"THE BIOLOGY OF THE CLUPEID, ILISHA AFRICANA (BLOCH) OFF THE NIGERIAN COAST".

A thesis submitted for the degree of
DOCTOR OF PHILOSOPHY (ZOOLOGY)
UNIVERSITY OF LAGOS

By

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JANUARY 1982.

I certify that the work embodied in this thesis for the degree of Doctor of Philosophy (Zoology) has been carried out under my supervision.

Dr. Kola Ikusemiju
(Supervisor).

DEDICATION

This thesis is dedicated to my parents, Mr. Y.O. Carew and late Mrs. M.A. Carew who had instilled in me the discipline to wade through life with all its difficulties and had shown particular interest in my academic pursuit.

ABSTRACT

Aspects of the biology of *Ilisha africana* (Bloch) caught off the Nigerian Coast were studied. These included the taxonomy, distribution, age and growth, food and feeding habits, reproduction and racial studies. The use of meristic and morphometric characters were employed in the taxonomy study.

I. africana was widely distributed along the Nigerian Coast within depths of 10 - 50m. The greatest abundance occurred at depths between 40m and 50m.

The size range of the specimens examined was between 4.2. and 28.7cm. Ageing of the species was carried out using the burnt otolith technique and the maximum age attainable was found to be 5 years while the size and age at maturity were 12.0 cm and 1 year respectively. Growth was found to be isometric in this species.

The food and feeding habits were studied using the numerical, volumetric and frequency of occurence methods. The major food items of *I. africana* consisted of crustaceans, fish, fish larvae and molluscs.

The larger fish fed more on larger food items while the diets of the smaller fishes consisted mostly of the smaller food items. Diets of fishes from shallow depths consisted of a greater variety of food organisms than the diet of fishes from the deeper waters.

The occurrence of ripe, ripe running and spent fish in all the months of the year indicated that spawning occured in the species throughout the year. However, higher percentages in the months of June to December and the higher values of the gonadosomatic indices (GSI) from May to December were used in delimiting the peak spawning season. Period of peak spawning coincided with the period of higher condition factors in the species.

Fecundity estimates ranged from 2,029 to 11,687 while the egg diameter ranged from 0.57 to 1.35 mm. The gonad maturation stages were classified as immature, ripening 1, ripening 2, ripe, ripe running and spent stages. The histological growth of the ovarian egg was monitored and the stages involved in oogenesis of I. africana were classified as oogonium, primary oocyte, primary vitellogenesis, secondary vitellogenesis, tertiary vitellogenesis, hyaline oocyte and corpora atretica.

A racial study of I. africana collected from Lagos Coast, off Benin, Brass and Bonny Rivers showed that they were not genetically separable populations. Significant differences were found only in the anal fin ray counts of specimens off Lagos Coast as compared with the other locations.

ACKNOWLEDGEMENT

I am most indebted to my supervisor, Dr. Kola Ikusemiju, who not only supervised this study but scrutinised and corrected several drafts of the thesis. I am also grateful to him for his patience and guidance throughout the period of study and for providing some of the relevant references.

I am very grateful to the authorities of the Nigerian Institute for Oceanography and Marine Research who sponsored me for the study. In particular, I am grateful to Mr. J.G. Tobor, the Acting Director of the Institute; Mr. M.A. Afinowi, Dr. T.A. Ajayi, Mr. J.O. Okpanefe, Captain C.O. Thomas, Mr. F.A. Adone, the fishing crew as well as other members of staff of the institute who in various ways made my study a success.

I am thankful to Dr. Femi Agbalajobi and Dr. O. Abass of the Computer Science Department as well as Mr. E.O. Omojokun of the Computer Centre for assistance in the statistical analysis of the data. My gratitude is also expressed to Mr. J.F. Ola and Mr. Yisa Ibraheem for assistance with the photography. I must not fail to express my gratitude to Mrs. C.A. Onibokun and Mr. I.O. Ikediashi for the secretarial assistance they offered.

I must express my profound gratitude to my husband, Mr. V.S. Marcus, who not only encouraged me to start the programme but had relentlessly helped and sacrificed a lot during the course of the study. I am also appreciative of my children Olufunmilayo, Oluwatosin and Olukemi who had had to make sacrifices during this study.

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INTRODUCTION

Along the Gulf of Guinea, Ilisha africana (Bloch) constitutes the dominant member of the family clupeidae and the Nigerian Coastal waters is the area of its greatest abundance (Guinean Trawling Survey Report, 1968). Though there are numerous references on the clupeids, much of the studies were related to their taxonomy hence Whitehead (1972) noted that the extent of the clupeid fauna was fairly well known but for the vast majority of the species, knowledge of their biology was still inadequate.

FAO Report (1966) noted that there was considerable stock of I. africana off the Nigerian Coast and thus expressed the need for a detailed biological study of this species. Since then, very few studies have been published on this species. Available information include those of Tobor (1966) on the taxonomy of the species and Fagade and Olaniyan (1973) who discussed the food of the species in Lagos Lagoon.

