important tools in fishery management in man-made lakes is a sound knowledge of the biology of the species inhabiting the lake and the factors affecting their growth, maturation, reproduction and distribution.

The effects of large impoundments formed by blocking natural rivers have been a subject of investigations by numerous scientific investigators. Changes in the water chemistry and general hydrology after inundation have been reported in Lake Kariba in Zambia/Zimbabwe (Harding, 1964; Attwel, 1970; Balon and Coche, 1974 and Begg, 1974) in Lake Kainji, Nigeria (Bako, 1965; Imevbore, 1969; 1970b; Visser, 1973; Imevbore and Bakare, 1974) in Lake Nasser, United Arab Republic and Lake Nubian, Sudan (Lagler 1969) in Lake Volta, Ghana, (Petr and Reynolds, 1969; Viner, 1979 and Petr 1972) in Lake Riolempa, Salvadore and Apanas, Nicaragua (Little, 1968) and Lake Kamburu, Kenya (Dadzie et al.,1979; Odingo and Nyambok, 1979). Fluctuations in population of plankton and other aquatic fish foods as a result of impoundments were Observed in Gebel Aulyia dam, Sudan (Brook and Rzoska,1954) in Lake Kariba (Boughey, 1963; Begg, 1970) in Lake Volta (Biswas, 1966) and in Lake Kainji (Adeniji, 1973).

Changes in fish composition and populations after impoundment were recorded in Lake Kariba (Jackson, 1961; Harding, 1964; Coke, 1969; Bowmaker, 1970; Balon, 1970 and Begg, 1970; 1974) in Lake Kainji (Banks, et al, 1965; Imevbore and Bakare, 1970; Motwani and Kanwai, 1970; Lelek, 1972; 1973; Lelek and El Zarka, 1973; Lewis, 1974a; 1974b) in Lake Volta (Petr, 1966; 1967a; 1968; 1969; 1974; Petr and Reynolds, 1969) and in Lake Kamburu (Dadzie et al., 1970 and Dadzie 1980).

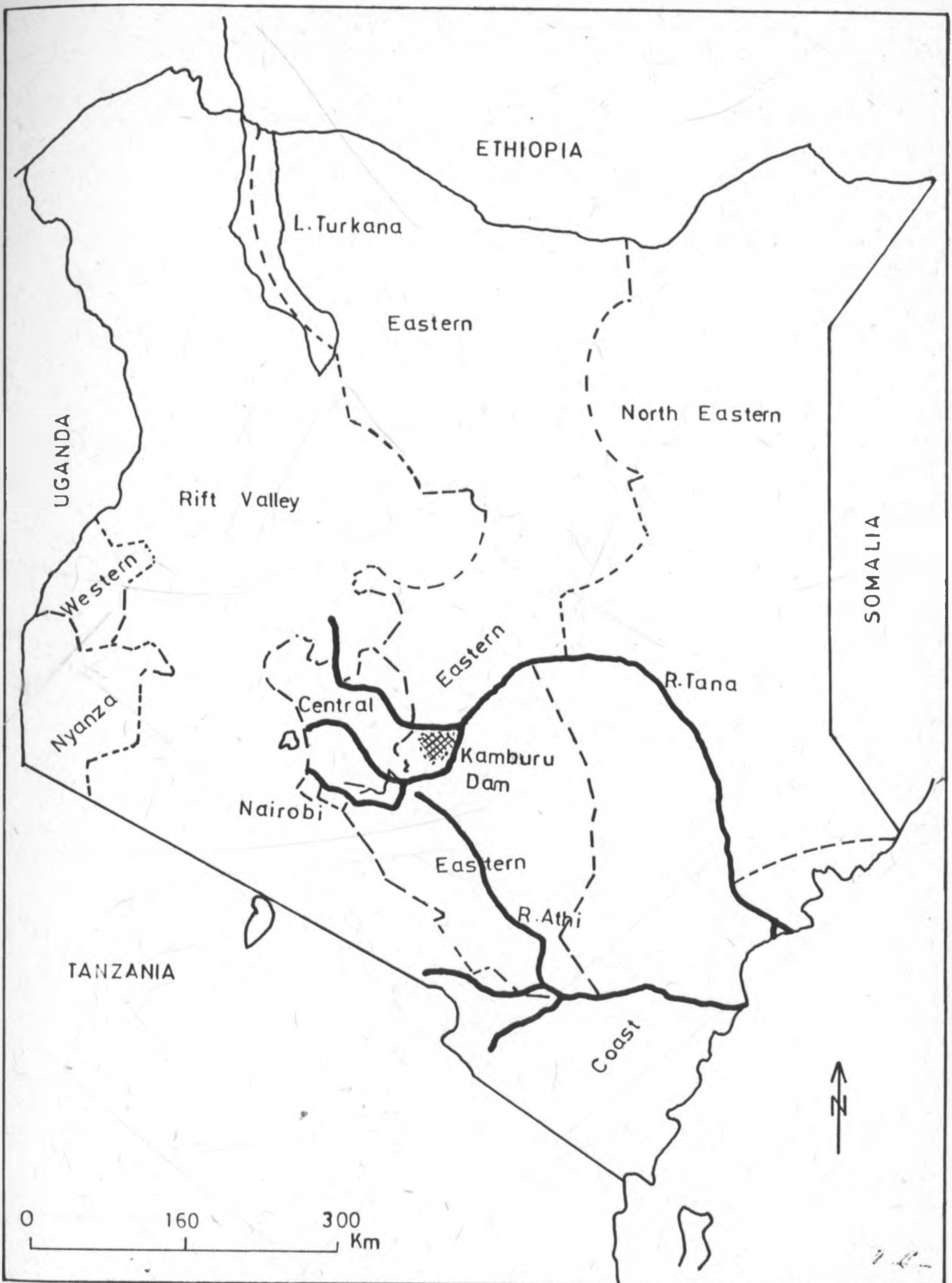
Investigations into the limnology of Lake Kamburu and the general biology of the fish population were carried out at the onset of the formation of the lake in 1974 by Dadzie et al., (1979), Odingo and Nyambok (1979) and Dadzie (1980). No other studies have been conducted since then. The lack of a detailed knowledge of the biology of the fish inhabiting the lake, coupled with the need to provide guidelines for conservation, management and rational exploitation of the stocks of fish inhabiting this lake necessitated the present investigations into the biology of Mormyrus kannume and this involved the study of:

1. The Limnological characterestics of the lake,
2. The length-weight relationship of the fish,
3. The condition factor
4. Length-frequency distribution
5. The food and feeding habits.
6. The patterns of reproduction

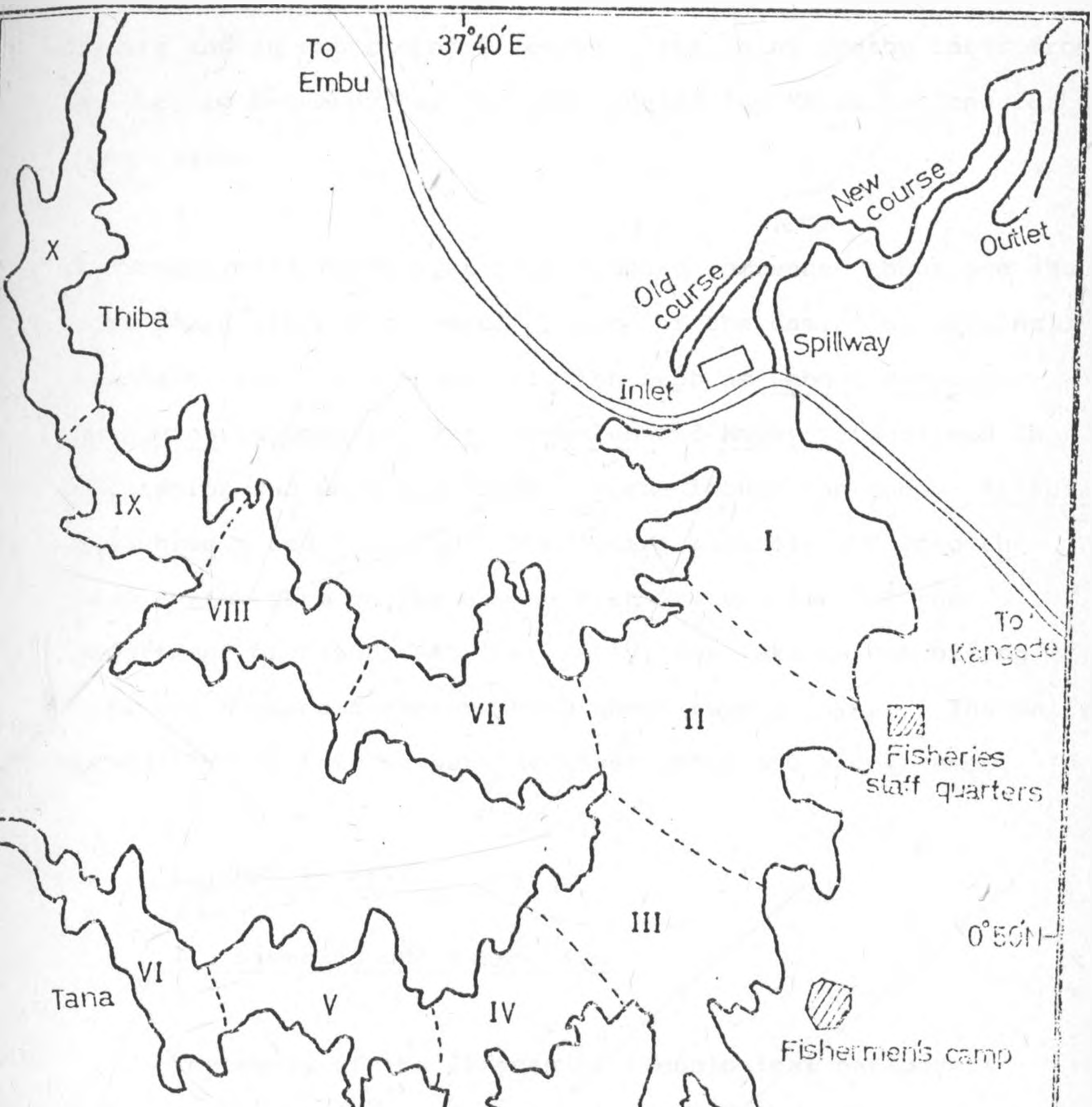
1:1 Lake Kamburu.

Lake Kamburu, lying at 0^{o} 50'S, 37^{o} 40'E and at an altitude of 900 meters above sea level, is in the Eastern Province, which is one of the arid areas of Kenya (Fig.1). The construction of the dam across the Tana River started in 1970 and was completed in 1974. It is currently one of the hydroelectric projects in operation on the Tana River. The Lake has an area of 1500 hectares and a maximum capacity of 150 million cubic meters of water fed by two major rivers -- The Tana and the Thiba, which join about 1.2. kilometers to the inlet of the hydro-electric dam (Fig. 2). The lake is about 10 kilometers long on the Tana and about 6 kilometers on the Thiba river. After passing through the electric generators, the water flows through an underground tunnel for 2.9 kilometers before it surfaces.

The lake is generally shallow with a substantially muddy



ETHIOPIA
L. Turkana
Eastern
North Eastern
UGANDA
Rift Valley
SOMALIA
Western
Eastern
Central
R. Tana
Nyanza
Kamburu Dam
Nairobi
Eastern
R. Athi
TANZANIA
Coast
N
0
160
300
Km


To
Embu
37°40'E
New
course
Outlet
Old
course
Spillway
X
Thiba
Inlet
IX
I
VIII
To
Kangode
VII
II
Fisheries
staff quarters
III
0°50'N
VI
Tana
V
IV
Fishermen's camp
0
1 KM

bottom. The depth increases from 2 meters at the river mouths to an average of 25 meters around the centre. At the deepest end, towards the intake, it goes up to 50 meters. The water level is fairly stable, with a mean annual variation of 1.5 meters and an extreme of 5 meters. The rainy season lasts from October to December for the short rains and March to June for the long rains.

The commercial fishery at Lake Kamburu commenced about one and a half years after successful closure of the dam. The originally abundant riverine species of fish such as Labeo, Barbus, Eutropius Synodontis, Petrocephalus and Mormyrus declined in population and were superseded by the lacustrine ones - Tilapia. Oreochromis and Cyprinus. The latter possibly got into the Tana system through the Sagana Fish Culture Farm of the Department of Fisheries. Currently, the lake is supporting over one hundred fishermen with about twenty boats. The daily production of Lake Kamburu averages about 500 kilogrammes.

2. LITERATURE REVIEW

2. 1. Limnological Parameters

The study of the effects of limnological parameters on the dynamics of organisms is an asset in management of water bodies. On man-made lakes, in particular, Obeng (1966) during the Accra Symposium asserted that the chemical, physical and biological characters of of new man-made lake becomes largely determined by the nature of the soils of the land it floods, the ions that are retained, the cycles of wave and wind movements which become established, and the adverse effects of pollution on the fauna.

In the same context, Lagler (1969) argued that any change in the physical and chemical nature of the lake waters naturally implied that the environment of the fish had also changed and the new environment may range from a hostile to a highly favourable one. One of the first man-made lakes in Africa to be investigated was Lake Kariba where Harding (1964) reported that the closure of the dam resulted in a very high biological productivity with anoxic conditions which later became less severe (Balon and Coche, 1974). Begg (1970, 1974) observed that the fish in Lake Kariba were essentially of riverine origin and that at the outset of static water, some species either sought those areas which were influenced by rivers or retreated from the new lake altogether while others adapted themselves to the new lacustrine condition.

Begg (op.cit) concluded that limnological parameters dictate the distribution of the aquatic flora and the invertebrate fauna. In Lake Kariba, Begg (1974) further stated that the "chemical revolution" resulted in the virtual disappearance of some fish species and also in the changes in composition of others. An immediate effect of the formation of Lake Kainji, which was formerly a stable and swampy riverine system (Bako 1964) was, an increase in organic detritus resulting from decay of flooded vegetation and complete absence of the swamps (Lewis 1974a & b). In a pre-impoundment survey of the same lake, Imevbore and Bakare (1974) found that the extensive swamp basin top soils were dominated by silt while the running water upstream had higher portions of sand. They further stated that the swamps deposits had higher organic matter than the river and hence concluded that for the deposit-feeding fish and molluscs, the swamps were richer feeding grounds that the river. The swamp waters were generally acid or weakly alkaline, oxygen values were appreciable while transparancy was high (Imevbore 1969, 1970a & b). After impoundment the water chemistry changed substantially, became more alkaline, with less oxygen values and the swamps literally disappeared (Visser, 1973).

In Lake Volta, the fish and other aquatic organisms changed in their population structure due to exposure to drastic changes in the physico-chemical parameters of the environment, when a riverine habitat was transformed into a lake (Petr and Reynolds, 1969). The first years of impoundments were characterised by poor oxygenation even in shallow waters (Petr, 1972; Viner, 1970). This was attributed to the fish movement, especially the oxyphillic mormyrids, from the static waters to riverine areas. The static conditions favoured algal blooms which in turn encouraged the proliferation of cichlids which feed on them (Petr, 1967a & b; 1968; 1969; 1974).

Attwel (1970) summarises that limnological changes as a result of impoundments of rivers are based on the fact that there occurs a reduction of the flow of water to very low velocities with consequent deposition of suspended particles and in many cases resulting in the development of thermal and chemical stratifications. A thermal capacity of a deeper body of water reduces the temperature range (Eccles, 1975).

Preliminary investigations carried out by Dadzie et al. (1979) and Odingo and Nyambok (1979) in Lake Kamburu, in its early stages indicated that the lake was still very young and hence many parameters had not significantly changed from the original riverine conditions.

Dadzie et al., (1979) observed that the water temperature varied from 22°C to 27°C at the surface and 21°C at the bottom, dissolved oxygen was uniform from surface to bottom and turbidity low. A more detailed research carried out in 1974, by Odingo and Nyambok (1979) and confirmed by Ward, Ashroft and Parkman (1976) revealed that the waters entering Lake Kamburu was exretemly turbid with a very high degree of siltation. The latter investigators based their results in the measurements of silt entering the dam while the former based theirs on the transparency of the water in the actual dam and, probably, after sedimentation.

From the reports of both authors, conductivity was uniform throughout the lake and averaged 40 µmhos. The p^H was also uniformly alkaline with an average of 9 both at the surface and the deeper parts of the lake while free carbon dioxide was at a low concenteration of 10.5 ppm. All these factors were attributed to the age of the lake, which was still very young. It was speculated that with more time both the physical and chemical parameters would change.

From this account it becomes clear that the effects of the dam on the limnological parameters of Lake Kamburu is not yet known. Since these parameters dictate not only the distribution of fish in the lake, but also the distribution of the zooplankton, phytoplankton and other aquatic organisms upon the fish feed, the need to conduct limnological studies on Lake Kamburu, four years after inundation becomes very real.

2.2. Biological Parameters

2.2.1. Distribution of Mormyridae.

Gunther (1962) stated that the family Mormyridae is a large freshwater fish which is indigenous to tropical Africa, where it is widely distributed. The ancestry is unknown since no fossil Mormyrids has so far been found. The family is both diverse and abundant in commercially Important numbers in West African water systems (Motwani and Kanwai, 1970) and various groups of Mormyrides are recognized in different African waters especially those connected with river affluents (Petr, 1966; 1967a & b; Blake, 1977a). Although not as commercially important as the Cichlidae and Cyprinidae, the group is, nevertheless, gaining increasing commercial importance also in the fishery of the affluent rivers of East Africa (Okedi 1966).

The Mormyridae are bottom dwellers varying in distribution from shallow inshore waters over both sand and rocky bottoms (Graham, 1929; Greenwood 1966; Okedi, 1971) to deep waters ranging 27-45 meters in depth (Scott, 1964).

Imevbore and Bakare (1974) found that the Mormyrids of River Niger were stable and confined mainly within the deeper regions of the running water while during the onset of rains, the fish moved around and upstream, and during this time there was active feeding and a few were spawning while Okedi (1971) found that the mormyrids of Lake Victoria had little food in their stomachs during the breeding season, confirming that there was reduced feeding activity during the breeding period. Corbert (1961), examined the stomach contents of Marcusenius nigricans, and observed that this fish was piscivorous. Apart from this, few mormyrids are piscivores and both Lake Victoria and West African mormyrids include the same groups of prey organisms in their diet and this tends to obscure any trophic divergence (Blake, 1977b).

Despite the wide distribution of mormyrids, one of the larger genera, Mormyrus, has limited distribution - from the lower Nile to Lake Victoria (Gunther, 1962). Whitehead (1959a) stated that the most notable species of Mormyrus, Mormyrus kannume,had been seen in the upper Tana but not yet positively identified. The same author also mentioned that M. tenuirostris (Peters) and M. hildebrandti (Peters) had been recorded from Athi and Tana rivers by Boulenger in 1909. The later species were tentatively synonomised with M. kannume of Lake Victoria and the Nile (Boulenger, 1911).

M. tenuirostris apparently differed from M. kannume only in the position of the dorsal fin. Whitehead (1959a) concluded that M. kannume was, infact, present in both the Tana and Athi rivers of Kenya.

From this summary, it is realised that the detailed biology of the Mormyrus spp. inhabiting the Tana system has not been extensively studied as those in the Nile basin, Lake Victoria, the Volta and the Niger waters.

It was therefore the objective of this research to investigate the biology of the *Mormyrus kannume* in the Tana system and compare the results with those of the same genus inhabiting other environments with a view to recording the response of this species to the limnological and biological changes in view of the fact that some of the Mormyrids of the Niger system are improving while those of the Volta system are still declining after impoundment.

2.2.2. Length-Weight Relationship

The Length-Weight relationship in fish has been studied to establish a mathematical formula that can best express the relationship between length and weight of a fish. The practical importance of this kind of study lies in the fact that in the field, the length of a fish is easier to ascertain than weight. If, therefore, a formula for the length-weight relationship is established, only the lengths of the fish that are sampled in the field can be taken and their weights derived later in the laboratory using the established formula.

This relationship may vary with the sex, stage of maturity and season of the year. Also, during their development, fish are known to pass through stages or stanzas in their life history which are defined by different length-weight relationship (Vaznetsov, 1953).

The length-weight relationship has been described by the formula:-

$$W=aL^n$$

Where W = weight
L = length

The value of the constant will be usually near 3 if the weight of fish varies with the cube of its length and if shape and specific gravity remain the same (Carlander, 1960, Ricker, 1973; 1975). When transformed into the logarithmic equation, which is also the most convenient and most usable form, the length-weight relationship is re-written as follows:-

$$\text{Log } W = \text{Log } a + n \text{ Log } L.$$

Carlander (op. cit) adds that the slope will usually be above 3 as fish become plumpier as they grow, and a fig. of 3 or close to 3 depicts an isometric growth. Isometric growth has been associated more with freshwater fishes. This is supported by the findings of Beckman (1945) on several Michigan fishes, Le Cren (1951) on perch, *Perca flubviatilis*: Whitehead and Sommeren (1959) on *Tilapia nigra*, Treasurer (1976) on *Salmo trutta*, Siddique (1977) on *Tilapia leucosticta*, Papageorgiu (1979) on the roach, *Rutilus rutilus* and Dadzie and Wangila (1980) on *Tilapia zillii*.

Such studies have not been carried out on *M. kannume* of Lake kamburu, the only existing report being that of Dadzie (1979) who, using only eight fish, described the following formular for the length-weight relationship:-

$$\text{Log } W = 0.77 + 1.95 \text{ Log } L.$$

2.2.3. Length - frequency Distribution

The analysis of length-frequency distribution is an important tool in fishery research. By making use of the result of such a study it is possible to make predictions of different age groups, time of spawing, size at recruitment etc. More importantly, a knowledge of the length-frequency distribution of a species of fish helps in growth estimations.

The length-frequency distributions of fish have been studied in a variety of freshwater species but only scanty information exists on M.kannume. Needham et al. (1945) reported the presence of size-classes in a population of brown trout (Salmo trutta), McIntyre (1952) provided information on the existence of age-groups in Tilapia nigra, Cala (1976) showed the presence of modes in Ide (Idus idus) and Neuman (1976) observed the presence of year-class strength in Perch (Perca fluviatilis). More recently, Mwalo (1983) has provided data on the length-frequency distribution of Synodontis spp.in Lake Victoria.

The only work on M. kannume was attempted by Dadzie et al. (1979) who, using only eight fish, observed that in Lake kamburu the small size fish showed only one mode at 24.4 cm while the larger size ones showed several modes, one at 26.5 cm, the highest at 32.5 cm and the last at 38.0cm total lengths. In view of the lack of detailed research on the length-frequency distribution of M. kannume in Lake Kamburu, it was thought necessary to include this study in the present research as it forms an important tool in fishery management.

2.2.4 Condition factor

The condition factor, also referred to as the coefficient of condition or the ponderal index, expresses in numerical terms, the degree of well-being or relative robustness (plumpness) of a fish. The factor is a useful index for monitoring age, growth rates and the effects of varying environmental conditions on a particular species of fish (Beckman, 1945). Although body weight or body length could be utilised in growth studies, the condition factor is a better index of growth and physiological condition of the fish, since a fish is a three dimensional object (Papageorgiou, 1979).

Changes in condition are analysed by a condition factor (K) based on the cube law (Hile, 1936; Thomson, 1942) which has the following equation:-

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

Where K = condition factor

W = Weight

L = Length

The coefficient of condition has been used in fishery work to study intraspecific differences related to sex, season, feeding condition, size groups and environments of very many fishes, though most attention has been on temperate ones. Not much work has been done on the condition factor of *Mormyrus spp.* and especially so in Lake Kamburu species.

The only available data is that of Dadzie *et al*. (1979) which showed that the condition factor of *Mormyrus spp.* from November, 1974 to January,1975 fluctuated between 0.6 in 24.9 cm length group and 0.3 in 42.0-43.9cm length group. This was considerably low and it was thus the interest of this investigation to find out whether the physiolocal state of the fish had improved or deteriorated four years after the first investigation.

2.2.5. Food and feeding habits

The study of the food and feeding habits of fishes is an important aspect in fishery investigations as food and its availability in the aquatic environment determines the growth of fish, shoaling behaviour , migration and also serve as a major indicator in fish exploitations.

A number of reports have been made on the food and feeding habits of different mormyrid groups in tropical Africa. Graham (1929), Worthington (1929), the East African Freshwater Fisheries Research Organisation (1948; 1951; and 1952) MacDonald (1956) and Scott (1964) reported that the elephant snout fish, Mormyrus kannume in Lake Victoria was a bottom feeder, feeding principally on the early stages of insects, such as the larvae of Chironomidae and Trichoptera and the nymphs of Odonata and Ephemeroptera and, after a few observations on the stomach contents of that fish, concluded that the food is a reflection of the bottom fauna on the region in which the fish is living and feeding. Corbert (1961) described the food of several species of Mormyrids including M. kannume in the same lake in detail while Greenwood (1966) as cited by Okedi (1971) threw much light on the habitats of these species. Okedi (op. cit) extended his study to cover the feeding preferences in some rivers which form the breeding grounds of these species, including description of the habitats, interesting features of the alimentary canal and seasonal variation in feeding intensity.

In West Africa, the mormyrids include the same groups of prey organisms in their diet as those of Lake Victoria. In Lake Kainji a few details are available on the feeding habits of mormyrids before impoundments and this include the works of Imevbore and Bakare (1970) who indicated that the chironomidæ were of most considerable importance. Lewis (1974a & b) stated that the mormyrids of the Niger system are obligate bottom feeding insectivores with the Larvae of chironomid midges predominating on their diets. He went further to state that the formation of Lake kainji would have resulted in a replacement of lotic species of benthic invertebrate by lentic forms and it was likely that during this transition period the overall benthic invertebrate population was sparce and that in the event of such a decrease one would expect a group of fishes such as Mormyrids with their rigid feeding requirements to migrate either into affluent tributaries or to the northern riverine arm of the lake and the river above the lake where suitable food would be more abundant.

Blake (1977b) noted that in the same lake, there was no change in diet with size on all mormyrid fishes except in Mormyrops deliciosus. He stated that large number of mormyrid have disappeared from the catches and concluded that although this may be related to diminished food supply, it is unlikely to be the sole factor in view of the available resources remaining in submerged trees.

Petr (1966; 1967a & b; 1968; 1969; 1972 and 1974,) while comparing mormyrid feeding habits in the Black Volta and the Volta man-made lake, indicated a shift from a high reliance on Chironimid larvae in the river to the frequent inclusion of Povilla spp. in thediets of mormyrids. He also recorded large numbers of grass seeds in the stomach of

Hyperopisus bebe in the lake during the dry season.

In Kenya, especially, no detailed investigations on the species have been carried out except those of Dadzie *et al*. (1979) and Dadzie (1980) which reported that the fish is a bottom feeder and feeds mainly on benthic insect larvae and planktonic copepods. The lack of information, coupled with the increasing importance of Lake Kamburu in fish production, makes it imperative, the need to carry out comprehensive investigation on this aspect of the biology of the species.

2.2.6. Patterns of Reproduction.

The increasing importance of fishery development expecially in man-made lakes, coupled with the great diversity displayed by teleosts, reflected in the range of reproductive phenomena seen in these animals, make it clear why the problem of reproduction and the studies of the gonads and their seasonal changes have been a subject of investigations by numerous workers. Most of the species on which information is available, however, are inhabitants of temperate waters where the marked seasonal changes have their peculiar effects on the process of development. Nevertheless some reports are available on the reproductive patterns of tropical fishes.

By virtue of their commercial importance, the reproductive potential of cichlids and cyprinids have received more attention than that of the mormyrids (Okedi, 1970). Although members of the Mormyridae at presant make up a relatively small part of the total landings of fish from lake Victoria the group is nevertheless becoming commercially important to the fishery of the affluent rivers (Okedi, 1966).

The normal habitats of Mormyridae have been described as varying from shallow inshore waters over both sand and rocky bottoms (Graham, 1929; Daget, 1954; Greenwood, 1966; Okedi, 1971) to deep waters 27-45 metres (Scott, 1964; 1974).

Some Mormyridae were found up to 25 kilometers up-river, from the river mouths indicating that they were anadromous, and ascending to breed in the rivers and swamps during the rainy seasons as suggested by Okedi (1969). Okedi (op. cit). While studying the breeding cycle of small mormyrid fishes of Lake Victoria, concluded that these fishes breed twice a year during the rainy seasons and spawning occurs in flooded rivers.

In a pre-impoundment survey of the Niger swamps before the formation of Lake Kainji, Imevbore (1970c) and Imevbore and Bakare (1974) described Mormyridae as swamp living and stable fish confined mainly within the deeper region of the running water during the dry season. At the onset of the rains, the authors added, the fishes move around and upstream while actively feeding and spawning. Imevbore (1970c) concludes that these riverine fishes also breed twice a year as those of Lake Victoria as reported by Okedi (1969). In a post-impoundment study of Lake Kainji, Blake (1977a) found that the mormyrids occurred in both the lacustrine as well as the lotic environment. However on examination of the gonads, throughout the period of the study, he observed that there were many ripening individuals but few running fish in the lacustrine environment. He therefore concluded that the riverine conditions are essential to the reproduction of the mormyride of Lake Kainji.

In Lake Volta and the Black Volta basin, Petr (1966; 1967a & by 1968; 1969; 1974) and Petr and Reynolds (1969) found that out of the the 19 fish families in the lake, 3 families of great economic importance in the river/Lake Mormyridae, Cichlidae and Characidae, had undergone remarkable changes in abundance and distribution. The first family, known to be common in rivers had almost totally disappeared from the Lake. The Mormyridae were originally numerous from the Black Volta river and after successful impoundment, Petr (1967a & b 1968) recorded that they disappeared from the dam area and migrated to the upper end of the reservoirs, where they were recorded regularly in commercial landing though in small numbers, even five years after damming, despite the development of large populations of Chironomidae and the Ephemeroptera, (Povilla adusta (Navas) in the lake, which form the basic food of this fish.

Lelek and El Zarka (1973), Lewis(1974a) and Blake (1977b) stated that in those West African environments (Lake Volta and Lake Lake Kainji system), since food is apparently available, other explanations must be sought to account for the presently lo numbers of mormyrids in those systems and concluded that the need for riverine conditions for reproduction could be an important factor. Similar migrations of riverine fishes have been recorded in Lake Kariba (Begg, 1974) Aswan dam on River Nile (Lagler, 1969) and Lake Kamburu (Dadzie et al, 1979 and Dazie, 1980).

In these waters, fishes have migrated from the lacustrine to the lotic environment. This brings into sharp focus the need for the present research to provide the much needed information for the management and rational exploitation of the fish and fishery of Lake Kamburu.

3. Materials and Methods:

Lake Kamburu was divided into 10 sampling sites (Fig. 2) from where both limnological and biological parameters were obtained during the research period lasting 12 months - from September, 1978 to August, 1979.

3.1. Limnological parameters:

Limnological parameters were taken weekly from each sampling site and monthly means of weekly results calculated. Sampling was done usually between 9 a.m. and 12.noon and movements from site to site was facilitated by the use of a Sesse canoe propelled by a 15.H.P. outboard engine.

3.1.1. Transparency:

The transparency of the water was measured using a Secchi disc. The disc was lowered into the water and the depth of disappearance recorded, it was then gradually lifted and the depth of appearance recorded. The mean of the two reading was determined and taken as the correct level of transparency.

3.1.2 Water Temperature:

The temperature of the surface, middle and bottom waters were measured using a Zeaton Electronic thermometer. This thermometer had six knobs, each of which could measure the water temperature at various depths by the operation of the knobs. The electrode heads were dropped in the water at different depths and the temperature read from the boat.

3.1.3. Oxygen concenteration:

This was analysed using the automatic oxygen probe calibrated in mg./l. This probe had long electrodes similar to the Zeaton thermometer and by the operation of the knobs, the surface, middle and bottom waters were analysed for dissolved oxygen concenterations at the different depths.

3.1.4. The rainfall records were obtained from the Department of Fisheries at Sagana (For the riverine records) and the East African Power and Lighting Company at Kamburu) (for the lacustrine records).

3.1.5 p^H

This was investigated using the Cole-Palmer Digisence P^H meter. Water samples from the surface, middle and bottom were obtained using the Friedlinger-Luzern water sampler and their P^H determined on the boat.

3.1.6. Conductivity:

Water samples from the lake were obtained from the surface, middle and bottom of the sampling sites using the Friedlinger-Luzern water sample. The evershed and Vignoles dionic conductivity meter was used to determine the conductivity. The limnological values were temperature compensated at 20^oC.

3.2. Biological Parameters:

Samples of Mormyrus kannume were obtained using fleets of graded gillnets with the following mesh sizes: 38mm, 45.5mm, 63.5mm, 76mm, 101.5mm, 142.2mm, 127mm, and 137.5mm. Each net measured 10 meters long. Thus a fleet of gillnets containing the nine different mesh sizes measured 90 meters long. Three fleets were set in each sampling site and both floating and sinking techniques were applied, both inshore and offshore. After an experimental period of both day and night inspection of the nets between 12th and 30th August, 1978, it was realised that fishes were caught only at night. It was therefore decided to check the nets in the mornings only starting from 6a.m. and usually lasting until 9.30a.m. Seine nets of 10mm and 14mm were used once weekly to try and capture young inshore fishes. Traditional double basket traps were also used with bread as bait. Fishes caught were put in polythene bags according to area and method of capture and transported to base.

3.2.1. Length-weight relationship:

The specimens captured were measured to the nearest 0.1cm (Standard length) and weighed to the nearest g. They were then separated into three groups as follows:-

i) Immature males and females

ii) Mature females

iii) Mature males.

The length-weight relationships were then computed for the three groups separately using the formula:-

$$\text{Log } L = a + n \text{ Log } W$$

Where L = Length

W = Weight

a and b are constants.

3.2.2 Length = frequency distribution:

The standard lengths of 679 male and female M. Kannume were measured to the nearest 0.1cm. The percentage frequency of fish in different length-classes were computed and the resulting data used in drawing the length-frequency polygons.

3.2.3 Condition Factor:

The coefficient of condition of immature males and females and mature males and females were calculated separately from the length and weight data. For this exercise, the cube law of Hile (1936) and Thomson (1942) which is expressed by the following equation was used:-

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

Where K = Coefficient of Condition

W = Weight of Fish

L = Length of Fish.

3.2.4 Food and Feeding Habits:

For the studies of food and feeding habits of M. kannume, the guts of 320 fish were carefully removed from the oesophagus to the last portion of the intestine and weighted to the nearest 0.1g. The fat surrounding the gut was then removed and the latter re-weighed to the nearest 0.1g and preserved in 6% formalin for later laboratory analysis of their contents.

The gut-content analysis were carried out on monthly basis. For this purpose each stomach was emptied into a petri dish containing a solution of 4% ethanol and examined under a binocular microscope. Some of the food items were sometimes in an advanced stage of digestion, and in those, only the undigested portion of the organisms, usually the head, were actually identified and counted.

The relative importance of the food items was assessed by the two methods of Corbert (1961)– "The occurence method" and "The main contents method". The types of food which occupied the stomach in the largest numbers were recorded first as the main contents and the rest followed in order of decreasing numbers. The number of stomach having common food items were re-grouped and the percentage of occurence of each food item in the stomach calculated. "The main contents method" espresses the number of each item as a percentage of the total number of food items identified whereas. "The occurrence method" expresses the number of stomachs examined in which a particular item occurs as a percentage of the total stomachs examined. The various food organisms were identified as far as possible to the generic level and counted.

The main contents and the frequency of occurrence methods take into account only food organisms in the gut. To gain some insight into the possibility forthe species having preference for certain food items over the others, the "ELectricity Index" of Ivlev (1961) was used to study selection by the fish against the availability of such food in the environment. Since M. kannume is a bottom feeder, Ekman's dredge was used to sample the bottom deposits from the sites shown in Fig. 2. Berg (1938) discussing the efficiency of the Ekman's dredge pointed out that there could be some sampling error due to the variable horizontal distribution of larvae, and concluded that a double sample should always be taken to reduce this error.

Five samples covering both inshore and ofshore were therefore taken weekly at each sampling site and at the same time as the gill nets were examined for fish. The bottom mud samples were passed through a fine sieve with a mesh size of 200mm and the larvae sorted from the residue, identified to the generic level and counted. Since the larvae often wriggled, turned and moved when they were still alive, they were usually warmed on a watch glass to reduce their mobility to facilitate ease of counting. The Electivity Index (E) was then calculated from the following equation:-

$$E = \frac{\text{"Ri"} - \text{"Pi"}}{\text{"Ri"} + \text{"Pi"}}$$

Where "Ri" = relative component of any ingredient in the ration in the stomach expressed as a percentage of the whole ration.

"Pi" = the relative value of the same ingredient in the food complex of the environment expressed as a percentage.

The value of "E" normally fluctuates between +1 for the exclusive positive selection and -1 for complete negative selection while the value 0 denotes complete lack of selection. For the purpose of clarity in this exercise, Electivity Index values beyond + 0.5 depict exclusive positive selection, those between + 0.5 and - 0.45 denote neutral or absence of any selection while those below - 0.5 show complete negative selection.

Monthly fluctuations of food items both in the guts of the fishes and in the environment were analysed to establish whether there was any variation in the feeding and if it was related to the food availability in the environment.

The intensity of feeding was studied by determining the gastrosomatic index (G.S.I) which reflects the degree of fullness of the stomach and expressed bythe followng equation:-

$$\text{Gastrosomatic Index (G.S.I)} = \frac{\text{Weight of gut}}{\text{Weight of fish}} \times 100$$

Monthly variations in gastrosomatic index were analysed and correlated with limnological parameters to elucidate the relationship between the changes in the environment and the feeding intensity.

To complement the study of the food and feeding habits it was found necessary to follow the dynamics of fat accumulation of taking monthly records of the abdominal fat content and calculating the percentage using the formula:

$$\text{Percentage fat content} = \frac{\text{Weight of the abdominal fat} \times 100}{\text{Body weight of fish}}$$

Monthly fluctuations of fat content were calculated and an attemp was made to correlate the dynamic of fat content with the G.S.I. and also with the limnological parameters.

3.2.5. REPRODUCTION

3.2.5.1. Sex Ratio

Monthly variations in the ratio of male to female M. kannume in the lake during the study period were determined by sexing all the fish in daily catches. In all, 343 males and 330 females were used in this study. The significance of the results were tested monthly using the Chi-square test of homogeneity. Juveniles were not included in this study as they were present in very limited numbers in the catches and their sexes could not be determined with certainty.

3.2.5.2 Size at first maturity

The minimum size at maturity was taken as the minimum length at which 50% of the fish in the population attain sexual maturity. For this purpose, the fish were grouped in 2cm. Length-classes and the percentage number of fish at various maturity stages in each length - class determined. Fish in stages III and above were considered mature for the purpose of calculating the size at first maturity.

3.2.5.3. Cyclical Changes in the Gonads.

The cyclical changes in the maturation of the gonads of M. Kannume. were studies following the monthly changes in the maturity stages of all the fish captured during the twelve month study period.

3.2.5.4. Gonado-somatic Index (g/s)

After the determination of the sex and maturity stage of the sampled fish the gonad was then removed, weighed to the nearest 0.1g and the relationship of the gonad weight to the body weight, called the Gonado-somatic Index, determined using the formula:-

$$\text{Gonado-somatic Index (g/s)} = \frac{\text{weight of gonad}}{\text{Weight of fish}} \times 100$$

The gonads were then labelled and preserved in 10% ethanol for fecundity estimations and egg-size measurements at a later date in the laboratory.

Observations on the monthly variations in the g/s served as a complementary tool for the studies of the cyclical changes in the gonads.

The gonadosomatic values were correlated with limnological parameters of the environment and gastrosomatic and fat content values of the fish.

3.2.5.5. Fecundity:

For the purposes of this study the definition of Alee et al (1949), Dice (1952), Nikolsky (1963) and Okedi (1970) which describe fecundity as the number of eggs contained in the ovary just prior to spawning was used. The ovaries of 80 ripe, mature or running females were used for this study.

The gravimetric method of egg estimation (calculated egg numbers) of Burrows (1951), Vladykov(1956) and Siddique (1977) was used in large ovaries. This method involved weighing the whole ovary, taking a portion of it and weighing it before counting all the eggs in the smaller portion just weighed. Assuming that eggs were evenly distributed the total egg counts were estimated by proportion.

In cases of ovaries with relatively small numbers of eggs, total egg counts was conducted. The ripe eggs were poured in a petridish and the total egg numbers counted. Although it was realised that there were secondary oocytes at the early stages of maturation, these were very few in the ripe and running females. The eggs were then placed on a blotting paper and rolled over to remove excess water. 50 eggs from each female were randomly selected and measured using an occular micrometer. The mean for each was then determined. The data were used to investigate the relationship between fecundity and egg size.

The relationship between fecundity and: (a) standard length, (b) body weight and (c) egg size were determined using the following logarithmic equations:

Log F = a + n Log L (L = Standard Length)

Log F = a + n Log W (W = Body Wieght)

Log F = a + n Log S (S = Egg — size).

4. RESULTS

In the course of sampling it was found necessary to divide Lake Kamburu into two environments, the lacustrine and the riverine ones. The lacustrine environments is presented in Fig. 2 as sampling sites 1, 11, 111 and V11 while the riverine ones are shown as sites V, V1, IX and X. There was a mixed environment and this is represented as sites IV and VIII.

4.1. Limnological Parametes

4.1.1 Transparency

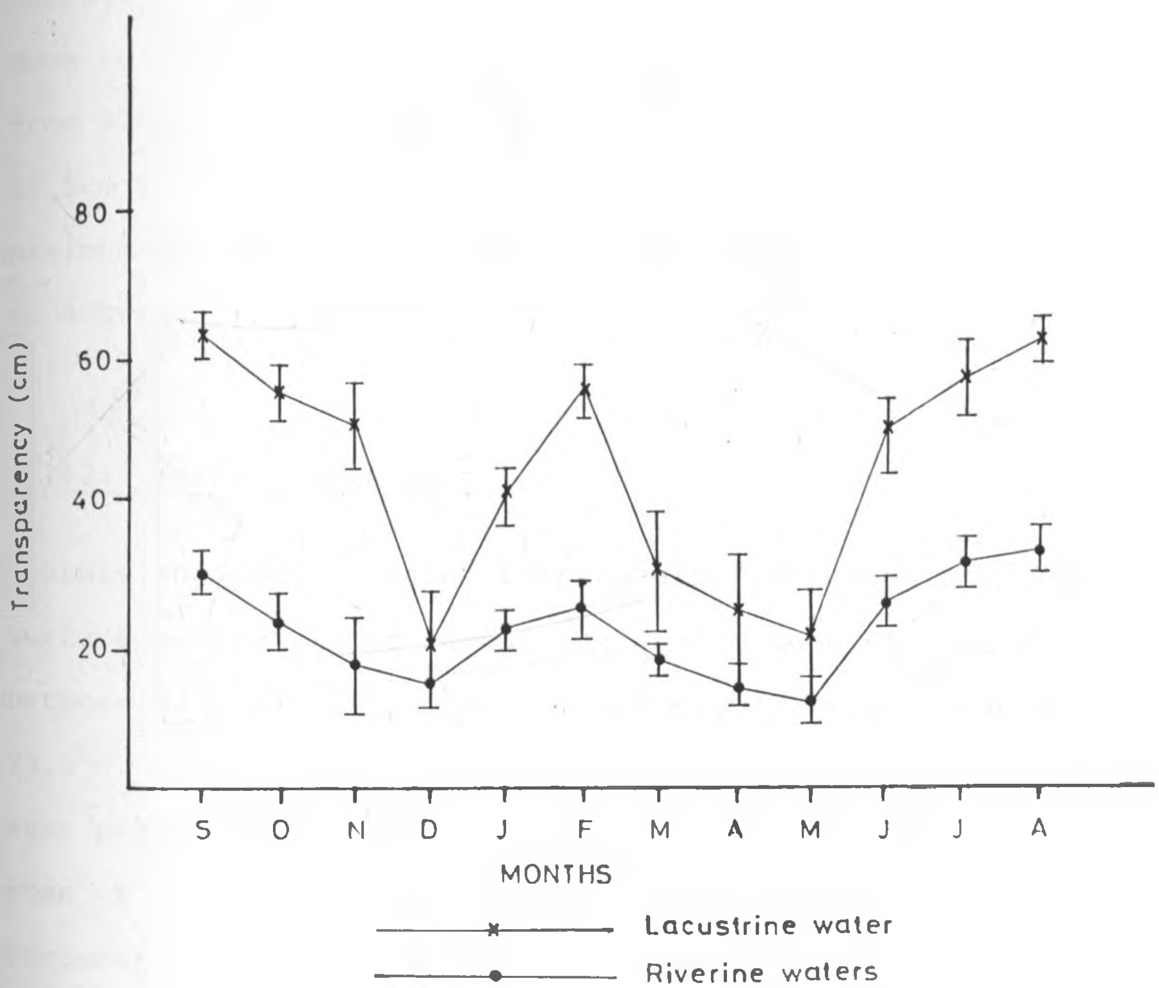
The lowest Secchi disc recording of 13.3cm. in April, 1979 and 11.5cm in May, 1979 (Table 1 and Fig. 3) were made at the river affluents (Fig. 2) where the water was most turbulent and hence most turbid. The highest values of 60cm, recorded in August, 1970 and 62cm in September, 1978 were obtained from the lacustrine environment, which was more stable and hence least turbid.

Monthly fluctuations in transparency in both the lacustrine and riverine environments as presented in Table 1,2 and Fig. 3 were also observed. In September, 1978 the highest transparency in the lacustrine environment was recorded after that a gradual reduction in transparency down to 20cm was obtained by

Table 1 Monthly fluctuations in transparency, temperature and p^H of Lake Kamburu

Month	Environ-ment	Mean Transparency (cm) + SD	Mean Temperature (°C) ± SD			Mean pH ±SD		
			Surf.	Mid.	Bot.	Surf.	Mid.	Bot.
Sept. 78	*L	62.0 ± 2.0	25.0 ± 0.9	22.0 ± 0.2	20.0 ± 0.2	9.80 ± 0.3	8.00 ± 0.3	7.80 ± 0.3
	**R	30.0 ± 3.0	21.8 ± 0.3	21.8 ± 0.3	21.8 ± 0.3	7.65 ± 0.1	7.60 ± 0.1	7.60 ± 0.1
Oct. 78	*L	54.0 ± 4.0	24.0 ± 1.0	22.0 ± 0.2	21.0 ± 0.2	9.20 ± 0.5	8.00 ± 0.3	7.70 ± 0.2
	**R	23.0 ± 1.1	21.6 ± 0.2	21.6 ± 0.2	21.0 ± 0.2	7.60 ± 0.1	7.60 ± 0.1	7.60 ± 0.1
Nov. 78	*L	50.0 ± 6.0	23.1 ± 0.9	22.0 ± 0.4	21.0 ± 0.2	8.80 ± 0.6	7.80 ± 0.4	7.70 ± 0.2
	**R	18.0 ± 1.2	21.4 ± 0.2	21.4 ± 0.2	21.4 ± 0.2	7.60 ± 0.1	7.60 ± 0.1	7.60 ± 0.1
Dec. 78	*L	20.0 ± 8.0	22.8 ± 1.1	22.0 ± 0.6	21.0 ± 0.2	8.80 ± 0.6	7.80 ± 0.4	7.40 ± 0.3
	**R	15.0 ± 1.8	21.2 ± 0.3	21.2 ± 0.3	21.2 ± 0.3	7.60 ± 0.1	7.60 ± 0.1	7.60 ± 0.1
Jan. 79	*L	40.0 ± 4.0	23.4 ± 0.9	22.0 ± 0.3	20.0 ± 0.3	8.70 ± 0.4	8.00 ± 0.4	7.40 ± 0.3
	**R	22.5 ± 2.0	21.8 ± 0.3	21.8 ± 0.3	21.8 ± 0.3	7.60 ± 0.1	7.60 ± 0.1	7.60 ± 0.1
Feb. 79	*L	55.0 ± 3.0	24.0 ± 1.1	22.0 ± 0.6	19.5 ± 0.4	9.00 ± 0.4	8.50 ± 0.3	7.40 ± 0.2
	**R	25.5 ± 2.0	22.0 ± 0.3	22.0 ± 0.3	22.0 ± 0.3	7.60 ± 0.1	7.60 ± 0.1	7.60 ± 0.1
Mar. 79	*L	30.0 ± 8.0	23.0 ± 1.2	21.5 ± 0.5	19.0 ± 0.3	9.25 ± 0.5	8.80 ± 0.4	7.60 ± 0.2
	**R	18.8 ± 1.8	21.6 ± 0.2	21.6 ± 0.2	21.6 ± 0.2	7.60 ± 0.1	7.60 ± 0.1	7.60 ± 0.1
Apr. 79	*L	25.0 ± 8.0	23.0 ± 0.6	22.0 ± 0.6	20.0 ± 0.4	8.70 ± 0.6	8.80 ± 0.4	7.50 ± 0.2
	**R	13.5 ± 1.5	21.2 ± 0.4	21.2 ± 0.4	21.2 ± 0.4	7.60 ± 0.1	7.60 ± 0.1	7.60 ± 0.1
May 79	*L	20.0 ± 8.0	22.4 ± 0.9	21.5 ± 0.4	20.9 ± 0.3	8.30 ± 0.7	7.80 ± 0.4	7.70 ± 0.3
	**R	11.5 ± 0.9	20.9 ± 0.4	20.9 ± 0.4	20.9 ± 0.4	7.60 ± 0.1	7.60 ± 0.1	7.60 ± 0.1
Jun. 79	*L	48.0 ± 5.0	23.5 ± 1.0	22.0 ± 0.4	20.0 ± 0.2	8.90 ± 0.6	8.00 ± 0.3	7.80 ± 0.2
	**R	25.0 ± 2.5	21.4 ± 0.2	21.4 ± 0.2	21.4 ± 0.2	7.60 ± 0.1	7.60 ± 0.1	7.60 ± 0.1
Jul. 79	*L	55.0 ± 4.0	24.0 ± 0.9	22.0 ± 0.9	20.0 ± 0.2	9.40 ± 0.4	8.40 ± 0.3	8.00 ± 0.2
	**R	30.0 ± 3.0	21.5 ± 0.3	21.5 ± 0.3	21.5 ± 0.3	7.66 ± 0.1	7.66 ± 0.1	7.66 ± 0.1
Aug. 79	*L	60.0 ± 2.0	25.0 ± 1.1	22.0 ± 0.6	20.0 ± 0.4	9.70 ± 0.4	8.50 ± 0.4	8.10 ± 0.2
	**R	32.0 ± 3.0	21.7 ± 0.4	21.7 ± 0.4	21.7 ± 0.4	7.60 ± 0.1	7.60 ± 0.1	7.60 ± 0.1

*L Lacustrine environment
**R Riverine environment
±SD Standard Deviation



80
60
40
20
Transparency (cm)
S O N D J F M A M J J A
MONTHS
Lacustrine water
Riverine waters

December 1978. In January and February, 1979 there was an increase in this parameter to 25.5cm, while the intervening months of March, April and May 1979 saw a reduction to 20cm.

From June 1979 onwards, there was a gradual increase in transparency reaching a maximum of 60cm in August, 1979. In the riverine environment, more or less similar pattern was exhibited. It was observed that from September, 1978 through to December, 1978 there was a decreasing transparency from 30cm to 15cm. From January, 1979 there was a two-month increase from 22cm. to 25cm and from March to May, 1979 a decrease to 11.5cm was observed. However, an increase culminating in a maximum Secchi disc reading of 32.0cm was observed from June to August.

4.1.2. Water Temperature

Monthly analyses of water temperature variations show that the surface waters of the lacustrine environment fluctuate between 22^{o}C and 25^{o}C (Table 1 and Fig 4) with a mean of 23.5^{o}C. The temperature of the river waters also follow the same pattern but fluctuates between 20.9^{o} and 22^{o}C with a mean of 21.5^{o}C. There was a progressive decline in water temperature from the surface waters to the bottom waters in the lacustrine environment, which registered a mean of 20^{o}C, In the riverine environment, however, there was virtually no differences in water temperature at various depths during the year (Table 1,3 and Fig. 4).

Throughout the period of the study, seasonal fluctuations in water temperature which were more pronounced at the surface waters of the lacustrine environment occurred. At the onset of the experiment, i.e. in September, 1978, the surface water temperature averaged 25°C. This gradually decreased to 22.8°C by December, 1978. There was a two-month increase of temperature in January and February, 1979 followed by a gradual decrease from 23°C to 22.4°C inMay, 1979. From June onwards there was a gradual increase reaching a maximum in August 1979 when a surface water temperature of 25°C was recorded.

The fluctuations in the riverine water temperatures were not as as pronounced as those in the lacustrine one. In September 1978 the river had a high temperature of 21.8°C which gradually and slightly reduced to 21.2°C in December 1978. There was a slight increase in January and February 1979 after which there was another gradual and slight decrease from March to May, 1979. From June onwards a gradual increase from 21.4°C reaching a maximum of 21.7°C in August, 1979 was observed.

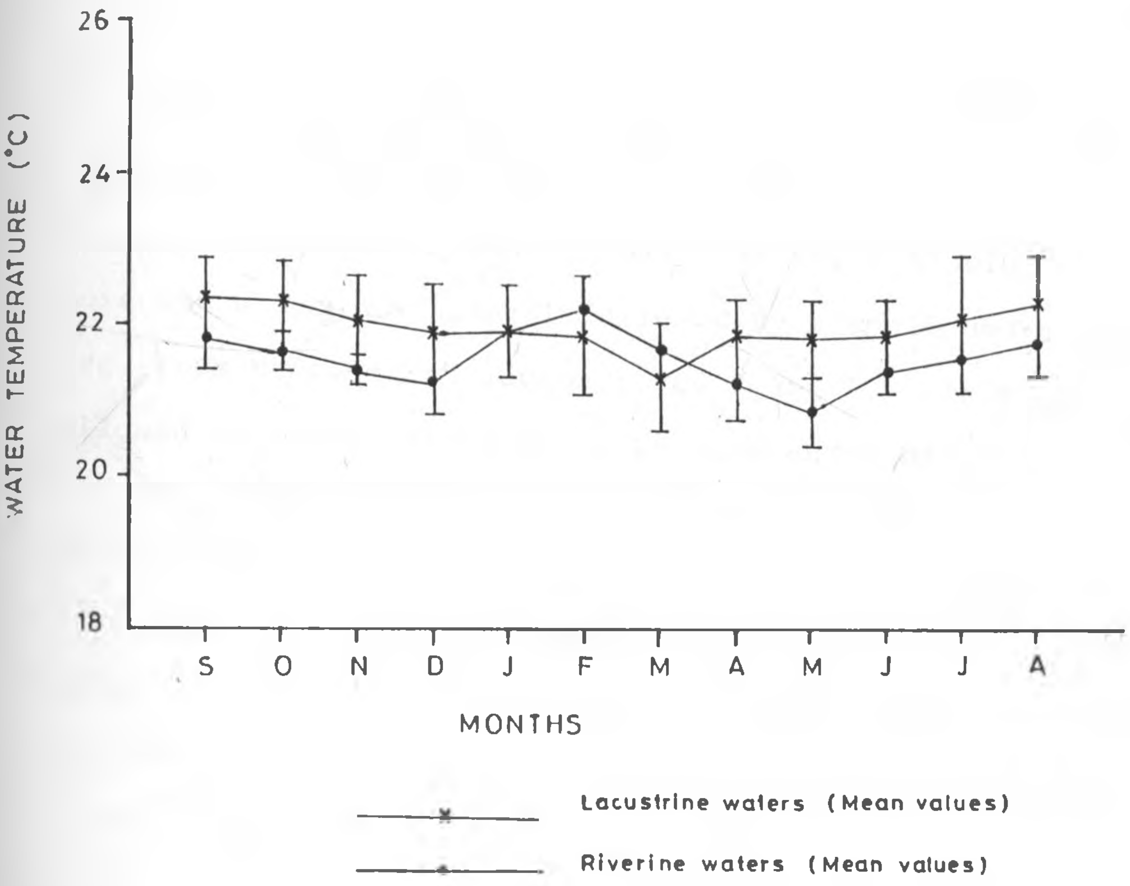
4.1.3. Oxygen concenteration

Mean monthly dissolved oxygen concenterations presented in Table 2 and Fig. 5 indicate that oxygen concenteration was higher in the riverine waters than in the lacustrine one.

In the river, the surface, middle and bottom layers had almost uniform oxygen concenteration throughout the period of study, and they ranged from 6.7mg/l to 7.4mg/l, with a mean of 7.2mg/l. The highest oxygen values of 7.4mg/l was recorded in September,

Fig. 4 - Monthly fluctuations in water temperature of Lake Kamburu and its effluents from September 1978 to August 1979.

Note: Vertical bars depict the standard deviations.



26
24
22
20
18
WATER TEMPERATURE (°C)
S O N D J F M A M J J A
MONTHS
Lacustrine waters (Mean values)
Riverine waters (Mean values)

1978, January, February and March 1979 where as the lowest figure of 6.7/l was observed in the month of May 1979. Both April and June 1979 recorded oxygen concenterations of 7.0mg/l . Generally there were no marked fluctuations in oxygen concenterations in the riverine environment except In the months of April, May and June when there was a marked drop. (Fig. 5).

In the lacustrine environment there were extremely little monthly fluctuations in the surface values of oxygen concenteration and ranged from 5.1mg/l to 5.8mg/l with a mean of 5.5mg/l (Table 2 and Fig. 5). In September, 1978, the oxygen concenteration of the surface waters was 5.8mg/l. In the following two months there was a drop to 5.3mg/l followed by a small and gradual rise, from December to February, to 5.7mg/l. This was again followed by a gradual decrease from March to May, 1979 which recorded 5.6mg/l and 5.1mg/l respectively. From June 1979 onwards there was a slight and gradual rise to August 1979 when a recording of 5.7mg/l was made. Similarly, middle and bottom layers exhibited very little monthly fluctuations in oxygen concenteration - between 4.1 and 5.3mg/l in the middle and 3.4 and 4.2mg/l at the bottom.

4.1.4. Rainfall:

The means of monthly rainfall are presented in Fig. 6
Both lacustrine and riverine rainfall records show that in September, 1978 the rainfall was very low-0mm for the lacustrine and 1.9mm for the riverine environments. This was followed by a heavy downpour in the month of October, 1978 resulting in the recording of a mean of 6.2mm in the river

Table 2 - Monthly variations in conductivity and oxygen concentration of Lake Kamburu From September 1978 to August 1979.

Note: *L - Lacustrine environment

**R = Riverine environment

±SD = Standard Deviation.