This study was therefore undertaken to provide information on some aspects of the biology of I. africana caught off the Nigerian Coast. Aspects studied included taxonomy, distribution, age and growth, food and feeding habits, reproduction and racial divergence **along the Nigerian Coast. The fishery of the species was also reviewed.**

LITERATURE REVIEW

There are about three hundred species in the herring family (Clupeidae), most of which live in the coastal seas of the temperate and tropical regions (Marshall, 1966). Amongst the numerous species, taxonomic studies on the genus Ilisha have engaged the attention of many authors (Fowler (1936), Poll (1953), Tobor (1966), Blache et al (1970), Rao (1972, 1973, 1974, 1975), Ramaiyan and Whitehead (1975)).

However, of all the clupeids, the taxonomy of Ilisha species, which had been based on different criteria have resulted in conflicting views. These have thus necessitated the needs for redescriptions and revisions of this group of fishes. A recent and very comprehensive taxonomic study of this group of fishes in the Indian waters was that of Ramaiyan and Whitehead (1975). This paper gave distinct descriptions as well as the various meristic and morphometric body ratios of the Indian Ilisha species. The form of the swimbladder was also emphasised as a diagnostic character to species differentiation.

In a similar manner to taxonomic studies meristic counts and morphometric characters have been used in racial studies. Another useful method is electrophoresis, though this has been of less common use. Available literature shows that numerous studies have been undertaken on the racial divergence among the Pacific herrings (McHugh, 1954). Many of the initial studies showed that the most satisfactory character for the detection of population differences in the Pacific herring was the mean number of vertebral centra. It was therefore probable that it was for this reason that subsequent investigators did not make equally thorough studies of other characters. In fact Chapman et al (1941), McHugh (1942) and Tester (1949) employed the exclusive use of vertebral counts in their studies. However McHugh (1951) noted that in Engraulis mordax mordax (Girard), fin ray counts and gill rakers provided useful additional information on the population structure of the species. Presently, there is probably no information on the racial divergence of I. africana.

Various aspects of the distribution of major clupeid species have been studied. Bainbridge (1963) reviewed the distribution and the biology of the bonga, Ethmalosa fimbriata (Bowdich) throughout its range of occurrence along the West African Coast from Senegal to Angola. Olsen and Lefevere (1969) described the length distribution of E. fimbriata in Midwest, Nigeria while Fagade and Olaniyan (1972) gave an account of its size and spatial distribution in the Lagos lagoon. The Guinean Trawling Survey Report (1968) gave an account of the distribution of the clupeids, including I. africana along the Gulf of Guinea. It noted that I. africana occurred at depths ranging between 10 - 50m but the greatest abundance was at depth of 20 - 30m. Fagade and Olaniyan (1972) described the vertical distribution of E. fimbriata. They noted that the juveniles were found in very shallow waters close to the shore while the mature adults were found in slightly deeper waters of the Lagos lagoon.

Generally, the concept of diurnal vertical migration is a common feature among clupeids and other pelagic species. Reynolds (1969) noted that Pellonula afzeliusi (Johnels) undertook a diurnal vertical migration to and from surface waters of the New Volta Lake, Ghana. Similarly, Ikusemiju (1973) noted the pelagic nature of P. afzeliusi at night in the Lekki lagoon, Nigeria.

The study of age and growth has engaged the attention of numerous fishery biologists including Blackburn (1950), Dannevig (1956), Christensen (1964), Tobor (1969) Bayagbona (1969), Fagade (1974), Ikusemiju (1976), Ezenwa (1978) and Warburton (1978). The commonly used methods of ageing fishes include the Petersen's method using the length frequency distributions and the examination and interpretation of growth marks formed on the hard parts of the fish such as scales, opercula, otoliths, vertebrae and spines. However, the use of the Petersen's method is limited and found inadequate in some fish species (Bayagbona (1969), Ikusemiju (1976)). It may be found suitable for ageing fish which live for only a few years and breed for a short period in the year as possible overlap in length distribution is then absent. This method has infact been recommended for supplementary use in conjuction with other methods (Fagade, 1974). Growth is influenced by many physical factors like temperature, food, length of daylight, salinity and pH. The effect of temperature and food on growth is pronounced among fish species in the temperate regions of the world, producing rapid growth during summer months and reduction or cessation of growth during the winter months. However, in the tropical regions where temperature variation is slight and food is available for the fishes throughout the year, uniform growth can still be interupted by other physiological factors such as breeding and salt tolerance (Fagade, 1974), Fagade further pointed out that the reduction in growth during particular periods resulted in the formation of growth marks on the hard parts of fishes. Blackburn (1950) noted that equivalent marks or rings were formed only in sexually mature fish and at a period when the fish spawned. These marks were thus termed spawning marks or spawning rings. This period of mark formation was also a period when the body fat was low. The variations of growth are manifested on the hard parts of fishes as hyaline and opaque zones and are used in ageing fishes. Dannevig (1956) showed that the transparent zones of otoliths which remained light after burning the otolith, consisted of only inorganic material while the opaque zones which turned dark after burning the otolith consisted of both inorganic and organic material.