Table 2		Mean conductivity (µmhos) ±SD*			Mean oxygen concentration (mg/1) ±SD*		
Month	Environment	Surf.	Mid.	Bot.	Surf.	Mid.	Bot.
Sept. 78	*L	250 ± 18.0	199 ± 12.0	177 ± 6.0	5.8 ± 0.2	5.2 ± 0.2	3.8 ± 0.2
	**R	114 ± 3.0	114 ± 3.0	114 ± 3.0	7.4 ± 0.4	7.4 ± 0.4	7.4 ± 0.4
Oct. 78	*L	200 ± 25.0	188 ± 10.0	175 ± 7.0	5.3 ± 0.3	4.9 ± 0.3	3.7 ± 0.2
	**R	106 ± 4.0	106 ± 4.0	106 ± 4.0	7.3 ± 0.3	7.3 ± 0.3	7.3 ± 0.3
Nov. 78	*L	190 ± 30.0	172 ± 8.0	170 ± 5.0	5.2 ± 0.4	4.1 ± 0.7	3.8 ± 0.3
	**R	109 ± 4.0	109 ± 4.0	109 ± 4.0	7.3 ± 0.2	7.3 ± 0.2	7.3 ± 0.2
Dec. 78	*L	188 ± 23.0	180 ± 15.0	170 ± 4.0	5.6 ± 0.7	5.2 ± 0.3	3.4 ± 0.2
	**R	110 ± 3.0	110 ± 3.0	110 ± 3.0	7.3 ± 0.2	7.3 ± 0.2	7.3 ± 0.2
Jan. 79	*L	190 ± 20.0	188 ± 14.0	174 ± 4.0	5.6 ± 0.7	5.2 ± 0.3	4.0 ± 0.2
	**R	112 ± 2.0	112 ± 2.0	112 ± 2.0	7.4 ± 0.1	7.4 ± 0.1	7.4 ± 0.1
Feb. 79	*L	194 ± 15.0	188 ± 14.0	176 ± 5.0	5.7 ± 0.6	5.3 ± 0.4	4.2 ± 0.3
	**R	113 ± 1.0	113 ± 1.0	113 ± 1.0	7.4 ± 0.2	7.4 ± 0.2	7.4 ± 0.2
Mar. 79	*L	198 ± 24.0	190 ± 9.0	176 ± 5.0	5.6 ± 0.3	5.2 ± 0.2	3.9 ± 0.4
	**R	108 ± 3.0	108 ± 3.0	108 ± 3.0	7.4 ± 0.2	7.4 ± 0.2	7.4 ± 0.2
Apr. 79	*L	180 ± 18.0	179 ± 13.0	173 ± 3.0	5.3 ± 0.3	4.9 ± 0.4	3.8 ± 0.2
	**R	106 ± 4.0	106 ± 4.0	106 ± 4.0	7.0 ± 0.3	7.0 ± 0.3	7.0 ± 0.3
May 79	*L	166 ± 24.0	165 ± 16.0	165 ± 4.0	5.1 ± 0.2	4.4 ± 0.3	3.8 ± 0.2
	**R	106 ± 6.0	106 ± 6.0	106 ± 6.0	6.7 ± 0.1	6.7 ± 0.1	6.7 ± 0.1
Jun. 79	*L	170 ± 32.0	168 ± 11.0	168 ± 11.0	5.4 ± 0.6	4.8 ± 0.4	3.6 ± 0.2
	**R	110 ± 4.0	110 ± 4.0	110 ± 4.0	7.0 ± 0.2	7.0 ± 0.2	7.0 ± 0.2
Jul. 79	*L	200 ± 30.0	180 ± 14.0	170 ± 7.0	5.6 ± 0.8	5.1 ± 0.5	3.8 ± 0.4
	**R	112 ± 2.0	112 ± 2.0	112 ± 2.0	7.2 ± 0.2	7.2 ± 0.2	7.2 ± 0.2
Aug. 79	*L	245 ± 10.0	200 ± 8.0	176 ± 5.0	5.7 ± 0.5	5.1 ± 0.4	3.9 ± 0.2
	**R	113 ± 1.0	113 ± 1.0	113 ± 1.0	7.2 ± 0.2	7.2 ± 0.2	7.2 ± 0.2

*L Lacustrine environment
**R Riverine environment

Table 3 - Monthly means of surface, midwater and bottom limnological parameters in Lake Kamburu from September 1978 to August 1979.

Note: Laç = Lacustrine environment

Riv = Riverine environment

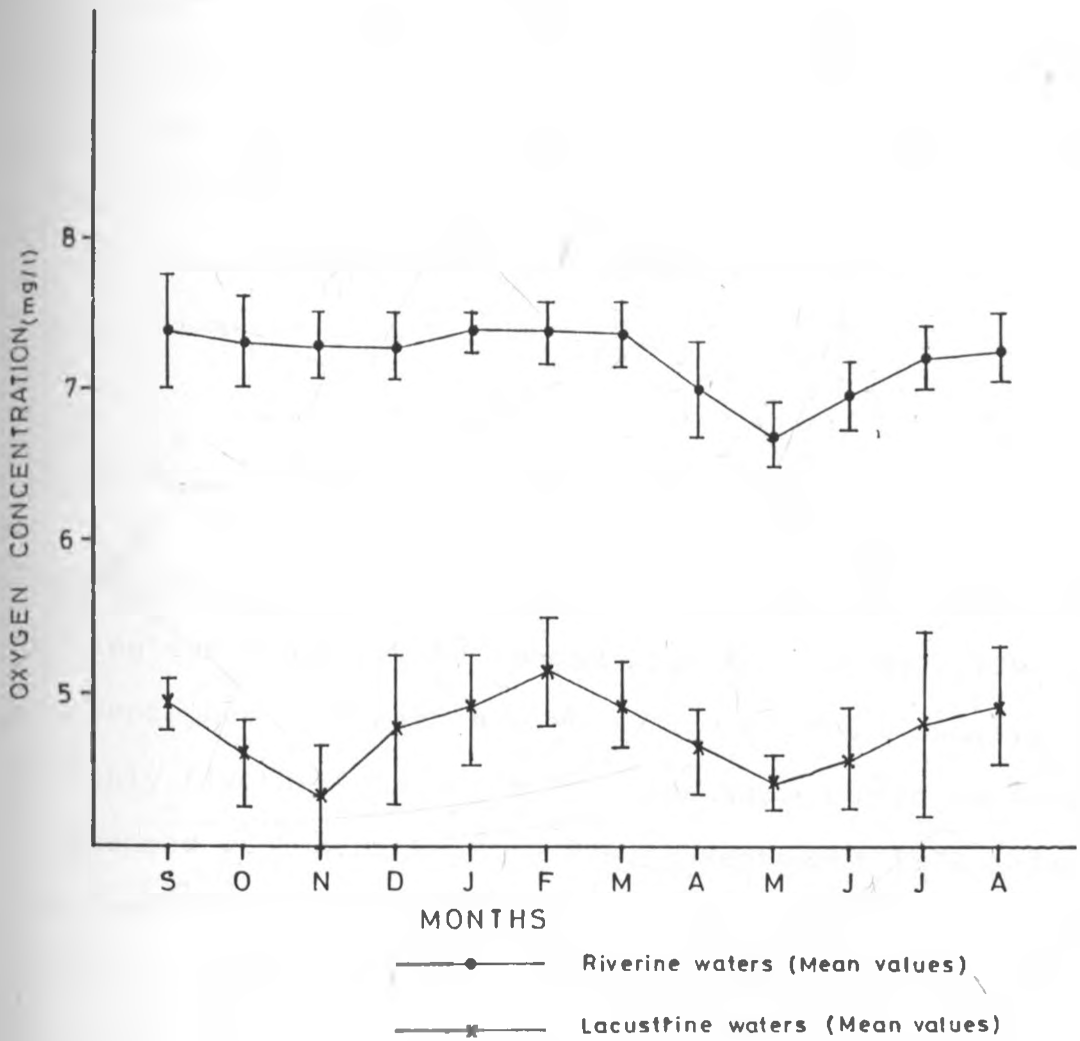
±SD = Standard deviation.

Month		Env.	Temp °C	Oxygen Conc (mg/1)
Sept.	78	Lac	22.3±0.4	4.9± 0.2
		Riv.	21.8±0.3	7.4±0.4
Oct	78	Lac	22.3±0.5	4.6±0.3
		Riv	21.6±0.2	7.3±0.3
Nov.	78	Lac	22.0±0.5	4.4±0.5
		Riv	21.4±0.2	7.3±0.2
Dec.	78	Lac.	21.9±0.5	4.7±0.4
		Riv	21.2±0.3	7.3±0.2
Jan	79	Lac	21.8±0.5	4.9±0.4
		Riv	21.8±0.3	7.4±0.1
Feb	79	Lac	21.8±0.7	5.16±0.4
		Riv	22.0±0.3	7.4±0.2
Mar	79	Lac	21.7±0.5	4.7±0.3
		Riv	21.2±0.4	7.0±0.3
Apr	79	Lac	21.2±0.7	4.7±0.3
		Riv	21.6±0.2	7.4±0.2
May	79	Lac	21.6±0.5	4.4±0.2
		Riv	20.9±0.4	6.7±0.2
June	79	Lac	21.8±0.5	4.6±0.4
		Riv	21.4±0.2	7.0±0.2
July	79	Lac	22.0±0.7	4.8±0.6
		Riv	21.5±0.3	7.2±0.2
August	79	Lac	22.3±0.7	4.9±0.4
		Riv	21.7±0.4	7.2±0.2

PH	Conductivity μmhos
8.5±0.3	209±12
7.7±0.1	114±3.0
8.3±0.3	188±14
7.6±0.1	106±4.0
8.1±0.4	177.3±14
7.6±0.1	109±4.0
8.0±0.4	179±14
7.6±0.1	110±3.0
8.0±04	184±13
7.6±0.1	112±2.0
8.3±0.3	186±11
7.6±0.1	113±1.0
8.3±0.4	177.3±11
7.6±0.1	106±4
8.6±0.4	188±13
7.6±0.1	108±3.0
7.9±0.5	165.3±145
7.6±0.1	106±6.0
8.23±0.4	168±18
7.6±0.1	110±4.0
8.6±0.3	183±17
7.7±0.1	112±2.0
8.8±0.3	207±8.0
7.6±0.1	113±1.0

Fig. 5 = Monthly variations in oxygen concenteration of Lake Kamburu and its affluents from September 1978 to 1979.

Note: Vertical bars indicate the standard deviations.


OXYGEN CONCENTRATION (mg/l)
8
7
6
5
S O N D J F M A M J J A
MONTHS
Riverine waters (Mean values)
Lacustrine waters (Mean values)

and 4.0mm in the lake. The following months realised a slight increase in the lacustrine and a drop in the riverine environments, until the month of February, 1979 when a significant drop to 0.3mm in lacustrine waters and 1.8mm in the riverine waters were realised. From the middle of March 1979 and the following months the rains started again reaching a climax in May, 1979 which recorded 7.5mm and 9.5mm for the lacustrine and riverine environments respectively. The rainfall then reduced from June, 1979 onwards reaching a a low level of 0.2mm for the lacustrine and 0.5 for the riverine environments in August, 1979.

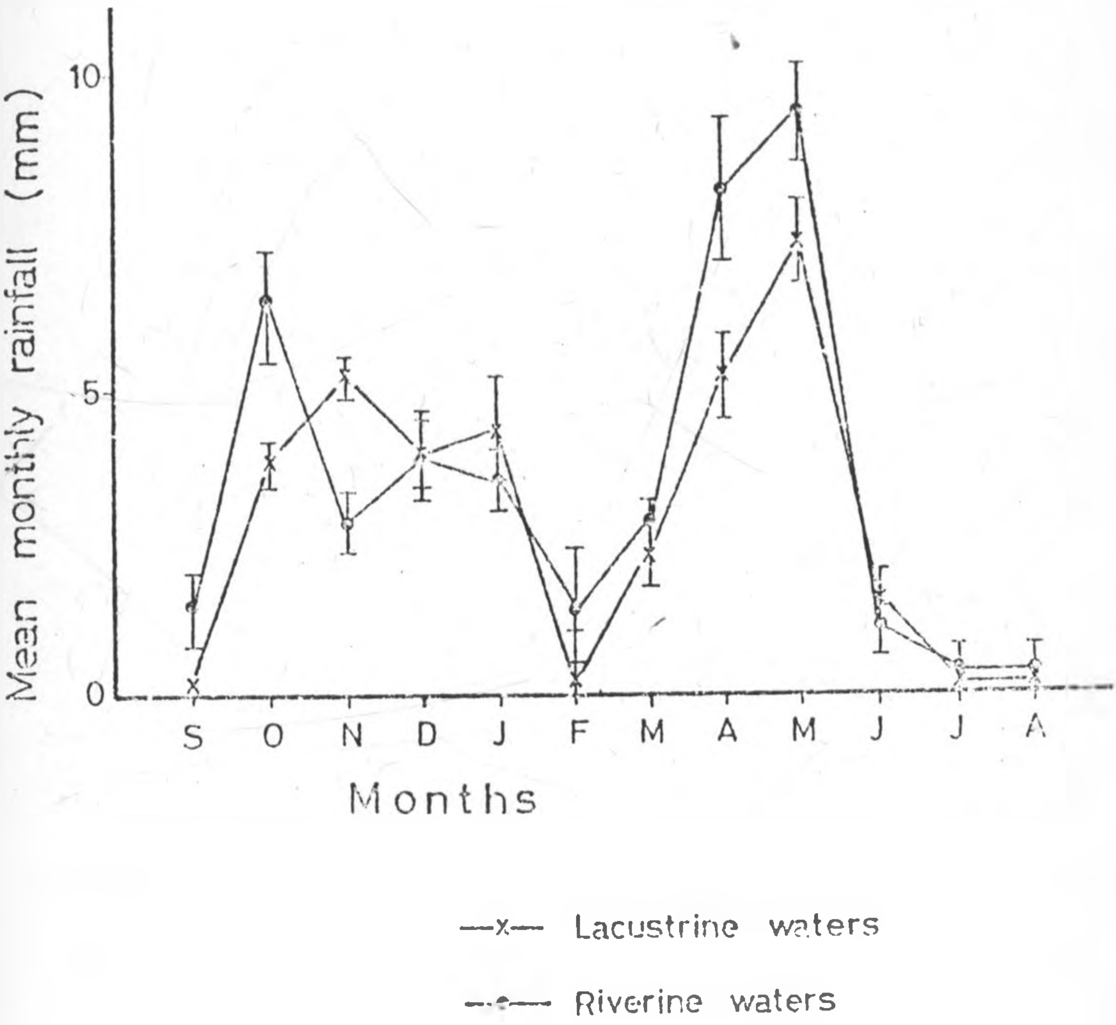
4.1.5 p^H

The surface p^H of the lacustrine environment of Lake Kamburu during the study period ranged from 8.3. in May 1979 to 9.8 in September 1978 with a mean of 9.0 (Table 1 and Fig. 7). Monthly fluctuations in the surface values were observed and this commenced with a high p^H of 9.8 in September 1978 reducing gradually in the following months and reaching a low figure of 8.7. in January 1979. There followed a two a month slight increase in p^H in February and March 1979 reaching a value of 9.25. April and May 1979 had a low value of 8.7 and 8.3 respectively followed by a gradual increase from 8.9 in June 1979 reaching a high value of 9.7 in August 1979. The p^H of the middle layer ranged from 7.8 in May 1979 to 8.8 in April 1979 with a mean of 8.2, while that of the bottom waters had a range of 7.4 recorded in February 1979 and 8.1 in August 1979 with a mean of 7.7 (Table 1) monthly fluctuations in midwaters and bottom waters in the lacustrine environments were very slight.

Fig. 6 Monthly fluctuations in rainfall of Lake Kamburu and its affluents from September 1978 to August 1979.

Note: Vertical bars indicate the standard deviations.

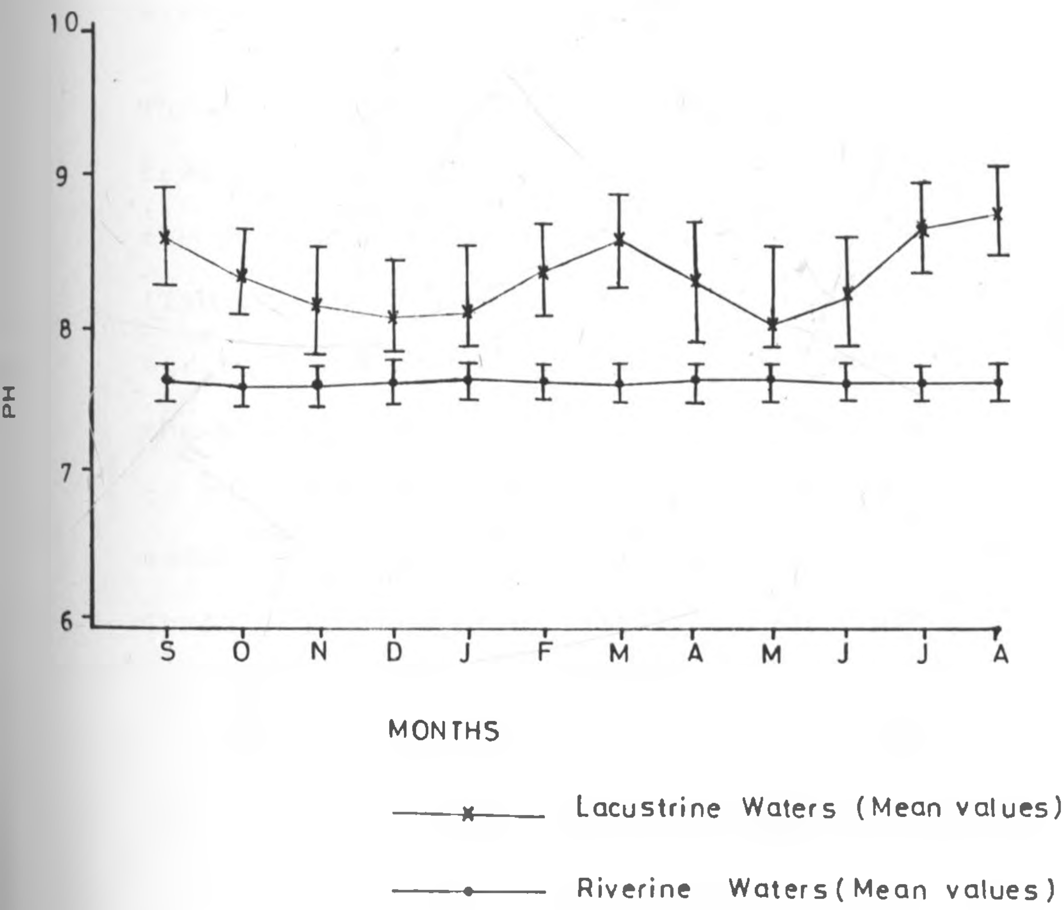
The graph was drawn from re-analysed data from the Department of Fisheries and the Kenya Power and Lighting COmapny.



Mean monthly rainfall (mm)
10
5
0
S
O
N
D
J
F
M
A
M
J
J
A
Months
—x— Lacustrine waters
—•— Riverine waters

Fig. 7 Monthly fluctuations in p^H of Lake Kamburu and its affluents from September 1978 to August 1979.

Note: The vertical bars indicate the standard deviations


10
9
8
7
6
PH
S
O
N
D
J
F
M
A
M
J
J
A
MONTHS
Lacustrine Waters (Mean values)
Riverine Waters (Mean values)

In the riverine environment a p^H of 7.6 was recorded from both surface and bottom layers throughout the period of the study. The fluctuations were very slight and therefore negligible (Table 1 and Fig. 7.). These results suggest that there was stratification in pH only in the lacustrine environment.

4.1.6. <u>The Conductivity</u>

The conductivity of the surface waters of Lake Kamburu ranged from 250 μmhos in September, 1978 to 166 μmhos in May 1979 in the purely lacustrine waters, with a mean of 198 μmhos (Table 2 and Fig. 8). There was a marked fluctuation in the surface conductivity commencing in September 1978 which recorded the highest value of 250 μmhos. This was followed by a drop to 200 μmhos in the month of October, and a further gradual reduction to December when a reading of 188 μmhos was made. There was followed a three-month increase reaching a maximum of 198 μmhos in March 1979. This was again followed by a three-month reduction ending in June 1979 with a value of 170 μmhos. In the following months the conductivity increased reaching a maximum of 245 μmhos in August 1979.

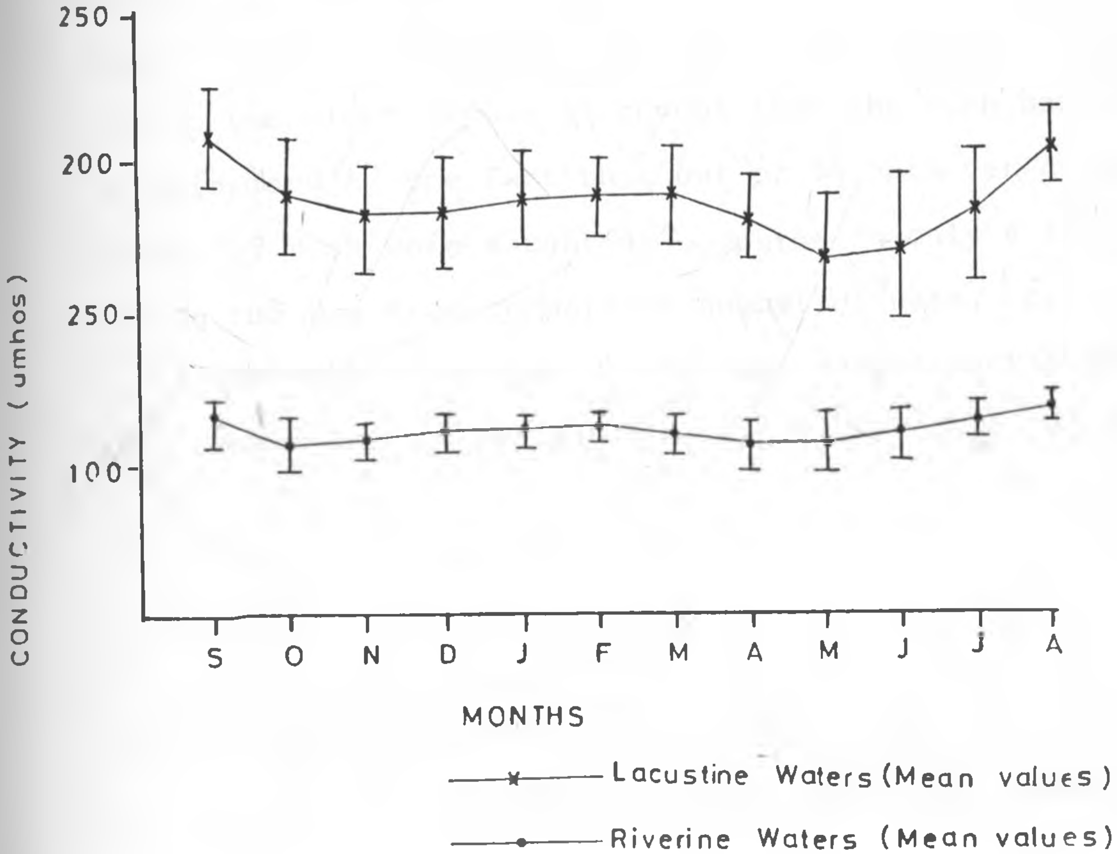
In the middle waters of the lacustrine environment, the conductivity varied between 165 μmhos recorded in May 1979 to 200 μmhos recorded in August 1979 with a mean of 183 μmhos. The conductivity was high, 199 μmhos, from the beginning of the study in September 1978 but by November it had reduced to 172 μmhos. It increased slightly in December and increased further in January and February 1979 equalling the October 1978 value of 188 µmhos. March saw a slight increase in the conductivity of the middle water up to 190 µmhos followed by two-month reduction to 165 µmhos. The conductivity started picking up again from June when a value of 168 µmhos was recorded. From this time the conductivity increased consistently reaching a peak in August 1979.

At the bottom of the Lake, the highest conductivity of 177 µmhos was recorded in September 1978. The conductivity then reduced gradually to 170 µmhos by December 1978. The intervening three months saw an increase in this parameter reaching 176 µmhos. A lower value of 173 µmhos was recorded in April followed by the minimum conductivity of 165 µmhos in May from when a gradual increase reaching a near maximum of 176 µmhos was recorded by August 1979. Relatively, the least fluctuation in conductivity was found at the bottom of the lake 165 µmhos - 177 µmhos as compared to 166 µmhos - 250 µmhos and 165 µmhos - 200 µmhos at the surface and midwaters respectively. The mean was also the least - 172 µmhos as compared to 198 µmhos at the surface and 183 µmhos in the middle.

In the riverine environment no difference in conductivity were found at different depths as compared to the variations evidenced at the various depths in the lacustrine environment. (Table 2 and Fig. 8). The conductivity varied between 106 µmhos recorded in October 1978 and May 1979 and 114 µmhos recorded in September 1978 with a mean of 109 µmhos .

Fig. 8 Monthly variations in conductivity of Lake Kamburu and its affluents from September 1978 to August 197

Note: Vertical bars indicate the standard deviations.


250
200
250
100
CONDUCTIVITY (umhos)
S O N D J F M A M J J A
MONTHS
Lacustine Waters (Mean values)
Riverine Waters (Mean values)

There was no marked monthly fluctuations in conductivity in the riverine waters. It was observed that water from the river entered the lake at a lower conductivity.

4.2. Biological parameters

Results of experimental catches from gill nets with varying mesh sizes set during the day when compared with the catches during the night (Table 4) reveal that the fish was nocturnal as evidenced by the fact that out of 54 nets set during the night, 49 fish were caught as compared to only 6 fish caught during the day from comparable number of nets. Difference numbers of fish caught at night were significantly higher than that caught during the day time. ($X = 33.496$ $P < 0.001$ df = 1).

Table 4 Mormyrid catches from experimental gill nets set in Lake Kamburu from 12th - 30th August 1978

Diel Periodicity	No. of nets set	No. of fish caught
Day Time	54	6
Night Time	54	49

Mesh sizes of nets (mm): 47.5, 51. 63.5, 76, 101.5 and 114.2.

During the study period, from 1st September 1978 to 30th August 1979, a total of 679 specimens were captured.

Sites I and II (extreme lacustrine environment) did not yield any Mormyrus spp. while sites III and VII (lacustrine environment and the mixed environment respectively yielded a total of 41 specimens. In sites IV and VIII (mixed environment) a total of 110 specimens were caught. The rest of the specimens were caught in sites V, VI, IX and X (riverine environment).

The beach seine and the mosquito seine nets did not catch any Mormyrus spp. at all, while the traditional double - basket caught a total of 25 of which six were juveniles. Two juveniles were captured in site VII and 4 in site X. It therefore follows that 654 speciments were captured through gill netting.

4.2.1. Length - weight relationship

The following equations were computed for the length-weight relationship of M. kannume

(i) Imature males and females combined

$\text{Log } W = -1.7859 + 2.8808 \text{ Log}$

$\text{SD Log } W = \pm 0.112$

$\text{SD Log } L = \pm 0.041$

$n = 35$
$r = 0.92$
$p < 0.01.$

(ii) Mature females

$\text{Log } W = 1.3091 + 2.5615 \text{ LogL}$
$\text{SD Log } W = \pm 0.184$
$\text{SD Lg } L = \pm 0.106$

$n = 320$
$r = 0.87$
$p < 0.01$

(iii) Mature males

$$\text{Log } W = -2.1546 + 3.1564 \text{ LogL}$$

$$\text{SD Log } W = \pm 0.119$$

$$\text{SD Log } L = \pm 0.085$$

n - 320
r = 0.84
$p < 0.02$

The length = weight relationships of mature females and males are presented in both their normal (scatter diagram) and longarithmic forms in FIgs. 9, 10, 11 and 12 respectively.

Fig. 9 length - weight relationships of females Mormyrus kannume in Lake plotted as a scatter diagram.

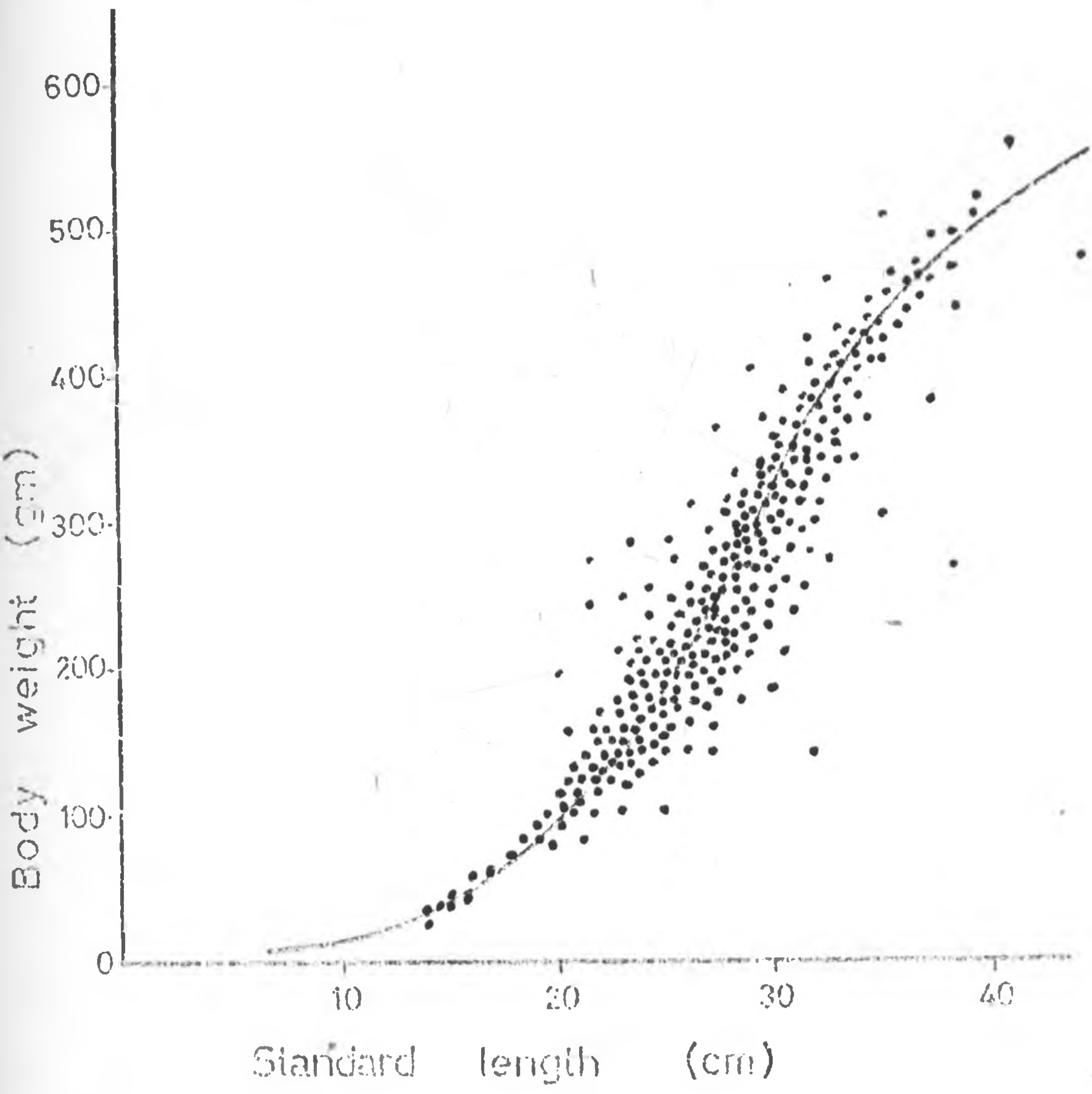

600
500
400
300
200
100
0
Body weight (gm)
10
20
30
40
Standard length (cm)

Fig. 10. Length - Weight relationships of mature females <u>Mormyrus kannume</u>

In Lake Kamburu plotted in their log drithmic values.

$$\text{Log. } W = 1.30906 + 2.5615 \text{ Log } L$$

$n = 320$

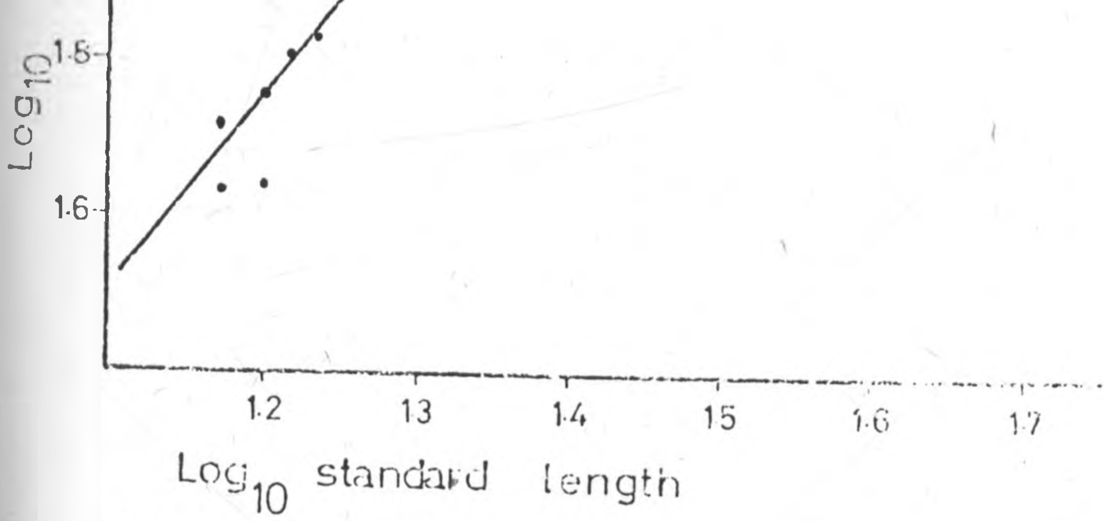
$r = 0.87$

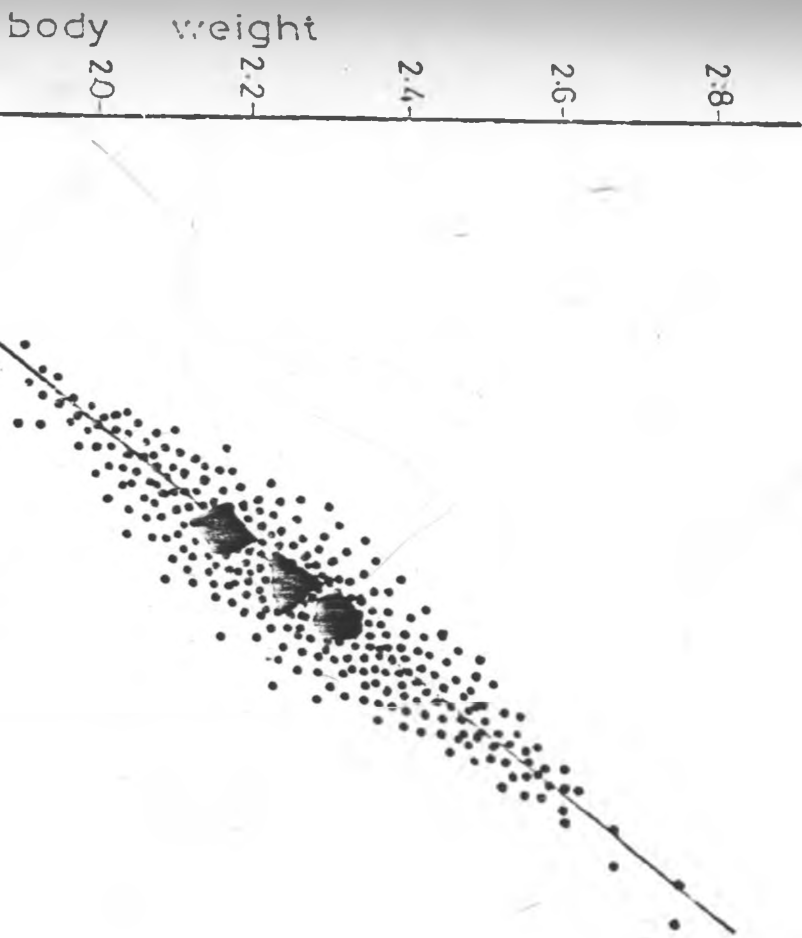
$p < 0.01$

▲ Represents 32 fish

● Represents 23 fish

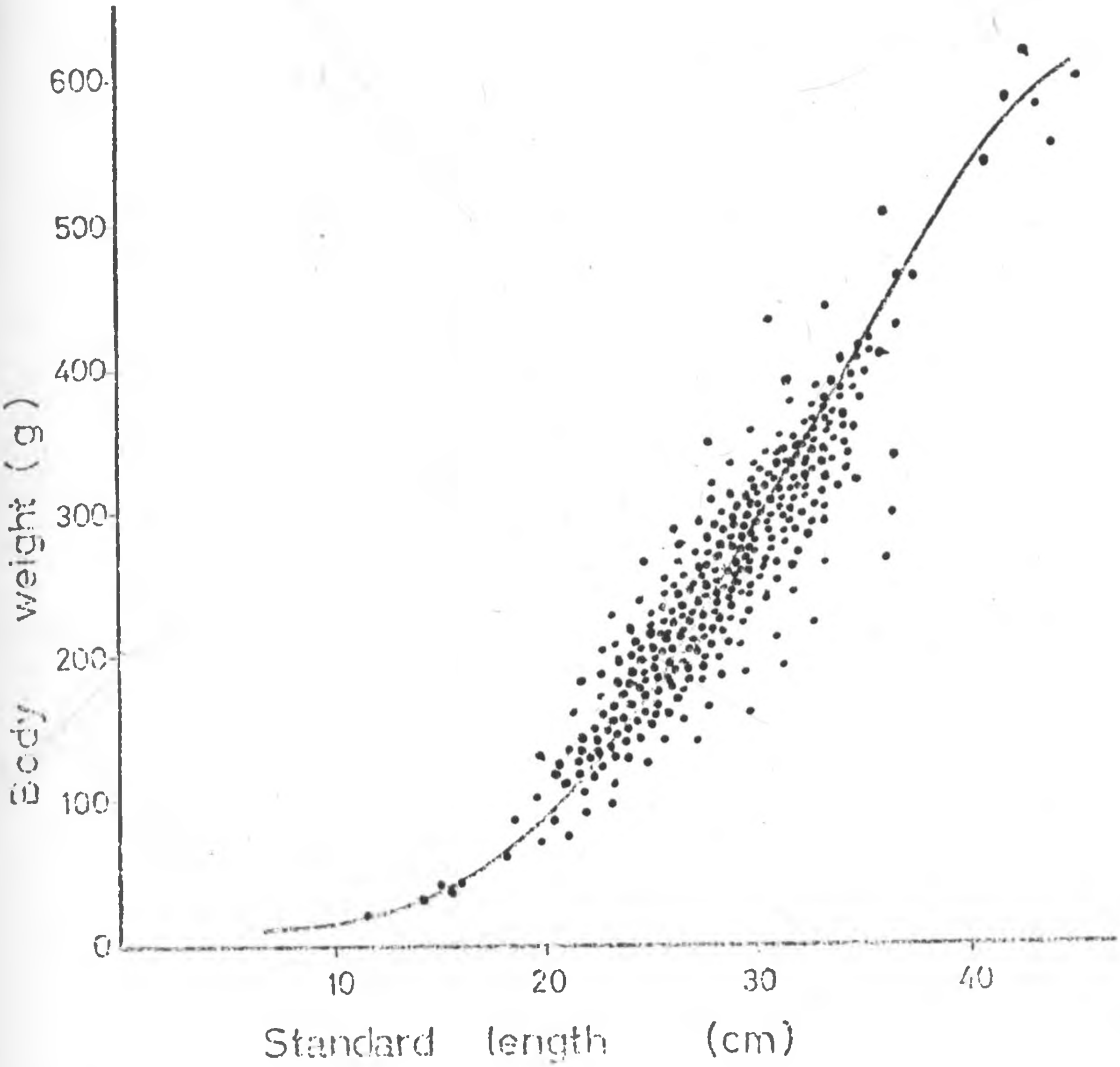
■ Represents 13 fish


Log10
1.8
1.6
1.2
1.3
1.4
1.5
1.6
1.7
Log10 standard length



body weight
2.0
2.2
2.4
2.6
2.8

Fig 11. Length - weight relationship of mature males of Mormyrus kannume in Lake Kamburu plotted as scatter diagram.



600
500
400
300
200
100
0
Body weight (g)
10
20
30
40
Standard length (cm)

Fig. 12. Length - weight relationships of the males of Mormyrus kannume in Lake Kamburu plotted in their log drithm values

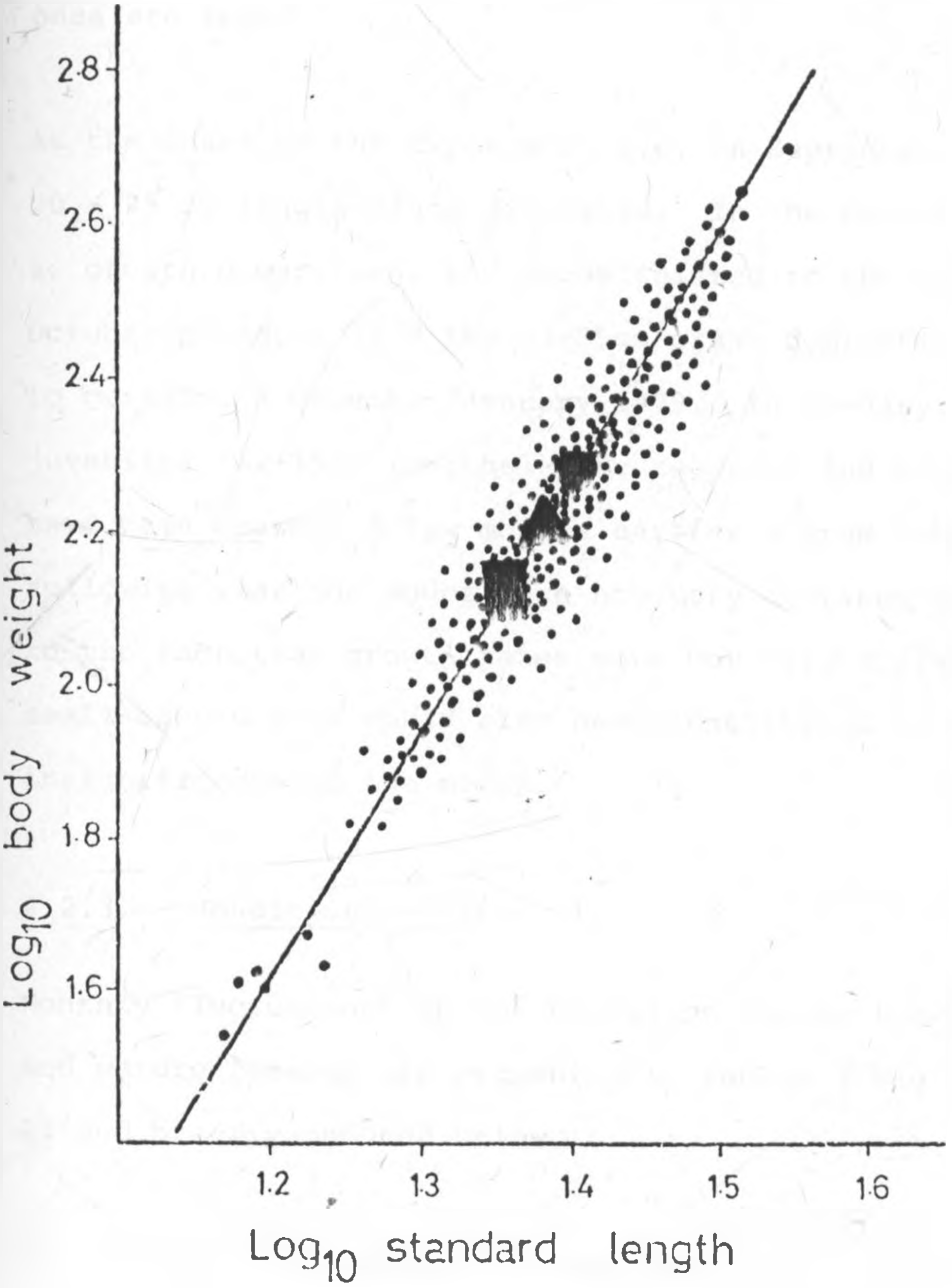
Log W = - 2.1564 + 3.1564 Log L

n = 320

r = 0.84

p.= 0.02

▲ Represents 40 fish
● Represents 25 fish
■ Represents 32 fish



2.8
2.6
2.4
2.2
2.0
1.8
1.6
Log10 body weight
1.2
1.3
1.4
1.5
1.6
Log10 standard length

4.2.2. Length - Frequenty distribution

The length - frequency distribution presented in Fig. 13 shows the existance of size classes ranging from 20cm when M. kannume enters the commercial fishery up to 40cm when the very mature ones are found.

At the onset of the experiment i.e. in September, 1978, the 20 - 25 cm length-class dominated. In the course of time and as growth progressed, the modes shifted to the right. In October/November 1978 the 25-35cm class dominated and seemed to persist in December/January 1979. In January, some juveniles (12-15cm lengths) were recorded and these could have been spawned a few months earlier. From February of the following year the modes were not very distinct due probably to the fact that growth rates were not very striking. The small sample size could also have contributed to the insignificance of the modes.

4.2.3. Condition factor

Monthly fluctuations in the condition factor for both immature and mature females are presented in Tables 5 and 6 and Figs. 14 and 15 and briefly annoted below.

It is noted that immature fishes had a generally higher condition factor than the mature ones. However, monthly fluctuation were more evident in the mature fishes than the immature although both groups followed a more or less similar pattern. At the onset of the experiment i.e. from September 1978, the condition factor of the mature fishes were generally low (1.08 and 1.0 for males and females respectively).

Fig.13 Monthly variations in length - frequency polygons of <u>M. kannume</u> in Lake Kamburu.

Note: "N" indicates the number of fish sampled.

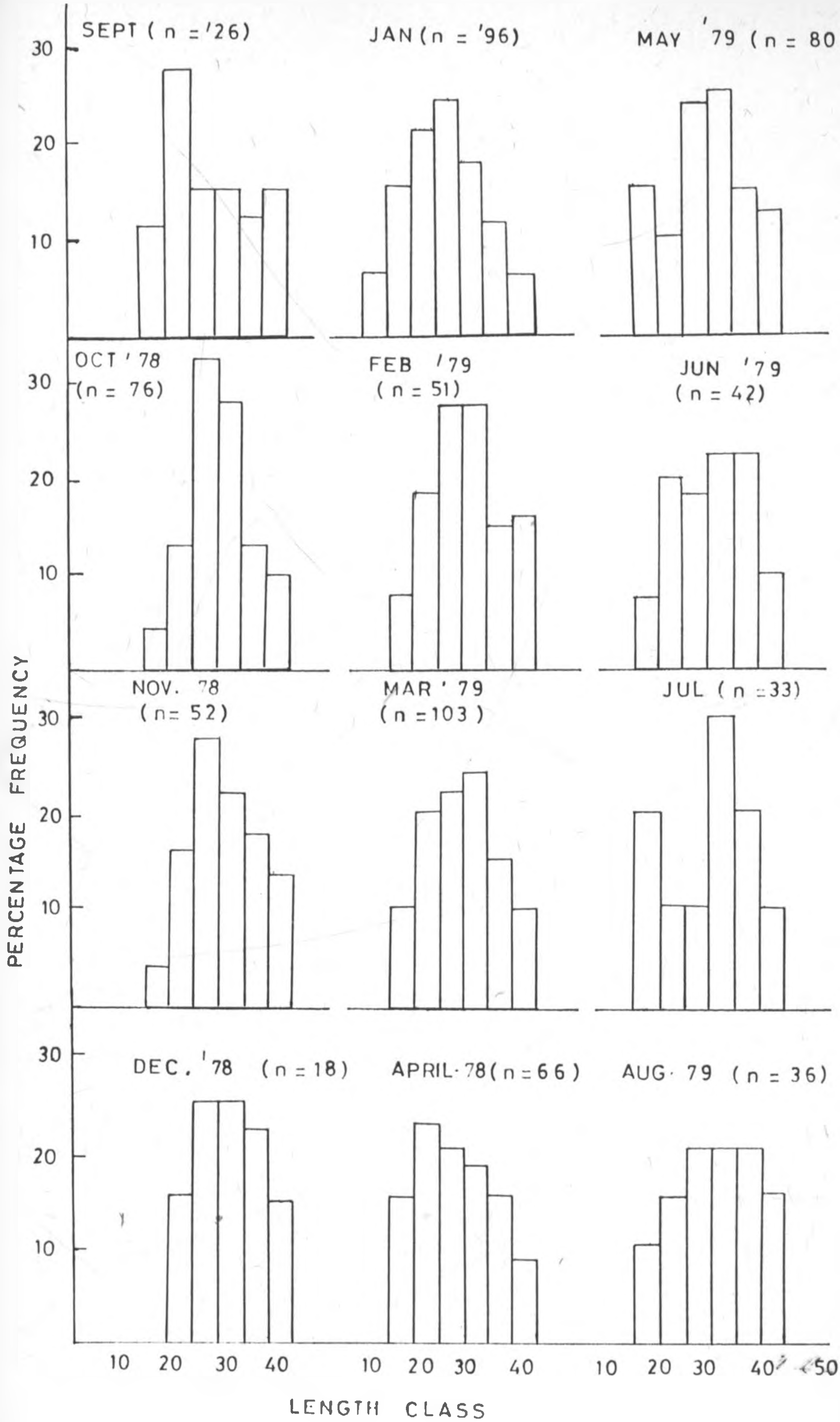

SEPT (n = '26)
JAN (n = '96)
MAY '79 (n = 80)
OCT '78 (n = 76)
FEB '79 (n = 51)
JUN '79 (n = 42)
NOV. '78 (n= 52)
MAR '79 (n =103)
JUL (n =33)
DEC. '78 (n = 18)
APRIL 78 (n = 66)
AUG 79 (n = 36)
PERCENTAGE FREQUENCY
10
20
30
40
50
LENGTH CLASS

Table 5 Monthly variations in the condition factor of males M. kannume in Lake Kamburu from September 1978 to August 1979.

Note: Figures in parentheses indicate the number of fish

CONDITION FACTOR

Month		Immature	Mature
September	78	(4) 1.13 ± 0.05	(12) 1.08 ± 0.02
October	78	(7) 1.25 ± 0.12	(37) 1.20 ± 0.04
November	78	(4) 1.15 ± 0.09	(23) 0.80 ± 0.02
December	78	(1) 1.25 ± 0.00	(10) 0.80 ± 0.02
January	79	(14) 1.23 ± 0.13	(23) 1.00 ± 0.04
February	79	(3) 1.30 ± 0.15	(22) 1.01 ± 0.03
March	79	(8) 1.38 ± 0.15	(45) 1.05 ± 0.03
April	"	(5) 1.31 ± 0.09	(25) 0.80 ± 0.03
May	79	(9) 1.25 ± 0.11	(34) 0.75 ± 0.02
June	79	(6) 1.28 ± 0.12	(16) 1.00 ± 0.20
July	79	(4) 1.28 ± 0.12	(13) 1.00 ± 0.30
August	79	(5) 1.33 ± 0.16	(17) 1.15 ± 0.04

NOTE : Figures in parentheses indicate the number of fish.

Table 6 Monthly fluctuation in the condition factor of female M. kannume in Lake Kamburu from September 1978 to August 1979.

Note: Figures in parentheses indicate the number of fish.

CONDITION FACTOR

nth		Immature	Mature
ptember	78	(2) 1.20 ± 0.09	(8) 1.0 ± 0.15
ctober	78	(11) 1.17 ± 0.11	(21) 1.15 ± 0.18
vember	78	(4) 1.14 ± 0.08	(21) 1.1 ± 0.11
cember	78	(3) 1.10 ± 0.08	(4) 0.8 ± 0.18
nuary	79	(14) 1.12 ± 0.08	(45) 0.9 ± 0.02
bruary	79	(8) 1.17 ± 0.13	(18) 1.10 ± 0.09
rch	79	(14) 1.21 ± 014	(36) 1.16 ± 0.21
ril	79	(4) 1.11 ± 0.13	(30) 0.9 ± 0.15
y	79	(10) 1.09 ± 0.20	(27) 0.8 ± 0.11
ne	79	(6) 1.08 ± 0.14	(14) 1.0 ± 0.19
ly	79	(5) 1.19 ± 0.30	(11) 1.11 ± 0.21
gust	79	(3) 1.20 ± 0.11	(11) 1.2 ± 0.25

Fig 14. Monthly fluctuations in the condition factor of immature and mature females of Mormyrus kannume in Lake Kamburu from September 1978 to August 1979.

Note: Vertical bars indicate the standard deviation.

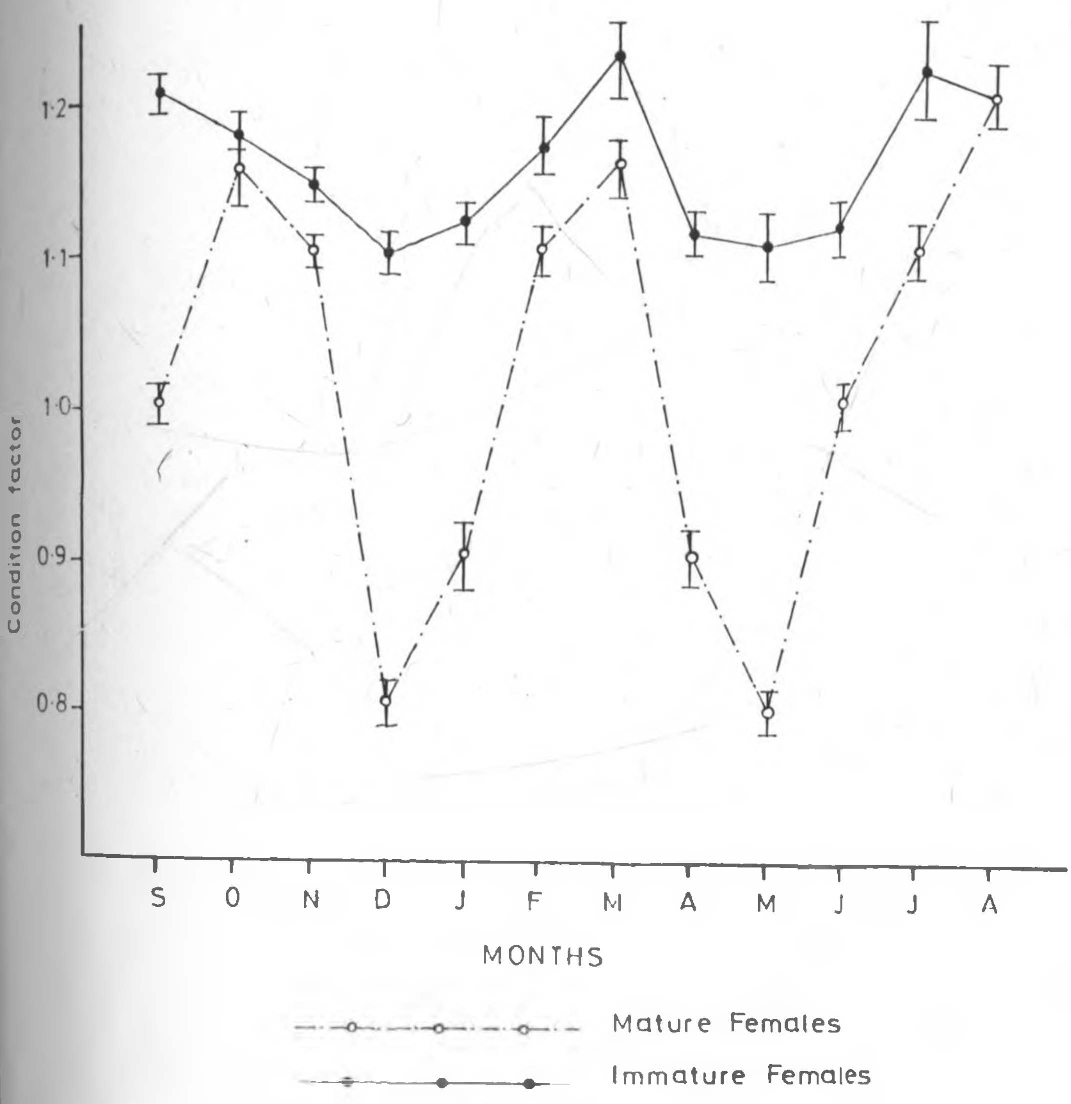
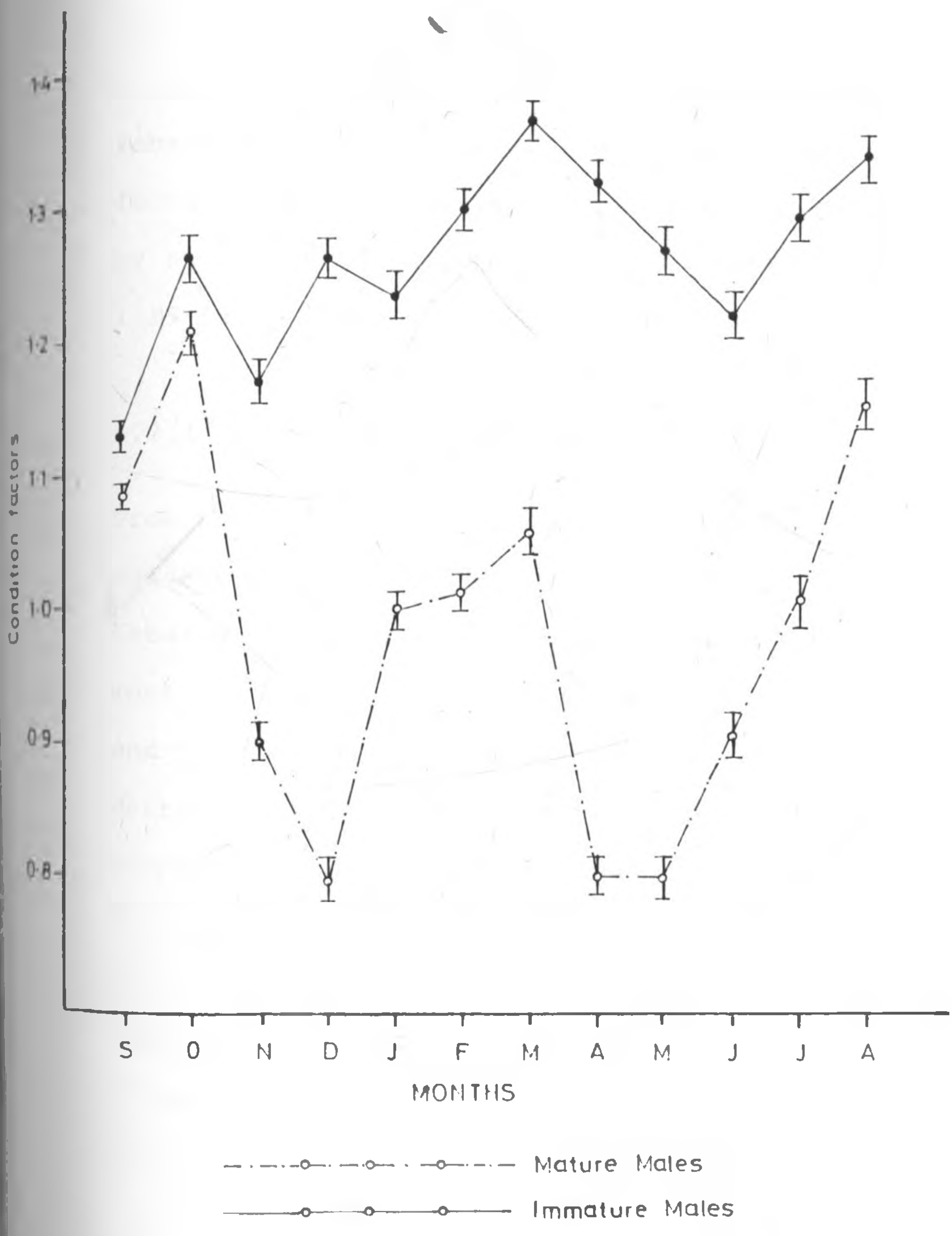

Condition factor
1·2
1·1
1·0
0·9
0·8
S
O
N
D
J
F
M
A
M
J
J
A
MONTHS
Mature Females
Immature Females

Fig.15.Monthly fluctuations in the condition factor of immature and mature males of *Mormyrus kannume* in Lake Kamburu from September 1978 to August 1979.

Note: Vertical bars depict standard deviation.



Condition factors
1·4
1·3
1·2
1·1
1·0
0·9
0·8
S
O
N
D
J
F
M
A
M
J
J
A
MONTHS
Mature Males
Immature Males

During the following two months the conditions factor in the females increased to 1.15. In the males however, the "K" factor Increased to 1.20 in October and reduced to 0.8 in November. The Letter "K" value was attained by the females in December when the "K" factor in males remained unchanged. Then followed an increase in January and February for males and in February and March for females. There was then a drop in condition factor in both sexes in April and May which was again followed by an increase reaching a peak in August 1979 when a "K" factor of 1.15 for males and 1.2 for females were recorded.

4.2.4. Food and feeding habits

From the results of the present investigations, it becomes evident that M. Kannume in Lake Kamburu is an insectivorous fish, feeding mainly on the aquatic stages of the class Insects. The most important foods were dipteran larvae Chironomus spp. and Tanytarsus spp., the ephemeropteran nymph, Baetis spp and detritus. These constituted 32.1%, 27.5%, 11.2% and ii.4% respectively as the main contents and 88%, 79%, 30.5% and 11.4% respectively in the frequency of occurence (Table 6 Figs 16 and 17). Empty guts were very rare in all the specimens examined with the exception of only one fish. Some had masses of benthic and detritus mixture which rendered detailed analysis difficult.

From Ekman's bottom samples it was observed that Baetis spp. Chironomus spp. and Tanytarsus spp. formed the majority of the food items and constituted 25%, 15% and 10% respectively of all the benthic organisms in the environment. High Electricity

Index was observed in the Odonata nymph Gomphus spp, Tanytarsus spp. Chironomus spp and Pteronocella spp. which were 0.9, 0.8 and 0.7 respectively (Fig. 17). It was observed that although Baetis spp was the most abundant food item in the environment it was not heavily fed on as evidenced by the low Electricity Index of only 0.1. There was a clear preference for the Odonata nymph Gomphus spp which although constituted only 0.5% of the food in the bottom samples, had an Electricity Index of 0.9 (Table 7, Fig. 17). The least Prefered food was the coleopteran larvae Promoresia spp which although consitituted 3% of the food available in the grab samples, had an Electricity Index of 0.03. Those that indicated negative selection included Cyclops spp (E=1), Hydropsyche spp (E = - 0.1), Daphnia spp. (E = - 0.04) and Promoresia spp (E = - 0.03). These that denoted exclusive positive selection included Gomphus spp. (E = 0.9), Tanytarsus spp. (E = 0.8) Chironomus spp. and Pteronacella spp. (E = 0.7 each). Those that demostrated absence of any selection included Baetis spp. (E = 0.1) and Chaoborus spp. (E = 0.3) (Table 7, Fig. 17)

Monthly fluctuations of major food items in the stomach were compared with that of the environment in monthly samples (Table 8 and Fig. 18). Chironomus spp. fluctuated between 30.7% and 33.9% in the guts and between 10% and 20.5% in the environment Tanytarus spp. between 25% and 32.1% in the gut and between 7% and 14% in the environment, Baetis spp. between 7.9% and 14.9% in the gut and between 22% and 26.6% in the environment, Hydropsyche spp. between 1.6% and 3.8% in the gut and between 0% and 12% in the environment, Pteronacella spp. between 1.6%

and 2.4% in the gut and between 0% in the environment, Chaoborus spp. between 1.1.% and 2.8.% in the gut and between 1.8% and 4.8% in the environment and Gomphus spp. between 1.4% and 7.2.% on the gut between 0% and 1.5.% in the environment.

From the drawings of the head and the mouth in Fig.19, it shows that the snout, mouth, lips and teeth of M. kannume are well adapted for insectivorous life. The long tube - like snout and a mouth with a row of tiny teeth are normally used for picking insects even if the latter are partially hidden in the mud and cracks of woodstumps or rocks.

Mean monthly Gastrosomatic Indices (G.S.I.) of M. kannume varies between 1.9 and 2.95 in females and 2.75 to 3.2 in males (Table 9 and Fig. 20). In both sexes higher mean values were observed in the months of September/October 1978, January/ February 1979 and July/August 1979. Lower values in G.S.I. were observed in the months of November 1978, and April/May 1979. The fluctuations were more evidenced in the females than males. An attempt was made to correlate the G.S.I. with the temperature, rainfall and some biological paramters and the results were as follows:

Between G.S.I. and Temperature.

Females

Riverine $r = 0.97$, $P < 0.001$ d.f. = 11
Lacustrine $r = 0.64$, $P < 0.025$ d.f = 11

Males

Riverine $r = 0.94$, $P < 0.001$, d.f. = 12
Lacustrine $r = 0.88$, $P < 0.001$, d.f. = 12

Between G.S.I. and Rainfall

Males

Riverine r = - 0.56 $P < 0.1$ d.f. = 11
Lacustrine r = - 0.5 $P < 0.1$ d.f. = 11

Females

Riverine r = - 0.74 $P<0.05$ d.f. = 11
Lacustrine r = - 0.72 $P<0.01$ d.f. = 11

Between G.S.I. and Condition Factor

Males/Males

r = 0.93 $P<0.001$ d.f. = 11

Females/Females

r = 0.64 $P<0.025$ d.f. = 11

Between G.S.I. and Gonadosomatic Index (g/s)

Males/Males

r = 0.98 $P < 0.001$ d.f. = 11

Females/Females

r = 0.88 $P < 0.001$ d.f. = 11

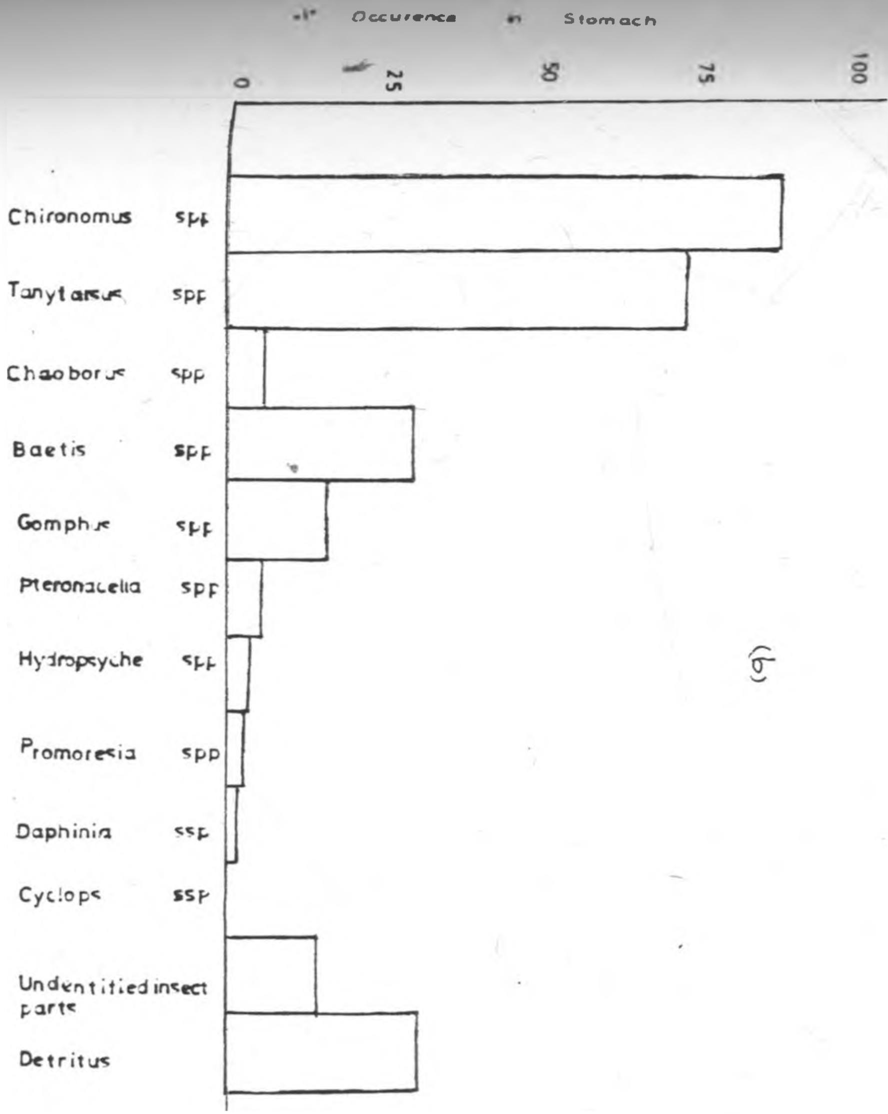
From the above observations, it is realised that there were significant and positive correlations between Gastrosomatic Index and Temperature, condition factor and Gonadosomatic Index. There was a negative correlation between G.S.I. and Rainfall.

Monthly fluctuations in the abdominal fact content are presented in Table 10 and Fig. 21). It is noted that fat accumulation in the abdominal cavities occurred throughtout the period of the

Table 7: Composition of food items as main contents and frequency of occurrance in the guts of M. kannume in Lake Kamburu, as compared to the composition o food items in the environment and the Electricity Index "E" (Food preference in the fish).

FOOD ITEMS	PERCENTAGE NO. IN THE GUT	PERCENTAGE OCCURENCE IN THE GUT	PERCENTAGE IN THE ENVIRONMENT.	ELECTRICITY IND INDEX 'E'
DIPTERA				
Chironomus spp.	32.1	88	15	0.7
Tanytarsus spp.	27.5	75	10	0.8
Chaoborus spp.	2.1	566	3	0.3
EPHEMEROPTERA				
Baetis spp.	11.2	30.5	25	0.1
ODONATA				
Gomphus spp	5.1	13.8	9.5	0.9
TRICHOPTERA				
Hydropsyche spp	2.1	5.6	7.0	0.1
Pteronacella spp.	2	5.5	2	0.7
COLEOPTERA				
Prompresis spp	1	2.8	3	0.03
CRUSTACEA				
Daphnia spp	0.7	2	5	-0.4
Cyclops spp	NIL	NIL	3	-1.0
UNINDENTIFIED				
INSECT PARTS	4.8	13	-	-
DETRITUS	11.4	31	-	-

Fig. 16: Composition of food items as "a" "main contents" and "b" "percentage occurrance" in the guts of M. kannume in Lake Kamburu from September 1978 to August 1979.


Occurence in Stomach
0
25
50
75
100
Chironomus spp
Tanytarsus spp
Chaoborus spp
Baetis spp
Gomphus spp
Pteronacella spp
Hydropsyche spp
Promoresia spp
Daphinia ssp
Cyclops ssp
Undentitied insect parts
Detritus
(b)

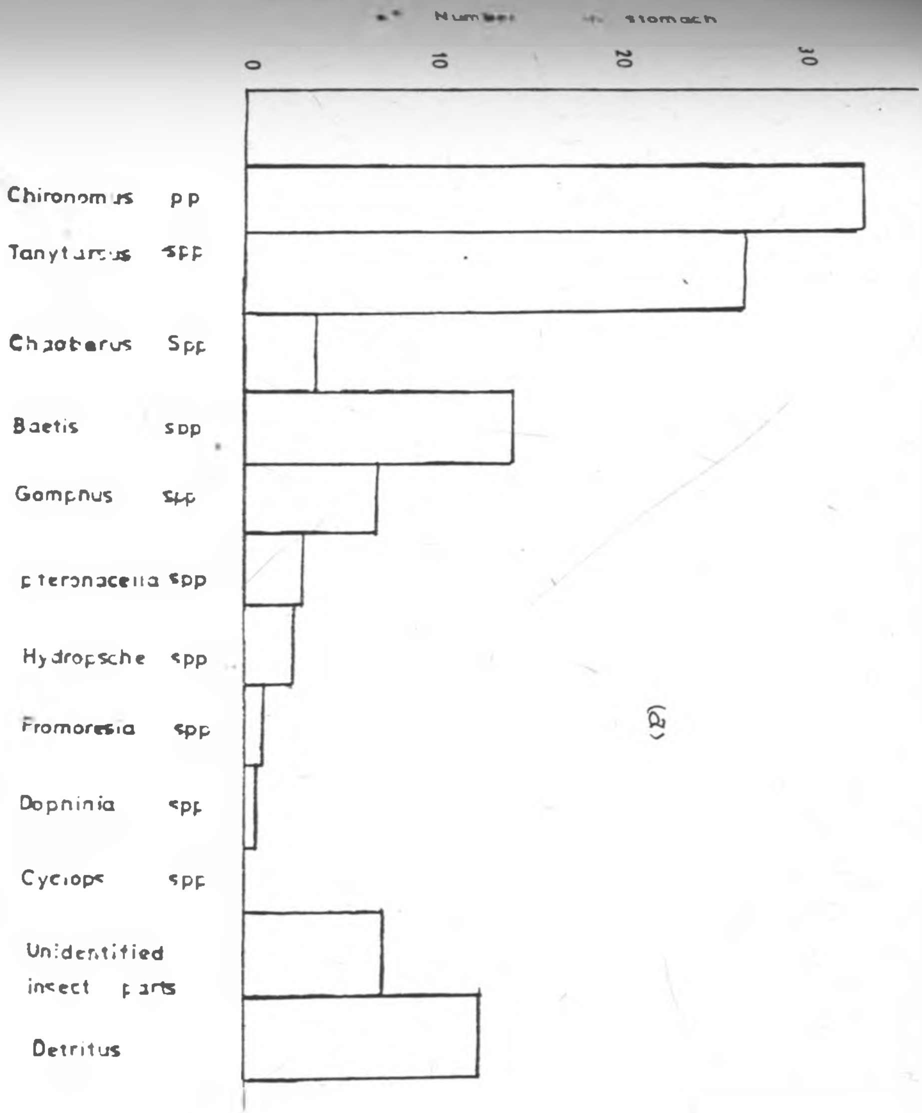
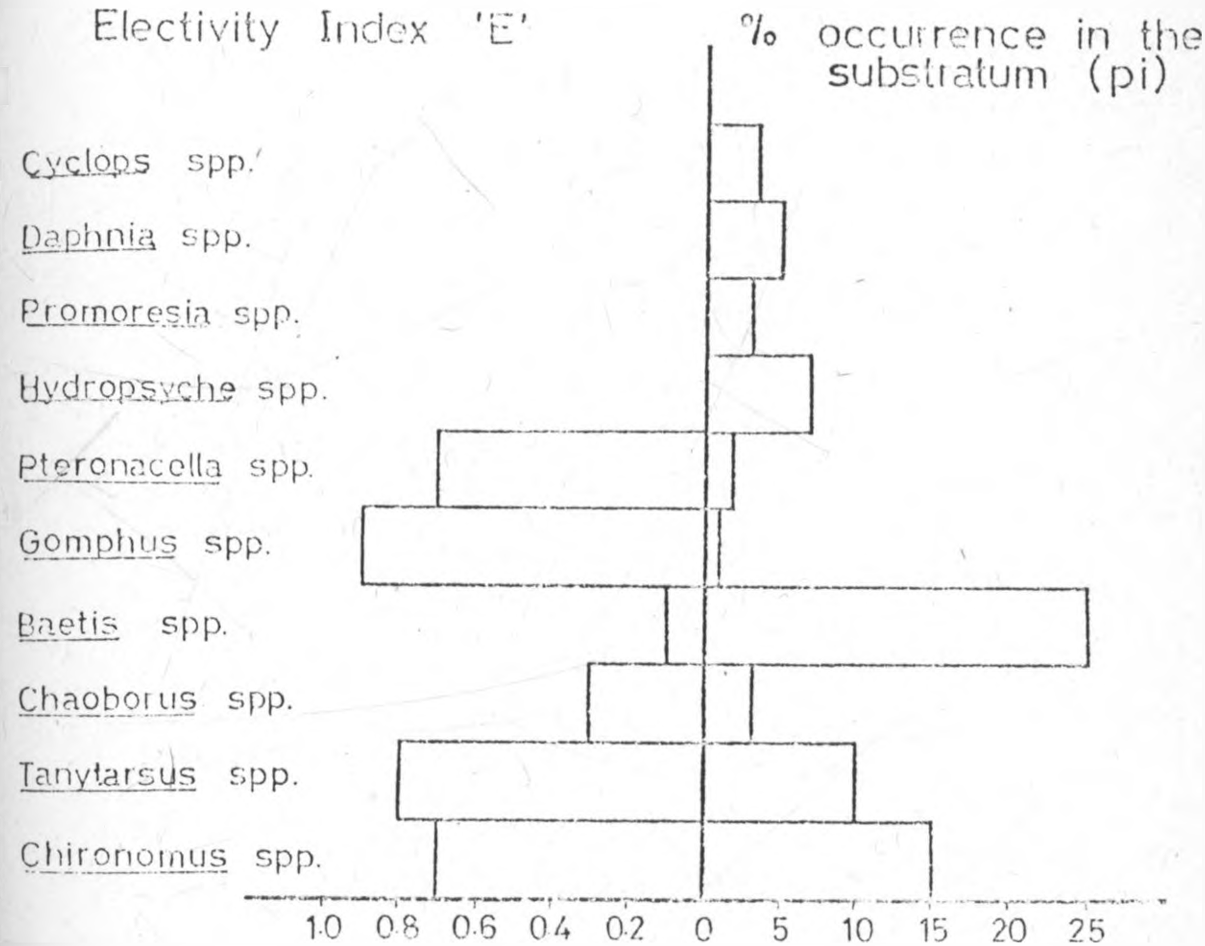

Number
stomach
0
10
20
30
Chironomus pp
Tanytarsus spp
Chaoborus Spp
Baetis spp
Gomphus spp
Hydropsche spp
Dopninia spp
Cyclops spp
Unidentified insect parts
Detritus
(a)

Fig. 17: The composition of food items in the environment and the Electricity Index of M. Kannume in Lake Kamburu from September 1978 to August 1979.

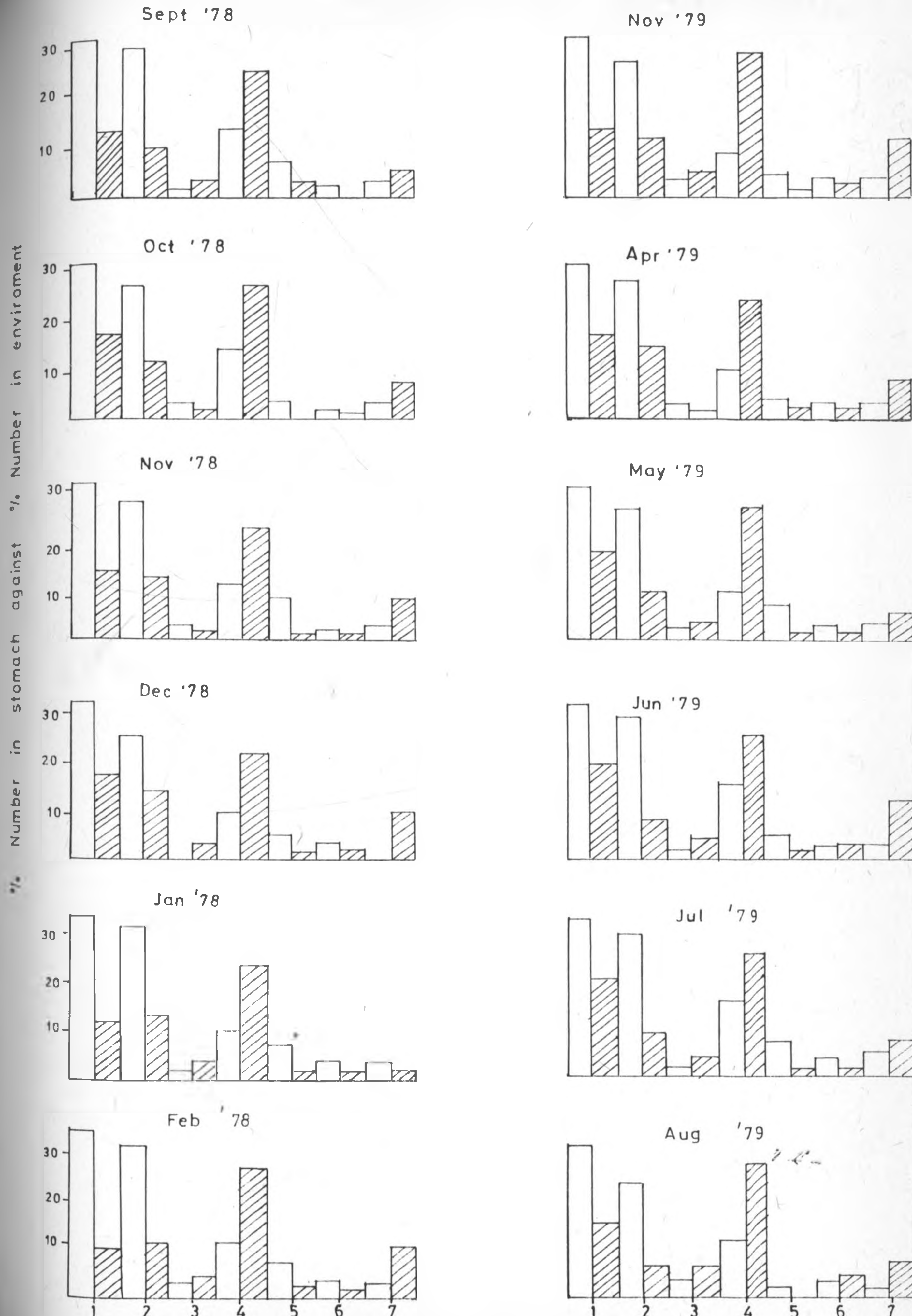


Electivity Index 'E'
% occurrence in the substratum (pi)
Cyclops spp.
Daphnia spp.
Promoresia spp.
Hydropsyche spp.
Pteronacella spp.
Gomphus spp.
Baetis spp.
Chaoborus spp.
Tanytarsus spp.
Chironomus spp.
1.0 0.8 0.6 0.4 0.2 0 5 10 15 20 25

Fig. 18: Monthly variation in the composition of food items as "main contents" in the guts of M. kannume in Lake Kamburu compared to fluctuations in the composition of the same food items in the environment.

Note: (a) Unshaded histograms depict the composition in the guts while shaded ones represent the composition in the environment.

(b) Column 1 stands for Chironomus spp
" 2 " " Tanytarsus spp
" 3 " " Chaoborus spp
" 4 " " Baetis spp
" 5 " " Gomphus spp
" 6 " " Pteronacella spp
" 7 " " Hydropsyche spp



% Number in stomach against % Number in enviroment
Sept '78
Oct '78
Nov '78
Dec '78
Jan '78
Feb '78
Nov '79
Apr '79
May '79
Jun '79
Jul '79
Aug '79
10
20
30
1
2
3
4
5
6
7

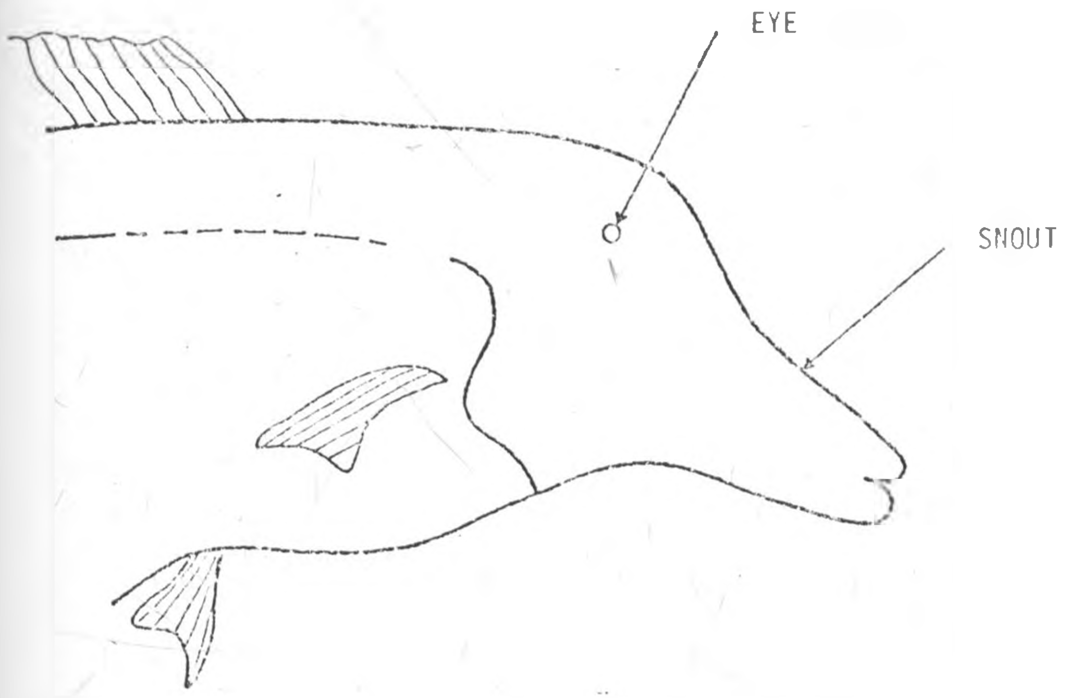
Table 8: Monthly fluctuations in common food items in the gut of *M. kannume* compared to the monthly variations of the same in the environment.

Common food items (% main contents against environment)

Months	Chironomus Gut.	Chironomus ENV.	Tanytarsus Gut.	Tanytarsus Env.	Chaoborus Gut.	Chaoborus Env.	Baetis Gut.	Baetis Env.	Gomphus Gut	Gomphus Env.	Pteronacelle Gut	Pteronacelle ENV	Hyrdopsyche Gut	Hyrdopsyche Env.
Sept.78	31.8	13	29	8	1.9	3.2	13.1	24.5	6.2	1.5	1.6	0	2.3	4.7
Oct. 78	31.7	16	26.8	11	2.7	1.8	13.4	26.6	4.1	0	1.8	0.8	2.1	5.6
Nov. 78	32.3	14	27.2	13	2.4	2.3	10.9	23	7.2	0.5	2.0	1.0	2.0	7.8
Dec. 78	31.8	17	25	9	1.1	3.3	9.2	22	5	0.3	2.1	1.8	1.6	8.0
Jan. 79	33.7	11	30.1	13	1.7	3.6	9.8	23.5	6.5	0.1	2.4	0	1.8	0
Feb. 79	33.9	10	32.1	11	2	3.4	11.8	26.4	7.1	1.2	2.0	0.9	1.9	10
Mar. 79	32.1	13	26.2	11	2.8	3.2	7.9	28	4	0	2.3	1.4	1.8	11.8
Apr. 79	31.5	16	27	14	2.5	1.9	8.9	24	2.8	1.1	2.2	1.6	2.2	7.8
May, 79	30.7	17	26.8	8	2.2	2.6	9.9	26.5	6.1	0	1.8	0	2.3	4.0
Jun. 79	31.8	19	28	7	1.8	2.8	14	24.8	4.8	0.8	1.6	1.8	1.6	12
Jul. 79	32.0	20	27.8	9	1.5	3.1	14.9	24.5	6.0	0.5	1.8	0	3.8	6.3
Aug. 79	31.5	15	23.7	6	2.6	4.8	10.6	26.2	1.4	0	2.4	2.7	1.8	6.0

Fig. 19: Diagram showing (a) - the long tube - like snout and (b) transverse section of the mouth with lips and rows of teeth.

(a)



(b)

Table 9: Monthly fluctuations in the Gastrosomatic Index of males and females of M. kannume in Lake Kamburu from September 1978 to August 1979.

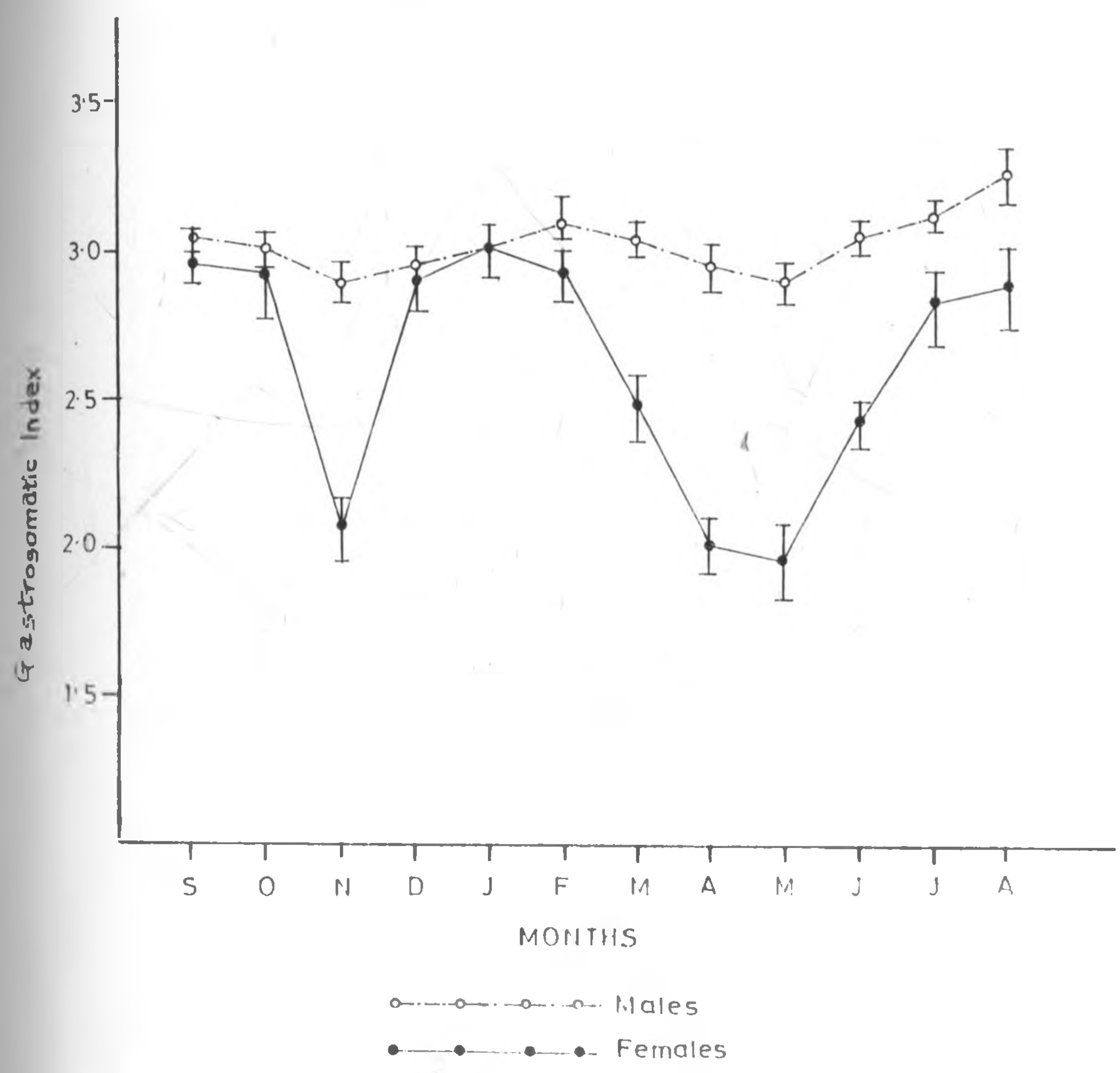
Note; Figures in parentheses indicate the number of fish ± SD = Standard deviation.

GASTROSOMATIC INDEX

MONTH		MALES	FEMALES
September	78	(16) 3.0 ± 0.1	(10) 2.9 ± 0.15
October	78	(44) 2.95 ± 0.15	(32) 2.8 ± 0.25
November	78	(27) 2.75 ± 0.1	(25) 2.0 ± 0.25
December	78	(11) 2.8 ± 0.1	(7) 2.75 ± 0.22
January	79	(31) 2.95 ± 0.2	(59) 2.95 ± 0.2
February	79	(25) 3.1 ± 0.1	(26) 2.75 ± 0.2
March	79	(53) 2.95 ± 0.1	(50) 2.4 ± 0.25
April	79	(32) 2.8 ± 0.15	(34) 1.9 ± 0.2
May	79	(43) 2.75 ± 0.15	(37) 1.8 ± 0.25
June	79	(22) 2.95 ± 0.1	(20) 2.3 ± 0.2
July	79	(17) 3.0 ± 0.1	(16) 2.65 ± 0.25
August	79	(22) 3.2 ± 0.2	(14) 2.7 ± 0.25

Fig. 20: Monthly variations in the Gastrosomatic Index of males and females M. kannume in Lake Kamburu from September, 1978 to August, 1979.

Note: Vertical bars indicate the standard deviation.



3·5
3·0
2·5
2·0
1·5
Gastrosomatic Index
S
O
N
D
J
F
M
A
M
J
J
A
MONTHS
Males
Females

Table 10: Monthly variations in the abdominal fat contents in M. kannume of Lake Kamburu from Septepber 1978 to August 1979.

Note: Figures in parenthesis indicate the number of fi

± SD = Standard Deviation.

ABDOMINAL FAT CONTENT (%)

MONTH		MALES	FEMALES
		(14)	(9)
September	1978	9.4 ± 1.6	11.2% ± 0.6
		(38)	(30)
Ocotober	1978	9.2 ± 0.8	10.8 ± 0.7
		(20)	(19)
November	1978	9.2 ± 2.8	10.5 ± 1.5
		(11)	(7)
December	1978	7.9 ± 1.1.	10.3 ± 0.8
		(29)	(59)
January	1979	8.5 ± 1.4	11.4 ± 1.0
		(25)	(26)
February	1979	8.1 ± 0.7	11.0 ± 1.0
		(50)	(48)
March	1979	7.9 ± 1.9	9.2 ± 0.9
		(30)	(32)
April	1979	8.6 ± 2.3	8.9 ± 2.0
		(43)	(37)
May	1979	8.6 ± 2.6	9.7 ± 2.5
		(20)	(20)
June	1979	7.8 ± 1.3	11.5 ± 1.5
		(17)	(16)
Junly	1979	9.6 ± 1.4	10.5 ± 1.9
		(22)	(14)
August	1979	9.0 ± 1.3	10.8 ± 2

study, although the actual values differed at different times of the year. At the onset of the experiments, the abdominal fat content averaged 11.8% of the body weight of females and 9.4% in the males. There followed a three month drop reaching the lowest value in December, 1978 with females registering 10.3% and males 7.9%. After an increase in January (11.4%) in females and 8.5% in males) the following two months saw a decrease in the fat content in the males which continued till April, 1979. The females showed an improved fat condition culminating in the maximum value of 11.5%. The males had an improved but stable fat condition in April - may but in June , the lowest value of 7.8% was recorded before increasing to the maximum value of 9.6% in July and reducing slughtly in August.

The proportion of the monthly abdominal fact content was correlated with the Gastrosomatic Index (G.S.I.) and Gonadosomatic Index (g/s) with the following results;

Between fat content and G.S.I.

Males/Males

$r = 0.89 \quad P < 0.001 \quad d.f. \quad 11$

Females/Females

$r = 0.91 \quad P < 0.001 \quad d.f. \quad 11$

Between fat content and g/s

Males/Males:

$r = 0.64 \quad P < 0.025 \quad d.f. \quad 11$

Females/Females

$r = 0.71 \quad P < 0.1 \quad d.f. \quad 11$

This observation denotes that there was a highly significant and positive correlation between the fat content and Gastrosomatic Index while there was a low and negative correlation between the fat content and the Gonadosomatic Index in both sexes of the fish.

4.2.5. REPRODUCTION

4.2.5.1 Stages of Maturation of the Gonads.

The six stage scale of classification described by Okedi (1969, 1970) was used for *M. kannume* with minor modifications. Most of the fish examined had single ovaries. In those which had two, the right one was always very much smaller - being more of a vestigial organ.

Females

Stage 1 - Immature:

Ovary small, translucent, pinkish in colour and lodged between the swim bladder and the abdominal wall. It is thread-like in appearance with the exception of the mid-point which is rounded. This mid-point serves as a point for growth of the ovary. The ovary occupies negligible percentage of the abdominal cacity at this time.

Stage II - Virgin and Unripe:

Ovary slightly increases in size and occupies 10% - 15% of the abdominal cavity, but it still maintains its translucenly and pinkish colour. Oocytes very minute and undistinguishable macroscopically but overall size of the ovary relatively larger that that of testis. The organ starts to assume a triangular to rhomboidal shape.

Stage III - Ripening:-

The colour of the ovary starts to change from pinkish to grewish due to accumulation of yolk in the oocytes and the latter are now distinguishable with the unsided eye. The ovary occupies 20% - 30% of the abdominal cavity and the size continues to increase, tending to draw out in the anterior and posterior directions from the mid-point. It attains an oval shape as it enters the next stage of maturity.

Stage IV - Ripe and Gravid

Ovary large and occupies considerable part of the abdominal cavity which becomes distended at this stage. As a result of active vitellogenesis the ovary becomes yellowish in colour.

Stage V - Mature, Ripe and Running

Intensification in the colouration of the ovary is observed and the organ puts on a golden-yellow colour. The abdomen is extensively distended and the ovary occupies 70% - 80% of the abdominal cavity. The eggs can be extruded by stripping.

Stage VI - Spent

The ovary becomes flaccid and shrunken with occassional residual eggs and some blooc clots oozing out upon application of pressure of the abdomen. The colour changes to dirty-brown or reddish brown. After spawning the ovaries return to Stage III, i.e. (vI - III).

Males:

Stage I - Immature

The testis is small, translucent thread-like and, as in the case of females, is lodged between the swin-bladder and the abdominal wall. Unlike the females, the organ at this stage lacks the bulb-like structure and this makes sex differentiation macroscopically easy even at this early stage.

Stage II - Virgin and Unripe.

Testis still small, thread-like and maintains its translucency. At this stage, the mid-point begins to acquire slight bulging appearance. The Stage II testis, apart from its bulk-like structure is also distinguishable from the ovary in the same stage by its relatively smaller sizes, occupying only about 5% of the abdominal cavity.

Stage III - Immature and Ripening

The testis develops a more prominant bulge in the mid-point region, and occupies between 5% - 10% of the abdominal cavity. It puts on a greyish colouration.

Stage IV - Ripe and Gravid.

The organ is enlarged, slightly lobate and occupies between 10 - 15% of the abdominal cavity. It becomes creamish in colour, but milt is not emitted upon stripping.

Stage V - Mature, Ripe and Running

The stage V testis has the same morphological appearance as that of the Stage IV except for the free flow of milt with a slight pressure on the peritoneum. The testis occupies about 20% of the abdominal cavity, looks creamish in colour and the milt granular to the naked eye.

Stage VI - Spent

The testis is shrunken and only small quantities of milt together with some blood clots ooze out upon application of pressure on the peritoneum.

4.2.5.2 Sex Ratio

Monthly catches and the sex ratio of M. kannume during the period of the study are presented in Table 11. Out of a total of 679 fish captured, 343 were males and 330 females. A total of 6 juveniles caught could not be sexed and are therefore not included in the anlaysis.

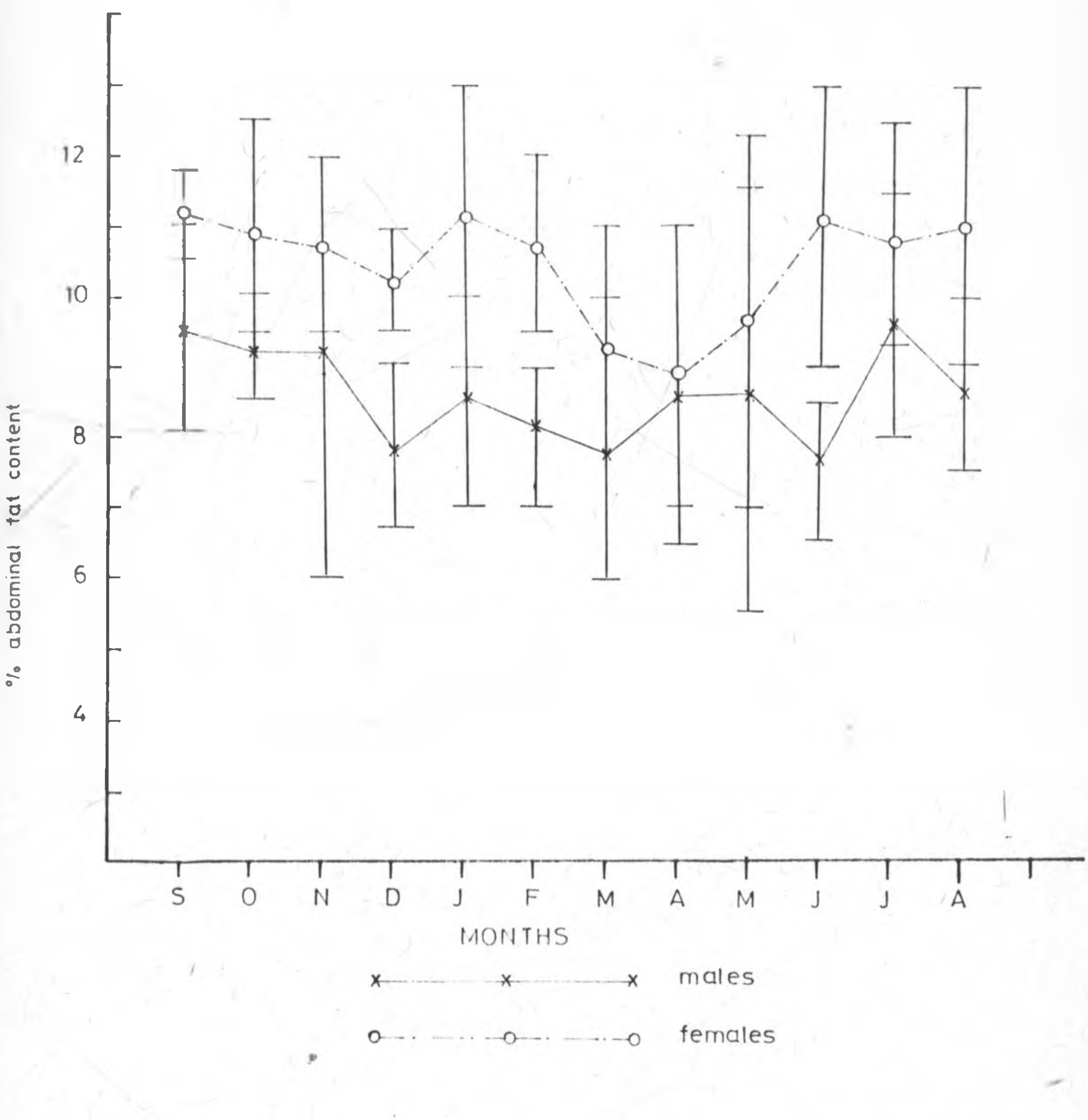
The ratio of males to females in the population was 1:1 throughout the study period. However in the months of September, October and December, 1978 and August, 1979 there was a preponderance of males over females and in January 1979 a reverse sex ratio of 1:2 (X^2 = 9.874; $P<0.02$; df = 1) between males and females were observed.

4.2.5.3. Size at First Maturity:

In M. Kannume of the present study, the females mature earlier than the males and maturity is also attained in the females at sizes smaller than in the males. Fifty percent of the fish are mature at 24.0cm in the females (Table 12 Fig. 21) and 24.8cm in the males (Table 12 Fig. 22).

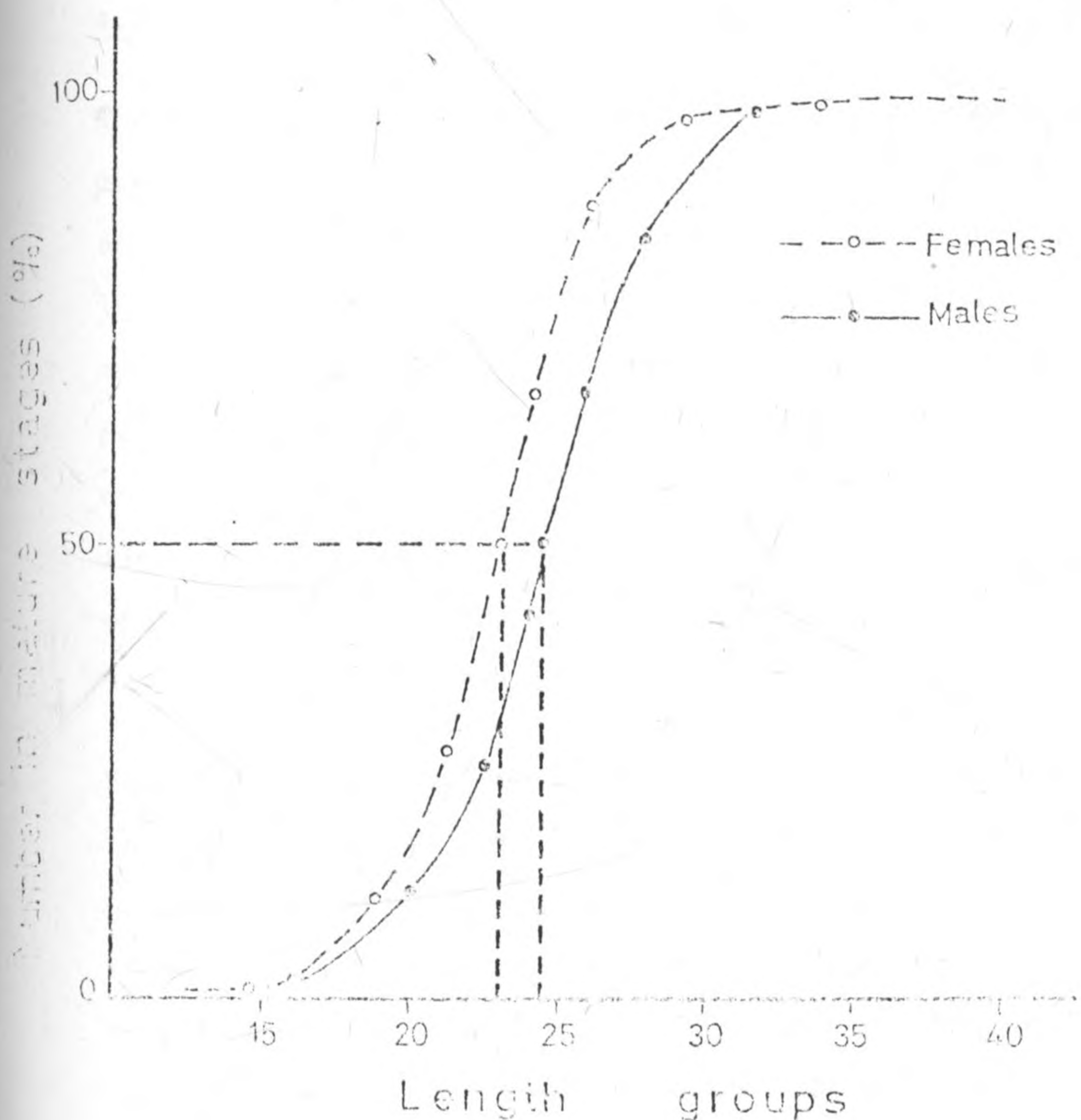
Fig. 21 Monthly fluctuations in abdominal fat content in males and females of M. kannume in Lake Kamburu from September, 1978 to August, 1979.

Note: Vertical bars depict the standard deviations.



% abdominal fat content
12
10
8
6
4
S
O
N
D
J
F
M
A
M
J
J
A
MONTHS
males
females

Fig. 22 Minimum size at the onset of sexual maturity of M kannume in Lake Kamburu.



Number in mature stages (%)
100
50
0
15
20
25
30
35
40
Length groups
Females
Males

The smallest mature female measured 22.9cm S.L. and the smallest mature male was 23.1cm S.L. The smallest spent fish caught measured 22.7cm and it was female.

4.2.5.4 Cyclical changes in the gonads

The monthly changes in the maturation of the gonads are presented in Figs. 23 and 24 and Tables 14 and 15 for females and males respectively. Mature females and males are present in the populations throughout the year but their numbeers and sex-ratios tend to undergo monthly variations. The highest percentages of mature females (Stages IV and V) were encountered in December, 1978 (28.6%) January (41%) April, 1979 (30%). Higher percentages of mature males were registered in the months of October 1978 (52.1%) November 1978 (44%) February 1979 (48%) March 1979 (50%) and May 1979 (42%).

From October, 1978, spawning started and it continued right through to July of the following year as evidenced by the presence of "running"and "spent" fish in monthly samples (Figs 23 and 24); Tables 14 and 15. These results indicate that M. kannume of Lake Kamburu is probably a continuous spawner and spawning takes place throughout the year. However no "running" males or females were encountered in August and September indicating that spawning probably stops during this period.

While it rained most of the year, monthly variations were also observed. The continuous dry season of July, August and September coincided with the period of cessation of spawning

Table 11: Monthly fluctuations in catch and sex composition of M. kannume in lake Kamburu from September, 1978 to August, 1979.

MONTH		TOTAL NO OF FISH CAPTURED	NO OF MALES	NO OF FEMALES	SEX-RATIO MALES : FEMALES		
September	1978	26	16	10	1.6:1	X^2 = 1.22 P> 0.5	df = 1
October	78	76	44	32	1.4:1	X^2 = 1.478 P> o.5	"
November	78	52	27	25	1.1	X^2 = 0.012 P<0.9	"
December	78	18	11	7	1.6:1	X^2 = 0.72 P< 0.5	"
January	79	96	31	59	1:2	X^2 = 9.874 P>0.005	"
February	79	51	25	26	1:1	X^2 = 0.079 P> 0.5	"
March	79	103	53	50	1:1	X^2 = 0.0146 P>0.5	"
April	79	66	32	34	1:1	X^2 = 0.1552 P>0.5	"
May	79	80	43	37	1:1	X^2 = 0.243 P>0.9	"
June	79	42	22	20	1.1	X^2 = 0.0392P>0.5	"
July	79	33	17	16	1:1	X^2 = 0.0049P> 0.9	"
August	79	36	22	14	1.6:1	X^2 = 1.44P< 0.5	"
		679	343	330	X^2 = 15.182P<0.5		df " 11

Note (i) 6 juveniles captured in January, 1979 could not be sexed and are therefore not included in the analysis.

Table 12: Percentage number of fish in various maturity stages in female *M. kannume* in Lake Kamburu.

No. of fish(%) in different maturity stages

Length Class/cm	No of Fish	I	II	III	IV	V	VI:
12.0 - 14.0		-	-	-	-	-	-
14.0 - 16.0	3	100	-	-	-	-	-
16.0 - 18.0	4	100	-	-	-	-	-
18.0 - 20.0	5	100	-	-	-	-	-
20.0 - 22.00	14	36.4	63.6	-	-	-	-
22.0 - 24.0	35	5.4	54.2	20.0	8.5	6.8	5.1
24.0 - 26.0	62	2.1	35.6	13.3	19	13.3	16.7
28.0 - 30.0	50	-	8	26	26	22	18
30.0 cm and above	78	-	5.9	14.7	26.5	23.5	29.4

Table 13. Percentage number of fish in various maturity stages in male M. kannume in Lake Kamburu.

No. of fish (%) in different maturity stages.

Length Class (cm)	No of Fish	I	II	III	IV	V	VI
12.0 - 14.0	1	100	-	-	-	-	-
14.0 - 16.0	3	100	-	-	-	-	-
16.0 - 18.0	1	100	-	-	-	-	-
18.0 - 20.0	5	50	50	-	-	-	-
20.0 - 22.0	12	38.5	61.5	-	-	-	-
22.0 - 24.0	41	5.8	57.9	10	8.8	3.5	14
24.0 - 26.0	60	-	40	13.6	18.4	12.8	15.2
26.0 - 28.0	69	-	17.1	23.7	23.7	14.5	25
28.0 - 30.0	52	-	13.8	20.7	27.6	20.7	17.2
30.0 cm and above	76	-	3.3	16.7	26.7	23.3	30

Table 14: Monthly changes in the maturity stages of females of M. kannume in Lake Kamburu.

STAGES OF SEXUAL MATURITY

MONTH		I		II		III		IV		V		VI	
		No	%	No	%	No	%	No	%	No	%	No	%
September	78	-	-	4	40	2	20	4	40	-	-	-	-
October	78	-	-	10	37	8	29.6	7	25	1	3.7	1	3.7
November	78	-	-	10	40	5	20.0	1	4	5	20.0	4	16.0
December	78	-	-	2	28.6	1	14.3	1	14.3	1	14.3	2	28.6
January	79	3	5.4	10	17.9	9	16.0	12	21.4	11	19.6	11	19.6
February	79	-	-	6	24.0	4	16.0	4	16.0	1	4.0	10	40.0
March	79	-	-	19	39.6	5	11	8	17	4	8	12	25.0
April	79	-	-	9	33	3	11	4	15	4	15	7	25.9
May	79	-	-	14	37.8	5	13.5	4	10.8	3	8.1	11	29.7
June	79	-	-	12	60.0	5	25.0	1	5.0	1	5.0	1	5.0
July	79	-	-	6	37.5	6	37.5	2	12.5	1	6.25	1	6.25
August	79	-	-	7	50	4	28.6	2	14.3	1	7.15	-	-

Fig. 23 Histograms depicting monthly fluctuations in gonadal maturation stages in the females *M. kannume* in Lake Kamburu from September 1978 to August 1979.

Note: "n" represents the number of fish sampled.

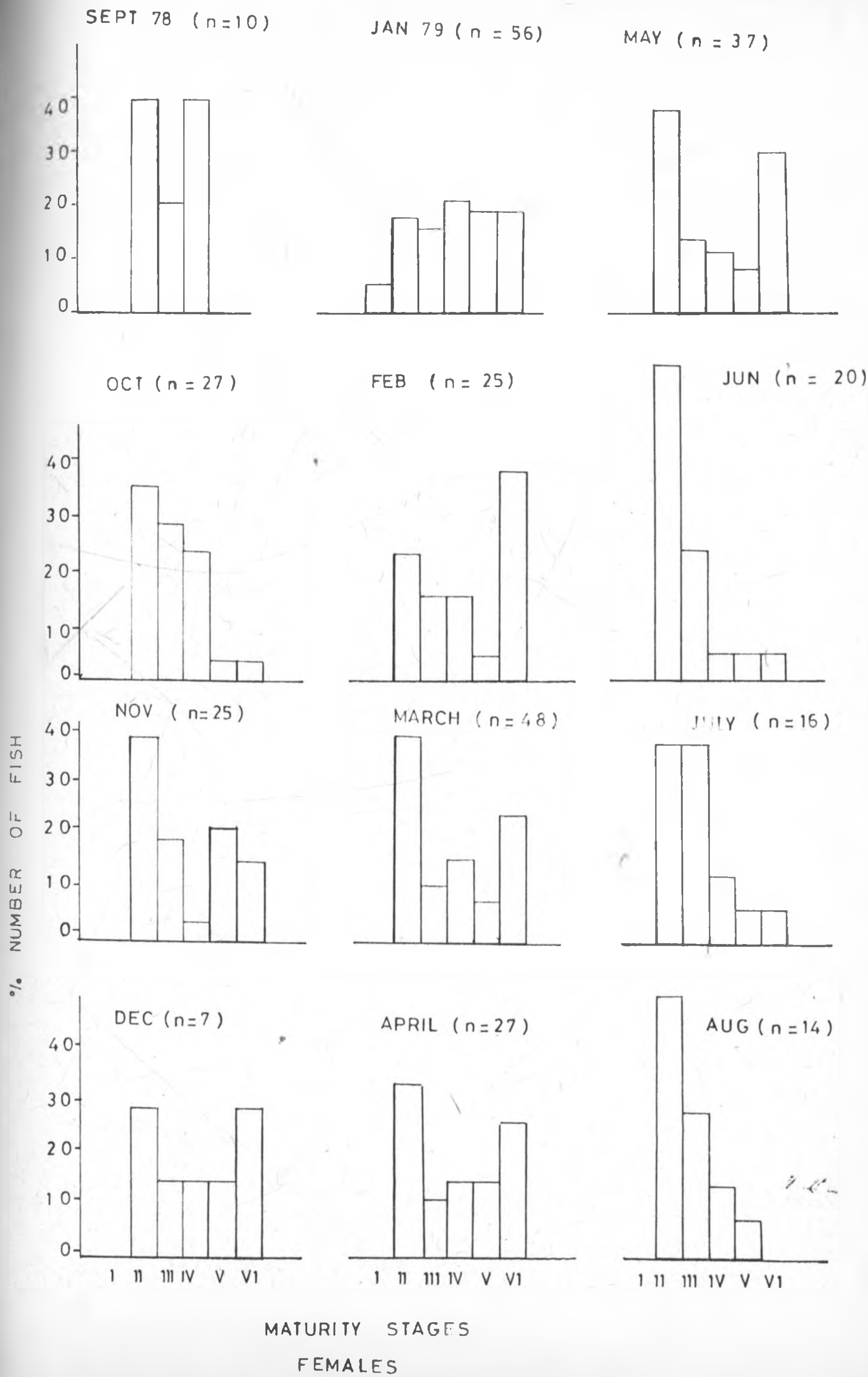
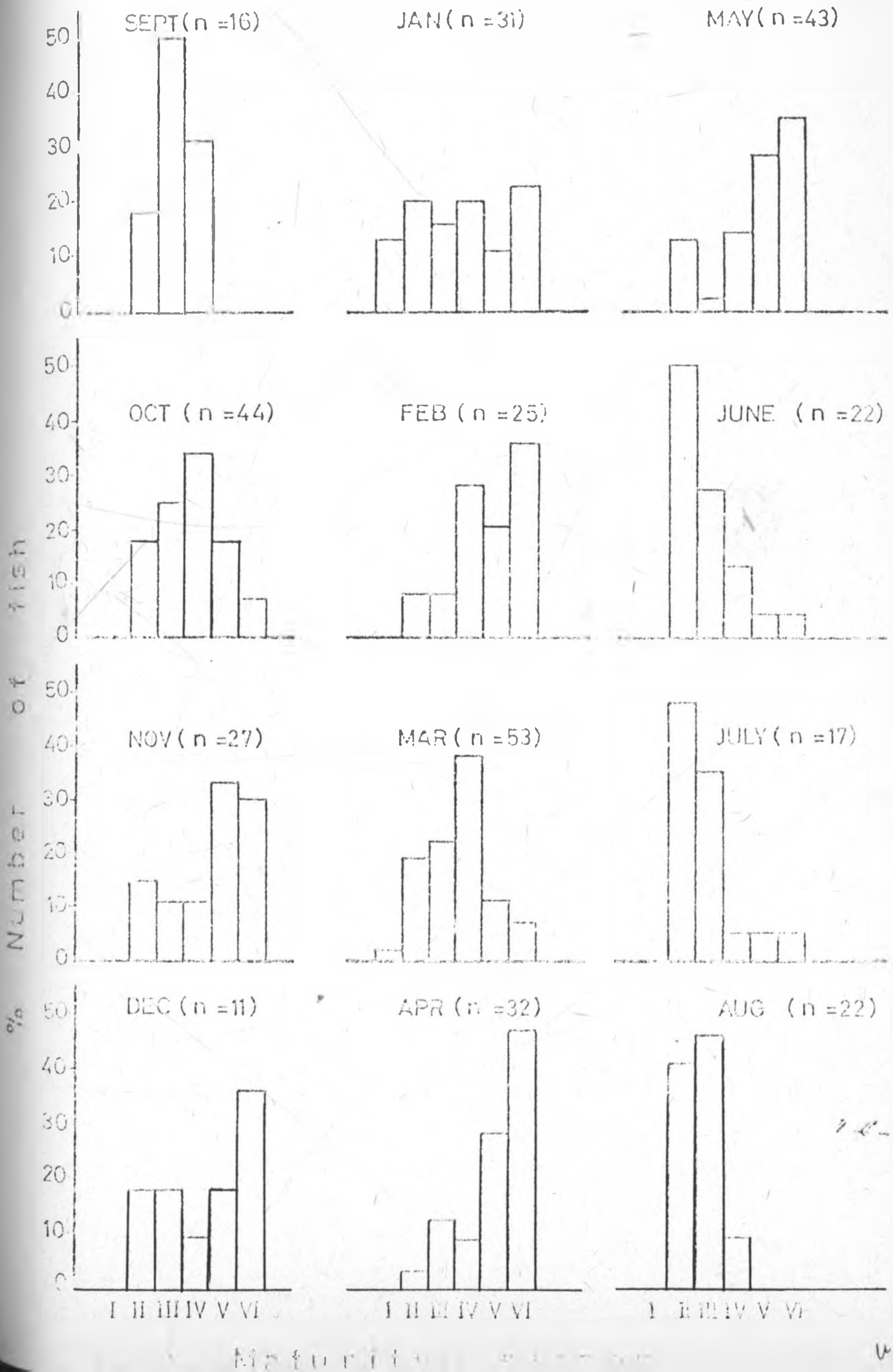

SEPT 78 (n=10)
JAN 79 (n = 56)
MAY (n = 37)
OCT (n = 27)
FEB (n = 25)
JUN (n = 20)
NOV (n= 25)
MARCH (n= 48)
JULY (n=16)
DEC (n=7)
APRIL (n=27)
AUG (n=14)
0
10
20
30
40
% NUMBER OF FISH
1 11 111 1V V V1
MATURITY STAGES
FEMALES

Fig. 24: Histograms depicting monthly fluctuations in the gonadal maturation stages in males of <u>M. kannume</u> in Lake Kamburu from September 1978 to August 1979.



SEPT (n =16)
JAN (n =31)
MAY (n =43)
OCT (n =44)
FEB (n =25)
JUNE (n =22)
NOV (n =27)
MAR (n =53)
JULY (n =17)
DEC (n =11)
APR (n =32)
AUG (n =22)
% Number of fish
0
10
20
30
40
50
I II III IV V VI
Maturity stages

Table 15: Monthly changes in the maturity stages of males of M. kannume in Lake Kamburu.

STAGES OF SEXUAL MATURITY

MONTH		I		II		III		IV		V		VI	
		No.	%	No	%	No	%	No	%	No	%	No	%
September	78	-	-	3	18.8	8	50	5	31.3	-	-	-	-
October	78	-	-	8	18	11	25	15	34.1	8	18	3	7
November	78	-	-	4	15	3	11	3	11	9	33	8	30
December	78	-	-	2	18	2	18	1	9	2	18	4	36.4
January	79	4	13	6	20	5	16	6	20	3	10	7	23
February	79	-	-	2	8	2	8	7	28	5	20	9	36
March	79	1	2	10	19	12	22	22	39	6	11	4	7.5
April	79	-	-	1	3	4	12.5	3	9.4	9	28	15	47
May	79	-	-	5	12	1	2.3	6	14	12	28	15	35
June	79	-	-	11	50	6	27	3	13.6	1	4.5	1	4.5
July	79	-	-	8	47	6	35	1	5.8	1	5.8	1	5.8
August	79	-	-	9	41	10	46	3	13	-	-	-	-

activities mentioned above, while the higher rainfall observed in October/November 1978, with the highest in April/May 1979.

Coincided with the period of increased spawning activities (Figs. 6,23,24 and 25). Although "ripening" individuals were captured from the upper sections of the lacustrine environment, "running" fish were captured only upriver i.e. in the purely riverine environment of Tana and Thiba headwaters.

4.2.5.5. Gonado-somatic Index (g/s)

The mean monthly variations in the gonado-somatic index (g/s) varied between 0.05 and 0.3 in the males and 0.6 and 2.5 in the females (Table 16 and Fig. 25). In November, 1978 and April, 1979 lowest g/s values were recorded, 0.6 and 0.7 respectively in females while lowest values of 0.09 and 0.05 wre recorded in December, 1978 and May, 1979 respectively for males (Table 16 and Fig. 25). Generally, the fluctuations in the gonado-somatic Index followed the same pattern in both males and females but the females demonstrated greater fluctuations than the males.

The peak spawning activities observed in October/November resulted probably in the drastic fall in the g/s of both sexes of fish from October to November (females) and October to December (males). Similarly, the increased spawning intensity observed in April and May, 1979 probably is

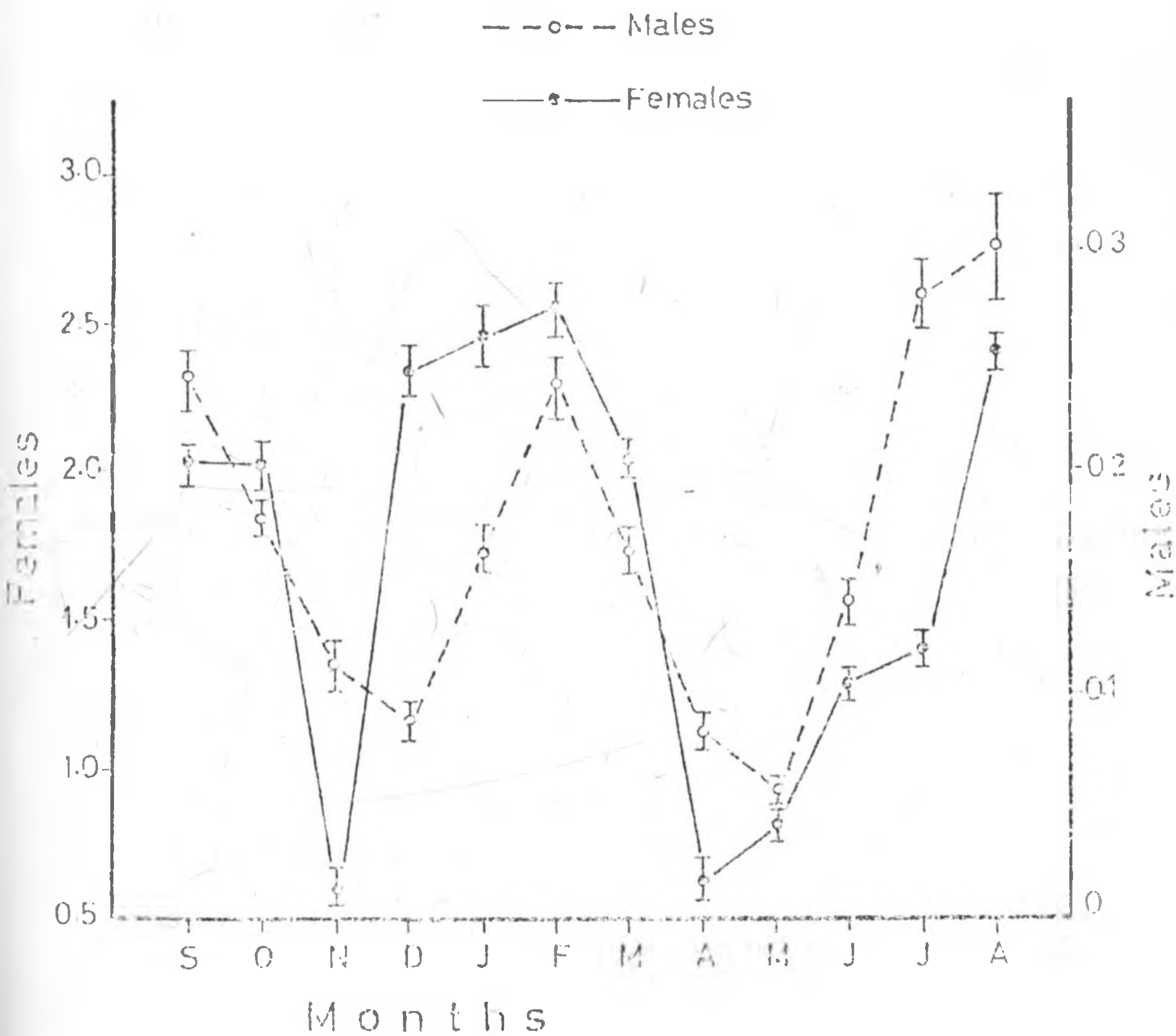
Table 16:	Monthly fluctuations in the Gonado-somatic Index (g/s) in males and females of <u>M kannume</u> in Lake Kamburu from September 1978 to August 1979.
Note:	Figures in parentheses indicate the number of fish.
	± SD = Standard deviation

GONADOSOMATIC INDEX (g/s) ±SD

NTH		MALES	FEMALES
eptember	78	(15) 0.23 ± 0.02	(10) 2.05 ± 0.2
ctober	78	(39) 0.18 ± 0.01	(28) 2.05 ± 0.25
vember	78	(27) 0.11 ± 0.01	(25) 0.6 ± 0.15
cember	78	(11) 0.08 ± 0.01	(7) 2.4 ± 0.25
anuary	79	(28) 0.16 ± 0.01	(56) 2.5 ± 0.25
ebruary	79	(25) 0.23 ± 0.02	(25) 2.6 ± 0.2
arch	79	(50) 0.15 ± 0.01	(50) 2.0 ± 0.15
pril	79	(30) 0.08 ± 0.01	(32) 0.7 ± 0.2
[illegible]	79	(43) 0.05 ± 0.01	(37) 0.75 ± 0.1
[illegible]	79	(20) 0.13 ± 0.01	(21) 1.25 ± 0.1
y	79	(15) 0.28 ± 0.02	(16) 1.35 ± 0.1
gust	79	(17) 0.3 ± 0.025	(12) 2.25 ± 0.15

Fig. 25 Monthly variations in the Gonado-somatic Index (g/s) in males and females of M. kannume in Lake Kamburu from September 1978 to August 1979.

Note: Vertical bars deplot the standard deviation.



Males
Females
3.0
2.5
2.0
1.5
1.0
0.5
Females
.03
.02
.01
0
Males
S O N D J F M A M J J A
Months

reflected in the drastic fall in gonado-somatic indices of both sexes during this period. These observations show that M. kannume in Lake Kamburu is a continuous spawner but it exhibits two spawning peaks and that the two rainy seasons recorded in the areas trigger intensified spawning.

An attempt was made to correlate the gonadosomatic indices with the means of water temperature, rainfall and biological parameters with the following results:

Between g/s and Temperature.

Males.

Riverine $r = 0.842$ $P < 0.001$ $df = 11$

Lacustrine $r = 0.54$ $P < 0.05$ $df = 11$

Females:

Riverine: $r = 0.644$ $P < 0.02$ $df = 11$

Lacustrine $r = 0.787$ $P < 0.05$ $df = 11$

Between g/s and rainfall

Males

Riverine $r = 0.94$ $P < 0.001$ $df = 11$

Lacustrine $r = 0.814$ $P < 0.001$ $df = 11$

Females:

Riverine $r = 0.92$ $P < 0.001$ $df = 11$

Lacustrine $r = 0.64$ $P < 0.025$ $df = 11$

Between and Condition Factor:

Males/Males:

r = 0.94 $P < 0.001$ df = 11

Females/Females:

r = 0.76 $P < 0.005$ df = 11

Between g/s and G.S.I

Males/Males;

r = 0.98 $P < 0.001$ df = 11

Females/Females:

r = 0.88 $P < 0.001$ df = 11

From the observations it can be deduced that there was a high and positive correlation between the Gonadosomatic Index and Temperature, and rainfall.

As far as the biological factors were concerned, there was a high and positive correlation between the Gonadosomatic index and both the condition factor and the gastrosomatic index showing probably that the Mormyrus spp of Lake Kamburu behaves similarly to those Mormyrids of other waters where intensified feeding takes place after spawning.

4.2.5.5. Fecundity

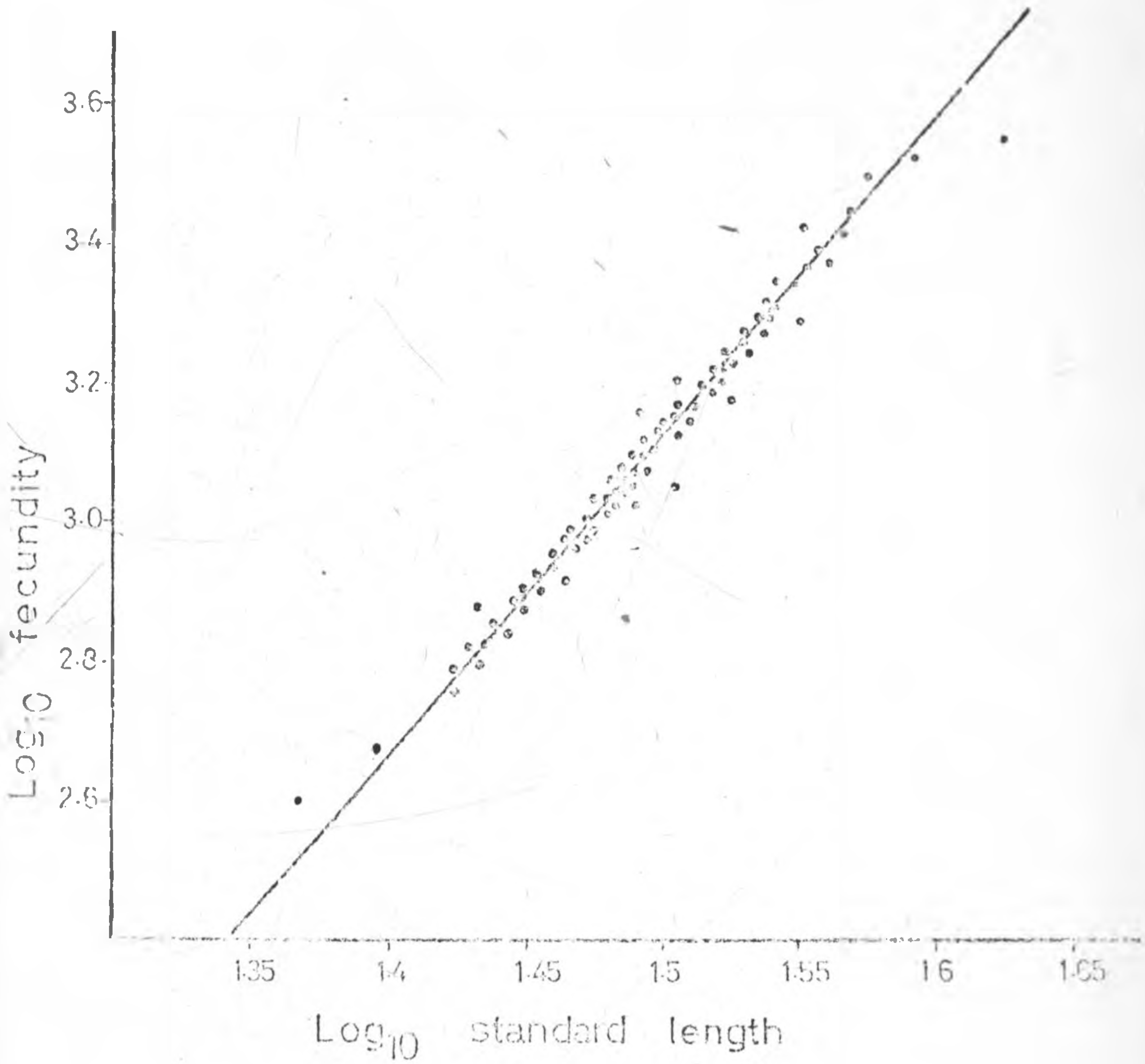
Fecundity of *M. kannume* ranged from 406 in a female measuring 22.9cm (158.9g body weight) to 3466 eggs in a 42.5cm fish (447.1g body weight) with a mean of 1600 eggs. from a total of 80 mature females. There was a wide

Fig. 26. Fecundity - Length relationship of M kannume in Lake Kamburu in their logarithmic values.

$$\text{Log. } F = -3.6706 + 4.4530 \text{ Log } L$$

$$n = 80$$

$$r = 0.82$$



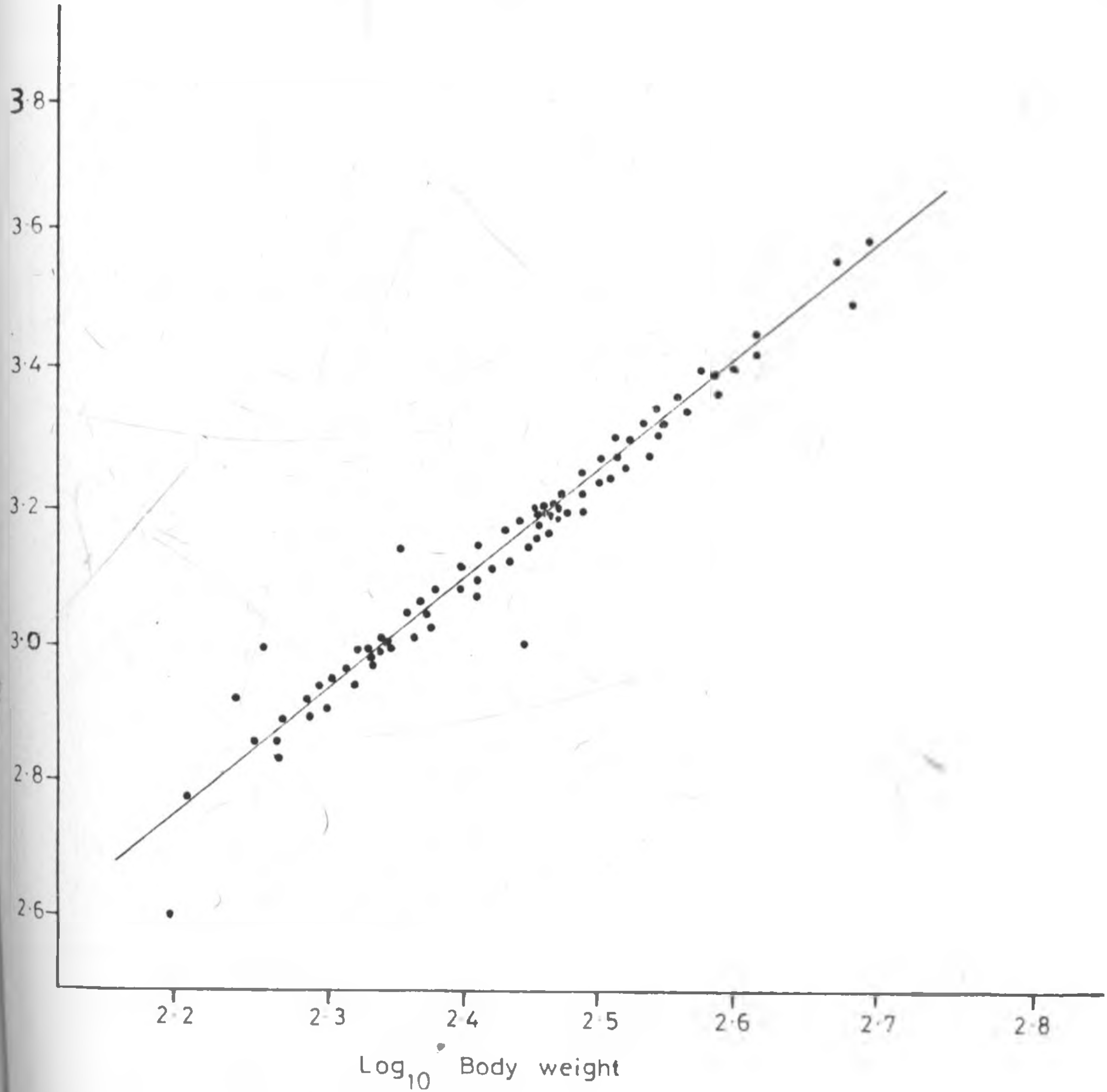
3·6
3·4
3·2
3·0
2·8
2·6
Log10 fecundity
1·35
1·4
1·45
1·5
1·55
1·6
1·65
Log10 standard length

Fig. 27. Fecundity-Weight relationship of M. kannume of lake Kamburu in their Logarithmic values.

$$\text{Log } F = -0.7785 + 1.6198 \text{ Log } W$$

$n = 80$

$r = 0.85$


3·8
3·6
3·4
3·2
3·0
2·8
2·6
2·2
2·3
2·4
2·5
2·6
2·7
2·8
Log_{10} Body weight

variatiion in fecundity among dishes of the same sizes. However, fecundity revealed a direct relationship with the standar length (Fig. 25) and body weight (Fig. 26) of the fish. Regression equations describing these relationships are:

(i) For Fecundity - Length Relationship:

$$\text{Log } F = 3.6706 + 4.5378 \text{ Log } L$$

$$r = 0.82$$

$$P < 0.001$$

(ii) For Fecundity - Weight Relationship.

$$\text{Log } F = 0.7785 + 1.6197 \text{ Log } W$$

$$r = 0.85$$

$$P < 0.001$$

Egg size ranged from 1.9mm in a 28.2cm (177.7g body weight) to 2.9mm in a 38.1cm (452g body weight) with a mean of 2.4mm. A fitted regression gave the following regression equation.

$$\text{Log } F = 0.3304 - 0.01598 \text{ Log } L$$

$$r = 0.01$$

$$P < 0.90$$

The result indicate that the size of the eggs bear no relationship to the number of eggs produced by a female.

5. D I S C U S S I O N S:

5.1 Limnological Parameters

The result of the present investigations reveal that four years after inundation, the man-made Kamburu Lake has experienced changes in some but not all, of its limnological parameters.

5.1.1 Transparency

Transparency in the new lacustrine waters was higher and turbidity low as compared to the river where the mobility of water rendered it less transparent and more turbid. This was probably due to sedimentation and also the fact that the lake was relatively calm. According to Ward *et al* (1976) the high turbidity which characterises the river affluents of Lake Kamburu are brought about by colloidal clay particles in semi permanent suspensions brought in by considerable mismangement of land within the catchment area.

5.1.2. Temperature

The formation of the Lake has resulted in a negligible change in the thermal regime. While Dadzie *et al* (1976) recorded surface water temperature of 22°C - 27°C, the present research revealed a surface water temperature of 22°C - 25°C.

The bottom water temperature also decreased only negligibly from 21° C to 20°C. These findings indicate that no serious changes in the water temperature has taken place four years after inundation.

5.1.3. Oxygen Concenteration:

Dazie *et al*. (1976) observed a uniform concenteration of dissolved oxygen throughout the lake at its formative stage.

and in April/May 1979 when the reverse should have occurred. This probably came about as a result of the run-offs passing through agricultural, range and bare lands carrying into the river dead vegetation, plant debris and a lot of silt-laod. Massive fish kills through asphyxation has also been recorded in the Tana and Athi river systems (Van Sommeren, 1962; Ward et al., 1976) and the major factor has been attributed to reduced oxygen tensions as a result of heavy silt-load brought about by the run-offs during heavy down porss. It is also worth noting that the oxygen concenteration increased towards the end of November and December, 1979 and this could have been attributed to the greater mobility of the water and on the assumption that the dead vegetation and silt which had initially accompained the initial rainfall were now reduced.

5.1.4. P^H

The P^H of the surface waters of Lake Kamburu does not seem to have changed at all as Oding'o and Nyambok (1979) recorded the same pH of 9 in the entire lake, indicating that a high basic medium existed at the surface of the lake. There was also very little monthly fluctuations at the surface. The deeper parts of the lake, however, seem to be undergoing remarkable changes as the p^H has shifted from basic (alkaline) to neutral with a mean of 7.7 Relating p^H to productivity, it shows that the surface water of Lake Kamburu is more productive than the deeper portion and this would relate to the presence of aquatic algae on the surface as mentioned earlier. The river, probably because of its and inability to retain these primary producters at the surface, is less productive, registering a homogeneous p^H of 7.6 throughout.

51.5 <u>Conductivity</u>:

Of all the limnological parameters investigated, remarkable changes were found only in the conductivity of the waters of Lake Kamburu. Remarkable increase in conductivity of the Lake waters from an average of 40 µmhos (Odingo and Nyambk, 1979) to 198 µmhos, was observed. This probably is as a result of an accumulation of dissolved ions brought in by run-offs, soil erosion and siltation from the adjacent agricultural lands, bringing in fertilizers and other chemicals as herbicides and pesticides. Since these materials brought in are all retained in the lake, continuous fluctuations in the conductivity of the water is always to be expected. According to Boyd (1979) solubility of oxygen in water decreases with increasing conductivity and this probably explains why the lacustrine environment has a higher conductivity but less oxygen than the riverine one.

The findings of these limnological investigations have revealed that changes in some limnological parameters (some marked while others little) have occurred in this man-made lake and, as suggested by Attwel (1970) , it becomes imperative the need to monitor continuously the effects of limnological changes on the aquatic ecosystem especially on the ichthyofauna in man-made lakes.

5.2. Biological Parameters

Studies of the distribution of fishes of Lake Kamburu showed that two years after inundation, Mormyrus spp. in Lake Kamburu have migrated to the upper reaches of the headwaters (Dadzie, 1980) in area marked sites III, IV and VII (Fig. 2). During the present investigations it has been found that this species has continued to move upstream as shown by the fact that the majority of this fish were found in sites V, VI, IX and X which are typical riverine environments. It is therefore realised that Mormyrus spp. of Lake Kamburu had not adjusted to the new environment brought about by inundation, even four years later.

5.2.1. Length-weight relationship.

In the length-weight relationships study of M.kannume in the present investigations, since the value of "a" for immature and mature sexes lie between 2 and 4 (2.8808 for immature males and females, 2.5615 for mature females and 3.1564 for mature males) it can be inferred from the postulation of Carlander (1969) that the growth of this fish is isomotric, similar to the observations of Le Cren (1951), Whitehead and Sommeren (1959), Treasurer (1976), Siddique (1977) and Dadzie and Wangila (1980) for most freshwater fishes. The equataions so obtained can therefore conveniently be used to compute weight from given length data.

5.2.2. Length-frequency distribution

The existence of modes in the length-frequency distribution of M.kannume in Lake Kamburu has been domonstrated both from theworks of Dadzie et al (1979) and from the present findings. These modes of different size classes could also indicate different age groups within the population.

Unfortunately, due to the small size-class the data cannot be used successfully in age determination.

5.2.3. Condition

The condition of the M. kannume in Lake Kamburu can be discribed as favourable as it did not fall drastically at any particular month. It was, however, realised that the condition factor of immature fishes were generally higher and this could be attributed to the continuous and vigorous feeding expected when animals are still young. The months having the highest "K" values - October 1978 and August 1979 were those prior to spawning. The general high values throughout the year could be attributed to the fact that this fish is a continuous spawner unlike those of the Lake Victoria basin (Okedi,1971) and the West African basin (Imevbore and Bakare,1974) which are seasonal spawners. It is normally accepted that during spawning fish do not feed actively and hence have low "K" values. However this was not evidently clear in M. kannume of L. Kamburu as high "K" values were obtained even during the peak spawning periods. This could be due to less expenditure of the accumulated fat in the body tissue since the species does not take distant spawning migrations but spawns only a few kilometres upriver.

5.2.4. Food and feeding habits

Graham (1929) as cited by Greenwood (1957) mentioned that the food of Mormyrus kannume, particularly over muddy substratum consisted, very largely, of Chironomid larvae. In the Annual Report of the East African Freshwater Fisheries Research Organization it was mentioned, (1948,1949) that in sandy and rocky substrata M.kannume feeds on a variety of foods including caddisflies, mayfly larvae, Povilla spp and shrimp Caridina spp. E.A.F.F.R.O. (1951,1952) assert that most of the feeding activity of M. kannume occurs at night over rocky and soft bottoms where the larvae of Povilla spp. form an important food. It is evident from these reports that any assessment of food of M. kannume must take into consideration, the habitat. MacDonald (1956) found that Tanypus spp, Tanytarsus spp and Chironomus spp were the most common food both in the mud and in the stomach of M.kannume. Corbert (1961) who studied M. kannume, M. Macrocephalus - catostoma, Marcusenius nigricans, M.grahami, Gnathonemus longibarbis and G. vistoriae found that these different momrmyrids fed on the same type of acquatic invertebrates, viz: chironomid and chaoborid larvae, povilla nymps and larvae of Tricorythus spp.

Other food items in smaller quantities were the lithophillic forms of the mayfiles Enthraulus spp and the hydropsychid caddiflies, Cheumatophsyche copiosa and C. falcifera.

Large fishes invaded swampy areas feeding on dead plant-material, swamp-living odonata larvae, Trimethis cariagrion and the water-stick insect, Ranata parripes. In all sizegroups Povilla spp. nymps were common.

Okedi (1971), while reporting on the feeding of five mormyrid fishes in Lake Victoria, found that the larvae of Chirnomidae and Povilla spp dominated the stomachs of those fishes while specific divergences were observed in the river affluents where Chirnomids fed on swamp moths Alma spp,Coleoptera, dysticid larvae, vegetable fruits of Cyperaceae and Polygonaceal and avoided Chironomidae and Povilla spp. The young fishes fed on a more restricted diet including, particularly, small-size food items of Ostracoda, Chironomidae, Hydracarina and Hemiptera nymps.

The preponderance of Chironomus spp, Tanytarsus spp and Chaoborus spp. in the gut of M. kannume in the present study strongly suggest that this species feeds mostly on acquatic insects, especially on their larval stages. Destritus, which were probably scooped from the bottom substratum together with the insects, formed a small percentage of the food in the gut. Although Baetis spp. were present in large quantities in the environment as reflected in the Ekman dredge samples, it was not heavily fed on and this confirms that the species is a selective feeder. Chaoborus spp were also not fed on and this could be due to the fact that at night when M. kannume normally feeds, this food item, being planktonic, ascends to the surface thereby avoiding predation by the bottom feeding predator. Corbert (1961) also made similar observations on on M. kannume in Lake Victoria. Petr (1967a, 1968), while comparing mormyrid feeding habits in the Black Volta river with that in the Volta Lake, indicated a shift from a high reliance on Chironomid larvae in the river to Povilla spp on the lake.

A very limited range of food organisms appeared in the gut of M. kannume in Lake Kamburu. This could probably reflect the scarcity of the benthos in the lake, a suggestion suported by the dredge samples. It is possible that the ability of the fish to survive on insect larvae would seem to offer ample opportunity for successful colonisation of the lake since food competition is not so high because of the limited variety of fish inhabiting it. The extreme change in lake habitats, however, resulting from inundation may adversely affect the population of benthic invertebrates and this in turn could affect the Mormyrus spp in Lake Kamburu.

The low Gastrosomatic Indices in November 1978 and April/May 1979 concided with the period of peak spawning. The considerable amount of energy expenditure which accompanies spawning migrations upstream to rocky substratum (Daget,1954), the act of spawning itself, and the fact that feeding intensity is reduced during these two events might have resulted in the low Gastrosomatic Indices observed. There was also a positive correlation between G.S.I. and condition factor, showing that a well-fed fish had a higher G.S.I. and vice versa.

The results of these investigations compare favourably with those of other workers discussed above. However, as a result of limited range of acquatic invertebrates in the lake, no clear-cut differences were observed in the diet of the juveniles as compared to that of the adults. There was also no observation on seasonal changes in food preference.

5.2.5 Reproduction

The pattern of reproduction in M. kannume reflected through the study of the annual changes in the maturity stages and gonadal weights suggest that the fish has a prolonged breeding period probably starting in November/December and ending in May, These findings are contrary to those of Okedi (1979) and Imevbore (1970b) that mormyrids bread twice a year. However the appearance of many "spent" fishes coincided with heavy rainfall, reduction in: p^H, conductivity and water temperature. Blake (1977a) made similar Observations on the spawning of mormyrids in Lake Kainji and concluded that those changes in the limnological parameters collectively triggered breeding in the species. "Running" and "spent" fishes were found exclusively in the riverine environment and this suggests that the riverine conditions are essential for the reproduction in this species. Blake (op. cit.) also found the same pattern of distribution of breeding mormyrids in Lake Kainji and the author stated that the fry were possibly rheophillic and running water may be a requirement in the nursery ground.

On the spawning grounds, Okedi (1969) commented that the fish was anadromous moving upriver to breed during the rains. Petr and Reynolds (1969), Imevbore (1970), Imevbore and Bakare(1974) and Blake (1977a) found that these groups of fishes of West African basin also move upstream to breed during the rains.

Dadzie(1980) cited the observations of Daget (1954) to the effect that most mormyrids prefer rocky river-beds near rapids were they can feed on bottom found and they also appear to prefer well oxygenated water and that their life cycle are associated with that environment. Dadzie (1980) concluded that Mormyrus spp. has not maintained itself in the new environment in Kamburu Lake due to lack of suitable environmental conditions, the most important being spawning and feeding grounds which have become covered with deposits of fine sediments.

In the context of maturation it is realised that females mature earlier than males. Some workers have attributed earlier maturation of females to a more active shorter life, (Jillet, 1968), in the present study, no evidence was found in support of this observation.

The fecundity of M. kannume in Lake Kamburu which ranges from 406 to 3466 with a mean of 1600 is considered low. This is evidenced by the fact that the same species from Lake Victoria and the Nile basin had a fecundity range of 1393-17,369 with a mean of 6,869 Okedi (1970), thus showing that the species in Lake Kamburu is much less fecund. It is possible that the change from a riverine to lacustrine environment has affected the reproductive capacity of the species on Lake Kamburu.

The regression equations describing the relationship between the number of eggs produced and the body weight and the body length were linear indicating that fecundity increases with increase in the length and weight of the female. There was, However, no relationship between fecundity and egg-size suggesting that irrespective of the size of the eggs, the number of eggs produced by a female can be either high or low.

Finally, from the findings of these observations rational exploitation of this fish can be brought to manageable levels by:-

1) Restricting mesh size of gillnets used in the spawning grounds - larger mesh-size which will catch larger fish which have spawned several times is recommended.

2) Restricting fishing activities in the spawning grounds during the height of the spawning period, from November/ December to May. This can be done by reducing the number of gill nets used by each fisherman.

3) Restricting nocturnal fishing if the species is threatened with extiction.

6. CONCLUSIONS.

1. Changes in some limnological parameters of Lake Kamburu are evident four years after the closure of the dam. Surface water temperatures, P^H and conductivity were higher in the lake as compared to similar paramaters in the affluent rivers. Conversely oxygen concenteration is higher in the rivers.

2. The new environment characterised mainly by a muddy substream, lacustrine conditions and low oxygen concenterations coupled probably with unfavourable P^H and high conductivity have acted adversely on the distribution of M. kannume in the lake and have forced the species to move upstream to rheophillic and oxyphilic environment with lithophilic substratum for spawning.

3. The equation for the length-weight relationship suggests that growth of the fish in the Kamburu Lake is isometric.

4. The condition of the fish is good following probably their move upstream, to riverine conditions.

5. M. kannume is an insectivorous feeder and its inferior mouth-long-like snout, is adapted for feeding on the bottom dwelling insects and their larvae and nymphs.

6. Chironomus spp., Tanytarsus spp. and Baetis spp. dominate the food of the fish in the stomach and also in the environment.

7. Gomphus spp. which was one of the least in the environment was highly selected by the fish.

8. Spawning takes place throughout the year but peak in spawning activities are encountered in November/December and April/May during the rainy seasons.

9. Rainfall serves as a stimulus for intensified spawning in M. kannume.

10. Spawning takes place only int the purely riverine environment and probably in the rocky river beds.

11. Females attain first maturity at 24.0cm. SL. whereas the males mature at 24.8cm.SL.

12. The sexes are present in equal proportions almost throughout the year.

13. Fecundity ranged from 406 to 3466 eggs with a mean of 1600 eggs and it increased with the length and weight of the female.

ACKNOWLEDGEMENTS.

I am greatly indebted to my Supervisor, Dr. Stephen Dadzie of the University of Nairobi whose tireless efforts, direction and constructive criticisms made the execution of the project possible. Special thanks goes to Dr. Malcolm Litterick, also of the University of Nairobi for this evaluation of the manuscript.

I wish to offer my gratitude to the Director of Fisheries, Mr. Norbert Odero for the provision of funds for postgraduate sponsorship and other necessary encouragements during the programme. I am also grateful to Mr. Arrow S. Oburu, the Assistant Director of Fisheries (Headquarters) for his moral, material and technical support. The special and morale-boosting encouragements, throughout the entire course from Mr. John O. Arunga, the Assistant Director of Fisheries (West Kenya) and Mr. Booker W. Oduor, the Senior Fisheries Officer (Headquarters) are greatly appreciated.

I would like to thank the staff of the Kenya Power and Lighting Company, Kamburu, the Sagana Fish Culture Farm and the Kenya Marine and Fisheries Research Institute, Kisumu, who were connected with this project in one way or another. On the same note I would like to acknowledge the assistance of Mr. Onyango Abuje formerly of the Museums of Kenya for identification of the aquatic invertebrates, Mr. Mwanga formerly of the University of Nairobi for Cartographic work, Mrs. R. Mbugua of the Department of Fisheries and Mrs. Rose Onyango of St. mary's School for typing the manuscript.

APPENDIX 1

RELATIONSHIP BETWEEN CONDITION FACTOR (K), FAT CONTENT (F/C) GASTROSOMATIC INDEX (G.S.I) AND GONADOSOMATIC INDEX (g/s) OF M. KANNUME IN LAKE KAMBURU FROM SEPTEMBER 1978 TO AUGUST 1979

MONTH		"K"		F/C		G.S.I		g/s	
		Males	Females	Males	Females	Males	Females	Males	Females
September	78	1.08	1.0	9.4	11.2	3.0	2.9	0.23	2.05
October	78	1.20	1.15	9.2	10.8	2.95	2.8	0.18	2.05
November	78	0.8	1.1	9.2	10.5	2.75	2.0	0.11	0.6
December	78	0.8	0.8	7.9	10.3	2.8	2.75	0.08	2.4
January	79	1.0	0.9	8.5	11.4	2.95	2.95	0.16	2.5
February	79	1.01	1.1	8.1	11.0	3.1	2.75	0.23	2.6
March	79	1.05	1.16	7.9	9.2	2.95	2.4	0.15	2.0
April	79	0.8	0.9	8.6	8.9	2.8	1.9	0.08	0.7
May	79	0.75	0.8	8.6	9.7	2.75	1.8	0.05	0.75
June	79	1.0	1.0	7.8	11.5	2.95	2.3	0.13	1.25
July	79	1.0	1.11	9.6	10.5	3.0	2.65	0.28	1.35
August	79	1.15	1.2	9.0	10.8	3.2	2.7	0.3	2.25

Appendix II; The standard length, weight, Fecundity and mean egg-size of M kannume in Lake Kamburu

STANDARD LENGTH (CM)	WEIGHT (g)	FECUNDITY	EGG-SIZE(mm)
22.85	159	406	2.15 ± 0.15
27.5	166	599	2.2 ±0.20
27.5	173	681	1.95 ± 0.10
27.9	181	680	2.25 ± 0.25
27.9	184	683	2.4 ± 0.25
27.9	188.4	696	2.8 ± 0.25
28.2	181.9	759	2.55 ± 0.15
28.1	182	692	2.75 ± 0.25
28.0	191	796	2.6 ± 0.22
28.2	195	844	2.1 ± 0.15
28.2	195	843	2.35 ± 0.2
28.1	200	882	2.8 ± 0.2
28.3	207	882	2.6 ± 0.15
28.2	178	982	1.9 ± 0.05
28.3	209	844	2.85 ± 0.25
28.2	214	881	2.9 ± 0.25
28.1	173.8	1000	2.2 ± 0.15
28.5	234	977	2.25 ±0.18
28.4	2344	1050	2.3 ±0.15
28.5	218.8	986	2.4 ± 0.22
28.5	275.4	998	2.35 ± 0.2
28.5	218.7	1359	2.85 ± 0.2
28.5	282	1685	2.8 ± 0.15
28.5	342.8	1995	2.7 ± 0.15
28.6	209	894	1.95 ± 0.05
28.6	257	1299	2.0 ± 0.2
28.6	219	1122	2.3 ± 0.25
29.5	214	1168	2.2 ± 0.15
28.8	269	1302	2.3 ± 0.07

Standard	Weight	Fecundity	Egg-Size(mm)
30.1	224	1258	2.2 ± 0.07
30.9	214	1047	2.7 ± 0.12
30.9	302	1549	2.4 ± 0.2
31.6	316	1629	2.6 ± 0.25
28.1	191	843	2.3 ± 0.15
30.8	263	1514	2.7 ± 0.1
31.5	309	1592	2.8 ± 0.20
38.8	447	3300	2.1 ± 0.1
35.6	457.1	3078	2.4 ± 0.25
33.8	412	2568	2.35 ± 0.3
35.6	403	2690	2.45 ± 0.2
31.6	275	1604	2.40 ± 0.15
33.1	251	1603	2.30 ± 0.15
32.5	281.5	1607	2.5 ± 0.3
33.1	278.6	1614	2.35 ± 0.25
31.6	316	1592	2.2 ± 0.05
31.6	280.5	1621	2.2 ± 0.25
33.1	288.4	1660	2.6 ± 0.2
33.7	295	1737	2.3 ± 0.25
33.0	348	1778	2.7 ± 0.15
32.1	324	1820	2.3 ± 0.2
33.4	316	1916	2.3 ± 0.25
33.5	335	1905	2.4 ± 0.3
33.1	302	1737	2.2 ± 0.15
33.1	324	1906	2.4 ± 0.2
33.7	546	1905	2.7 ± 0.15
33.8	343	1995	2.8 ± 0.15
33.9	355	1998	2.5 ± 0.2
34.5	377	2041	2.5 ± 0.2

Standard	Weight	Fecundity	Egg-Size
33.9	363	2137	2.4 ± 0.25
33.9	380	2290	2.3 ± 0.3
34.3	259	2188	2.1 ± 0.25
34.7	347	2339	2.8 ± 0.15
35.6	372	2344	2.0 ± 0.15
35.7	398	2455	2.0 ± 0.2
33.9	380.1	2511	2.1 ± 0.2
33.9	416.8	2570	2.5 ± 0.25
35.5	419	2691	2.2 ± 0.2
35.7	468	3090	2.3 ± 0.25
38.9	452	3311	2.9 ± 0.15
42.5	484.2	3466	2.8 ± 0.15
30.8	275.4	1479	2.3 ± 0.25
31.6	285.8	1629	2.35 ± 0.25

8 LITERATURE CITED:

Adeniji, H.A (1973) Preliminary investigations into the composition and seasonal variation of the plankton in Kainji Lake, Nigeria. In "Man-made Lakes - their problems and environmental effects". Geophysical Monograph series 17: 617 - 617.

Alee, W.C., Park, G, Emerson, A.E. Park, T and Schmidt, K.F (1949) Principles of Animal Ecology. W.B. Saunders Co Philadelphia and London.

Attwell, R.I.G. (1970) Some effects of Lake Kariba on the ecology of a flood plain of the Mid-Zambezi Valley of Rhodesia. Biol. Conserv. Netherl. 2 (3): 117-128.

Bako, T.W. (1964) The Kainji dam: Its meaning to Nigeria Northern Nigeria Rev. 1 (2) : 16-17.

Balon, E.K. (1971) Replacement of Alestes Imberi Peters 1852 by A. Lateralis Boulenger 1900. In Lake Kariba, with ecological notes. Fish. Res. Bull. Zambia 5: 119-162.

Balon, E.K. and Coche A.G (1974) Lake Kariba. A man-made tropical ecosystem in Central Africa. La Haye W. Junk. N.V. 767.

Banks, J.W., Holden M.J. and McConnel, R.H. (1965) Fishery Report in the first scientific Report of the Kainji Bilogical Research Team. (Ed. White) University of Liverspool.

Beauchamp, R.S.A. (1964) African man-made lakes, Heatherdead. Central Electricity Res. Labs. Cleeve Road Survey.

Beckman, W. (1945) The length-weight relationship factors for conversion between standard and total length and coefficients of condition for seven Michigan fish. Trans. Am. Fish. Soc. 75: 237-256.

Begg, G.W. (1970) Current appraisal of Limnothrisa miodon in Lake Kariba. Mimeographed Reports on Lake Kariba Fisheries Rec. Inst. Kar. Rhodesia 20.

Begg, G.W. (1974) The distribution of Fish of Riverine origin in relation to the Limnological Characteristics of the five basins of Lake Kariba. Hydrobilogia 44:2 - 3:277-285.

Benson, N.C. (1973) Econological studies of phytolankton in the newly forming Volta Lake of Ghan. J. West. Afr. Sc. Ass. 11:14-19.

Berg, K. (1937) Contribution to the biology of Corethra meigen (Chaoborus lichtenstein) Biol. Medd. Kbh. 13 (11) 1-101.

Berg, K. (1938) Studies on the bottom animals of Esrom Lake. K. danske Vidensk. Selok. Skr. (9) 8: 1-255.

Biswas, S. (1966) Ecological studies of phytoplankton in the newly forming Volta Lake of Ghana. J. West Afr. Sci. Ass. 11: 14-19.

Blake, B.F. (1977a) Food and feeding of the Mormyrid fishes of Lake Kainji, Nigeria, with special reference to seasonal variation and interspecific differences. J. Fish. Biol. II (3): 315-328.

Blake, P.F. (177b) The effect of the impoundment of Lake Kainji, Nigeria, on the indigenous specifies of mormyrid fishes. Freshwater Biol. 7: 37 - 42.

Boughey, A.S. (1963) The explosive development of a floating weed vegetation on Lake Kariba. Adansonia 3: 49 - 61.

Boulenger, G.A (1911) Catalogue of fresh water fishes of Africa in the British Museum (Natural History) London. Vol. 2: 1 - XIII, 1 - 525.

Bowmaker, A (1970) A prospect of Lake Kariba. Optima, June, 1970 68 - 74.

Boyd, C.E. (1979) Water quality in warm water fish ponds. Auburn State Univ. Agric. Exp. Sta. Craftmaster Printers Inc. Opelica. Alabama. 3 - 8.

Boyo, A.E (1962) Medical problems of the Niger dams project. Proc. Soc. Sci. Ass. Nigeria 5: 54p.

Brook, A.J. and Rzoska, J. (1954) The influence of the Gebel Aulyia dam on the development of the Nile plankton J. Anim. Ecol. 23: 101.

Burrows, R.E. (1951) An evaluation of methods of egg enumaration. Progve. Fish. Cult. 13: 79 - 85.

Cala, P. (1976) Age at maturity, testicular development and seasonal changes in the testis of Ide, Idus Idus (L) (Pisces, Cyprinidae) in the river Kaulingean, South Sweden. Ins. Freshwater Res. Fish. Bul. Lund. 55: 5 - 14.

Carlander, K.D (1969) Handbook of Freshwater Biology. Vol. 1 lowa State Univer. Press. Ames. lowa pp. 5 - 13.

Coke, M. (1969) Some observations on fish population dynamics in Lake Kariba. Limn. Soc. S Afr. Newclater.

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

Croxton, F.E. (1959) Elementary statistics with application in medicine and the biological sciences. Dover Publications, Inc. New York.

Dadzie, S. Odingo, R.S. and Ongoma, A (1979) Aquatic ecology and fisheries in "African Dam: Ecological Survey of the Kamburu/Gitaru hydro-electric dam area, Kenya, (R.S. Odingo ed.) Ecol. Bull. (Stockholm) 29: 65-84.

Dadzie S. (1980) Recent changes in the fishery of a new tropical man-made lake, Lake Kamburu (Kenya) J. Fish. Biol. 16 : 361 - 367.

Dadzie, S. and Wangila, B.C.C. (1980) Reproductive biology, length-weight relationship and relative condition of pond raised Tilapia zillii (Gervais). J. Fish. Biol. 17: 243 - 253.

Daget, J. (1954) Les poisons du Niger Superior. Mem. del. IFAN. Dakar.

Dice, L.R. (1952) Natural communities, Univ. Michigan Press. Ann. Arboa.

Eccles, D.H. (1975) Fishes of the African Great Lakes as candidates for introduction into large tropical impoundments. J. Fish. Biol. 7: 401 - 405.

East African Freshwater

Fisheries Research Organisation (1948) Annual Report.
" " " (1949) " "
" " " (1951) " "
" " " (1952) " "

Evans, W.A. and
Jennes, J. (1967) Pre-impoundment bush clearance, Kainji Lake Basin, Northern Nigeria. Mimeograp Rept.

Graham, M (1929) The Victoria Nyanza and its fisheries. A report on the fishing survey of Lake Victoria, 1927 - 1928. Crown Agents for the Colonies London.

Green Wood, P.H. (1957) The fishes of Uganda III. The Uganda Journal, 21: 64 - 68, 80.

Green Wood, P.H (1966) The fishes of Uganda 2nd Ed. Uganda Society Kampala.

Gunther, S. (1962) Freshwater fishes of the world. Transl. by Tucker Denys. W. Vistabooks, Long acres Press 68 - 73.

Harding, D (1964) Hydrology and fisheries in Lake Kariba. Verh. Int. Ver. Limnol. 15: 139 - 149.

Hartland-Rowe R.C.B (1958) The biology of a tropical may fly, Povilla adusta Navas. (Ephemeroptera, Polymitarcidae) with special reference to the lunar rhythm of emergence. Rev. Zool. Bot. Afr. 58: 185 - 202.

Harper, W.M (1971) Statistics. The M and E handbook series. MacDonald and Evans Ltd. London P. 119 - 153.

Hile R. (1936) Age and growth of the cisco, Leucichthys arteli (Le Sueur) in the Lakes of the north-eastern highlands. Wisconsin, U.S. Bur. Fish. Bull. 38: 211 - 317.

Imevbore, A.M.A. (1960) Biological Research at the Kainji Lake Basin, Nigeria, July, 1965 - September 1966 In (L.E. Obeng ed) 50-56. Man-made Lakes : Accra Symphosium Ghana University Press.

Imevbore, A.M.A. (1970a) Some general features of the Kainji Reservoir basin. In Kainji Lake studies Vol. I Ecology pp. 17-26 (ed) S.A. Visser. Ibadan University Press.

Imevbore, A.M.A. (1970b) The Chemistry of the River Niger in the Kainji reservoir area. Arch. Hydrobiol 67: 412 - 431.

Imevbore, A.M (1970c) Some preliminary observations on the sex-ratios and fecundity of the fish in the River Niger in Kainji Lake studies Vol. I Ecology: pp. 87 - 98.

Imevbore, A.M.A. and Bakare O. (1970) The food and feeding habits of non-cichlid fishes of the River Niger in the Kainji reservoir area. Kainji Lake studies, Vol. I Ecology pp. 49 - 64 (ed) S.A. Visser, Ibadan University Press.

Imevbore, A.M.A. (1971) Floating Vegetation of Lake Kainji, Nigeria. Nature 230: 599 - 600.

Imevbore, A.M.A. and Bakare O. (1974) A pre-impoundment study of swamps in the Kainji Lake Basin. Afr. J. Trop. Hydrobiol . Fish. 3(1): 79 - 93.

Ivlev, V.S (1961) Experimental ecology of the feeding of fishes. Yale Univ. Press, New Haven.

Jackson, P.B.N. (1961) Ichthyology. The fish of the middle Zambezi, Kariba studies Manchester Univ. Press. Manchester. 36pp.

Jackson, P.B.N. (1965) The establishment of fisheries in man-made lakes in the tropics - Man-made lakes. Academic Press.

Joseph, A.F and Martin F.J (1902) A preliminary account of the chemistry of the Nile Sudd. J. Soc, Chem. Industry 29: 91 - 94.

Jillet J.B (1968) The Biology of Acanthoclinus quadridactylus (Block and Schneider) Teleostei-Blennioidae. I. Age, growth and food. Aust. Journ. of Marine and Freshwater - Research Vol. 19 No. 1: 1-8.

Lagler, K.F (1956) Freshwater fishery biology. W.M.C. Brown Co Bengue, Iowa.

Lagler, K.F Bradach, J.E. and Miller R.B. (1962) Ichthyology. John Wiley and Sons. 226 - 461.

Lagler, K.F (1969) Man-made lakes. Planning and Development UNDP/FAO of U.N. Rep. Rome. Italy 37-47.

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

Lelek, A (1972) Fish populations of Kainji Lake, Trends in their development and utilization. F.A.O/U.N.D.P. Technical Report of the Government of Nigeria (F1:SF/NIR). 24. Tech. Rep. 2).

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

Lelek A, and Elzarka S. (1973) Ecological comparison of the pre-impoundment and post-impoundment fish faunas of the River Niger and Kainji Lake. Nigeria. American Geophysical Monograph Series 17: 655 - 660.

Lewis, D.S.C. (1974a) The effect of the formation of Lake Kainji (Nigeria) upon the Indigenous Fish populations. Hydrobiolo-gia, 45 (2-3) 281 - 301.

Lewis, D.S.C. (1974b) Report of the University of Ife-University of Southampton. Kainji Research Project. O.D.M. Publications.

Lind, E.A. and Kukko, O. (1974) Seasonal variation in gonad-weight condition and activity in the roach, Rutilus rutilus(L) in Lake Kjulajarvi. Finland. Ichthyol. Fenn. Borealist 2: 67 - 115.

Little, E.C.S. (1968) Handbook of utilization of aquatic plants: Acompila-tions UNDP/F.A.O Rome.

Little, E.C.S. (1969) Weeds and Man-made Lake. In Obeng, L.E(d) Man-made Lakes, the Accra symposium. Ghana Univ. press and Oxford Univ. Press. London.

MacDonald, W.W (1956) Observations on thebiology of chaoborids and chironomids in Lake Victoria and on the feeding habits of the elephant snoit fish, Mormyrus kannume (Forsk). J. Anim. Ecol. 25: 36 - 53.

McIntyre, A.D (1952) The food of halibut from North Atlantic fishing grounds. Her. Maj. Sta. Off. Mar. Res. 3: 3 - 20.

Motwani, N.P and Kanwai, Y. (1970) Fish and fisheries of the coffer-dammed right channel of the River Niger at Kainji. In Kainji Lake studies, I. (Ecology. Ed. Visse. S.A) 27 - 48 Univ. of Ibadan.

Mwalo, O.M. (1983) Some hydrobiological observation at the mouths of two affluent rivers of Lake Victoria, with special emphasis on Synodontis spp. (Pisces : Mochocidae) MSC. Thesis. Univ. of Nairobi.

Nawar, G. (1959a) Observations on the breeding of six members of the Nile Mormyridae, Ann. Mag. Nat. Hist. 13,2: 603 - 606.

Nawar, G. (1959b) A study of the fecundity of the Nile mormyrid, Hyperopisus bebe, Lacepede Ann. Mag. Nat. Hist. 13,2: 493 - 504.

Nedeco C. (1959) River studies and Recommendations. Improvements of Niger and Benue, Amsterdam. North Holland Pub. Company.

Needham, P.R. Moffeet, J.W. and Slatter, D.W. (1945) Fluctuations in wild brown trout populations in Convict Greek, California J. of Wild and Man 1: 9-25.

Neuman, E (1976) The growth and year class strength of Perch (Perca Fluviatilis in some Baltic Archipelagos, withspecial reference to Temperature. INS. FRESH RES. DROT. REP. 55: 57 - 70.

Nikolsky, G.V (1963) The Ecology of Fishes Academic Press. London and New York.

Obeng, L.E. (1969) An address to the International symposium. Ed. Obeng. L.E. Man-made Lakes. The Accra Symposium. Ghana Univ. press and Oxford Univ. Press. London.

Odingo, R.S. and Nyambok, I.O (1979) Geology, erosion and sedimentation. In "Final report on Trans-disciplinary ecological study of the Kamburu/Gitaru Hydroelectric dam area of the Tana River Basin of Eastern Africa" 15 - 35.

Okedi, J. (1966) Some aspects of the commercial fishery of the Mormyridae with special reference to the smaller species. E.A.F.F.R.O. Ann. Rep. (1965), 49 - 55.

Okedi, J. (1968) Notes on the behaviour of the small mormyrid fishes of Lake Victoria E.A.F.F.R.O. Ann. Rep. (1967) 42 - 48.

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

Okedi, J. (1970) Study of the fecundity of some mormyrid fishes from Lake Victoria E.Afr. Agric. for J. XXXV (4): 436 - 442.

Okedi, J. (1971) The food and feeding habits of the small Mormyrid fishes of Lake Victoria, East Africa. (Pisces : Mormyridae). Afr. J. Trop. Hydrobiol. Fish. 1 (1): 1 - 11.

Papageorgious, N.K. (1979) The length-weight relationship, age, growth and reproduction of the roach Tutilus rutilus (L) in Lake Volvi, Italy. J. Fish. Biol. 14: 529 - 538.

Petr, T. (1966) Fish population changes in the Volta Lake over a period of May 1965 - July 1966. Volta Basin Res. Project. Univ of Ghana.

Petr, T. (1967a) Fish population changes in the Volta Lake in Ghana during its first sixteen months. Hydrobiologia 30: 193 - 220.

Petr, T. (1967b) Food and food preferences of the commercial fishes of the Volta Lake. Univ. of Ghana. V.B.R.P. Tech. Rep. X:22.

Petr, T. (1968) Distribution, abundance and food of commercial fish in the Black Volta and the Volta man-made lake in Ghana during its first period of filling. (1964-1966) I. Mormyridae. Hydrobiology, 32: 417 - 448.

Petr, T. (1969) Fish population changes in the Volta Lake over the period. January 1965 - September 1966, in "Man-made Lake". The Accra symposium (Ed. Obeng L.E) 220 - 284.

Petr, T. (1972) Benthic fauna of a tropical man-made lake (Volta Lake, Ghana). Arch. Hydrobiol. 70: 484 - 533.

Petr, T. (1974) Distribution, abundance and the food of commercial fish in the Black Volta and the Volta man-made lake during its filling period. (1964 - 68) II. Characidae. Hydrobiologia 45: 303-337.

Petr, T and Reynolds J.D (1969) The first population changes in the Volta Basin Research Project. Univ of Ghana. Tech Rep. X:32.

Reed, W. (1967) Fish and fisheries of Northern Nigeria Ministry of Agriculture, Zaria, Gaskiya printers. pp. 44.

icker, W.E (1973) Linear regression in fishery research. J. Fish. Res. Bd. Can 30 (3): 409 - 434.

Ricker, W.E. (1975) Computation and interpretation of biological statistics of fish populations. Bull. Fish. Res. Bd. Can. 191: 382.

Scott, D.B.C. (1964) A preliminary report on reproduction in Mormyrus kannume. Forskal. E.A.F.F.R.O. Ann. Rep. 1962/63: 75-76.

Scott, D.B.C. (1974) The reproductive cycle of M. kannume (Forsk) osteoglossomorpha, (Mormyriformes) in Lake Victoria. J. Fish. Biol. 6: 447 - 542.

Siddique, Q.A. (1977) Reproductive biology, length-weight relationship and relative condition of Tilapia leucosticta (Trewavas) in Lake Naivasha J. Fish. Biol. 10: 251 - 260.

Sokal, R.R. and Rohlf, F.J. (1969) Biometry. The Principles and practice of statistics in biological research. W.H. Freeman and Company San Francisco pp. 776.

Thompson, D.A. (1942) On growthad form. New ed. Cambridge Univ. Press.

Treasurer, J.W (1976) Age, growth and length-weight relationship of brown trout, Salmo trutta (L) in the Loch of Strarthbed, Aberdeenshire, J. Fish. Biol. 8: 241 - 253.

Tweddle, D. (1975) Age and growth of the catfish Bagrus Meridionalis (Gunther) in Southern Malawi. J. Fish. Biol. 7: 677-685.

Van Sommeren, V.D (1962) The migration of fish in small Kenya river Rev. Zool. Bot. Afr. LXIV: 3-4.

Vaznetsev, V.V. (1953) Development stages of yound fishes. "General problems in Ichthyology" Russ. Akad. Nank. Press. Moscow.

Vinner, A.B (1970) Hydrobiology of the Volta Lake, Ghana I. Stratification and circulation of water. Hydrobiologia 35: 209 - 229.

Vinsser, S.A (1973) Pre-impoundment features of the Kainji area and their possible influence on the ecology of the newly formed lake. Geophysical Monograph Ser. 17: 590 - 595 American Geophysical Union.

Vinsser, S.A. (1974) Composition of waters of lakes and rivers in East and West Africa. Mimeograph Report.

Vladykov, V.D (1956) Fecundity of wild speckled trout (Salvelinus fontinalis) in Quebec lakes. J. Fish. Rec. Bd. Can.13 : 799-841.

Ward, K. Ashcroft, L.G and Parkman CC. (1976) Upper Tana Reservoir Pre-construction environmental study. WAPCONSTULT ENGINEERS (E.A) Agip House Nairobi. pp. 37 - 88.

Welcome, R.L (1967) The relationship between fecundity and fertility in the mouth-brooding cichlid fish, Tilapia leucosticta J. Zool. Lond. 151: 453 - 468.

Welcome, R.L (1976) Some general and theoretical considerations on the fish yield of African Rivers. J. Fish. Biol. 8 (4) 351 - 364.

White, E (1965) The first scientific report of the Kainji Biolotical Research Team. Liverpool.

White head, P.J.P. (1959a) The anadromous fishes of Lake Victoria. Rev. Zool. Bot Afr. LIX: 329 - 363.

White head, P.J.P. (1959b) The andromous fishes of Lake Victoria. Rev. Zool. Bot. Afr. LIX: 329 - 363.

Whitehead, P.J.P and Van Semmeren V.D (1959) The culture of T.nigra (Gunther) in ponds. The early growth of males and females at comparable stocking rates, and the length-weight relationship. E.Afr. For. J.25: 169 - 173.