Methods of ageing fish by observing the hyaline and opaque zones in scales, otoliths and bones have met with varying degrees of success in tropical fishes (Bayagbona 1969). Tobor (1969) and Fagade (1974) also expressed the difficulty of using this method in tropical fishes while Ezenwa (1978) and Warburton (1978) have both succeeded in using the dorsal spines and otoliths to age tropical catfishes.

The food of sardines and the various feeding habits have engaged the attention of many biologists (Hardy (1924), Hand and Berner (1959), Muzinic (1960), Legarf and Maclellan (1960), Adeniyi (1972), Fagade and Olaniyan (1972, 1973), Okera (1973), Ramaiyan and Whitehead (1975)). Basically, the food consisted of plankton and to a large extent, the various compositions depended on the constituents of the plankton in the area. The incomplete overlap of diets of fishes in the same environment and hence the avoidance of serious competition for food has been demonstrated in many fishes (Swynerton and Worthington (1940), Hartley (1948), Maitland (1965), Cadwallader (1975) and Ikusemijù and Olaniyan (1977)). Swynerton and Worthington (1940) related how fishes chose different feeding grounds and when some of them had the same feeding ground, how they fed on different organisms or different species of the same organism. Hartley (1948) in his own contribution after studying the food of 11 fish species, noted that in no two fish species was there a true identity of feeding habit, though there was some degree of competition between the fishes. Though Frost (1950) indicated that the diets of salmon and trout were identical and they formed a pair of species in close competition, Maitland (1965) noted that each of these fishes and three other fish species, apart from having common food items, the diet of each fish had a peculiar characteristic. Cadwallader (1975) noted that with few exceptions, the same food organisms were utilised by the galaxiid, the bully, the eels and the trout but the relative proportion of each food type in the diets varied between the species. Ikusemiju and Olaniyan (1977) also noted differences in the diets of three Chrysichthys species from the Lekki lagoon, Nigeria.

The diets of fishes relative to their sizes have also been studied by earlier authors such as Swynerton and Worthington (1940), Frost (1950), Maitland (1965), Fagade and Olaniyan (1972) as well as Ikusemiju and Olaniyan (1977). Similarly, records on feeding inter-relationship between fish species include those of Hartley (1948), Frost (1950), Maitland (1965), Fagade and Olaniyan (1973), and Cadwallader (1975). In his own contribution, Hynes (1950) not only studied the food of two freshwater sticklebacks (Gasteroteus aculeatus and Pygosteus pugitius) but also reviewed the various methods used in the analysis of food of fishes, namely the numerical, frequency of occurrence and the volumetric methods.

A biological parameter needed for the estimation of the absolute size of a spawning population of fish from the total egg production data is the average fecundity of a representative female in the population (Hislop and Hall, 1974). Bagenal (1968), further defined fecundity of fish as the number of ripening eggs in the female prior to the next spawning period. Presumably because of its importance in population statistics, clupeid fecundities have been widely studied and aspects that have been commonly examined included the fecundity - length, fecundity - weight and fecundity age relationships, (Nagasaki (1958), Fagade and Olaniyan (1972), Burd and Howlett (1974) and Otobo (1978)). Fecundity has also been demonstrated as a racial character and thus used in distinguishing different fish stocks

(Dmitriev (1958), Nagasaki (1958), Burd and Howlett (1974)).

The importance of histological sections of gonads in sex determination in fishes was noted by Dolan and Power (1977). In addition to this, histological sections of gonads are also useful in accurate determination of the various gonad maturity stages in fishes as well as in the monitoring of histological growth of fish gonads (Htun-Han (1978)).

MATERIALS AND METHODS

Field work

The training vessel, 'Federal Argonaut' was used for the collection of samples used in the study. The vessel is 20m long and it has an engine capacity of 425HP. The length of the trawl net used for fish collection was 22m with body mesh size of 7.5 cm. and stretched cod end mesh size of 3.75 cm. The net was made of cotton material. Fishing trips were made during the first and third weeks of the month and the duration of the hauls was usually one hour. Most of the fish samples used in the study were caught off the Lagos Coast and here fishing was done between latitudes 3° 11'E and 3° 35'E and longitude 6° 17'N and 16° 24'N. Fishing was usually done at predetermined depths ranging from 5 - 25 fm (10 - 50m). The fish collected in each haul were sorted out on the deck, washed and reserved for further work in the laboratory. All the specimens to be used in the laboratory except those to be used for age determination were preserved in 10% formalin. Samples of fish were also obtained off Benin River, Bonny River and Brass. Plankton samples were collected and preserved in 4% formalin. Fig. 1 is a map of the Nigerian Coast indicating the sampling stations.

Laboratory work

Two thousand, nine hundred and thirty-six (2,936) specimens of *I. africana* were caught between November 1978 and October 1980 and examined in the study. The total length and standard length of each fish were recorded to the nearest tenth of centimetre and the total weight of each fish was recorded to the nearest tenth of a gram. Each fish was then opened up, the sex was determined by visual

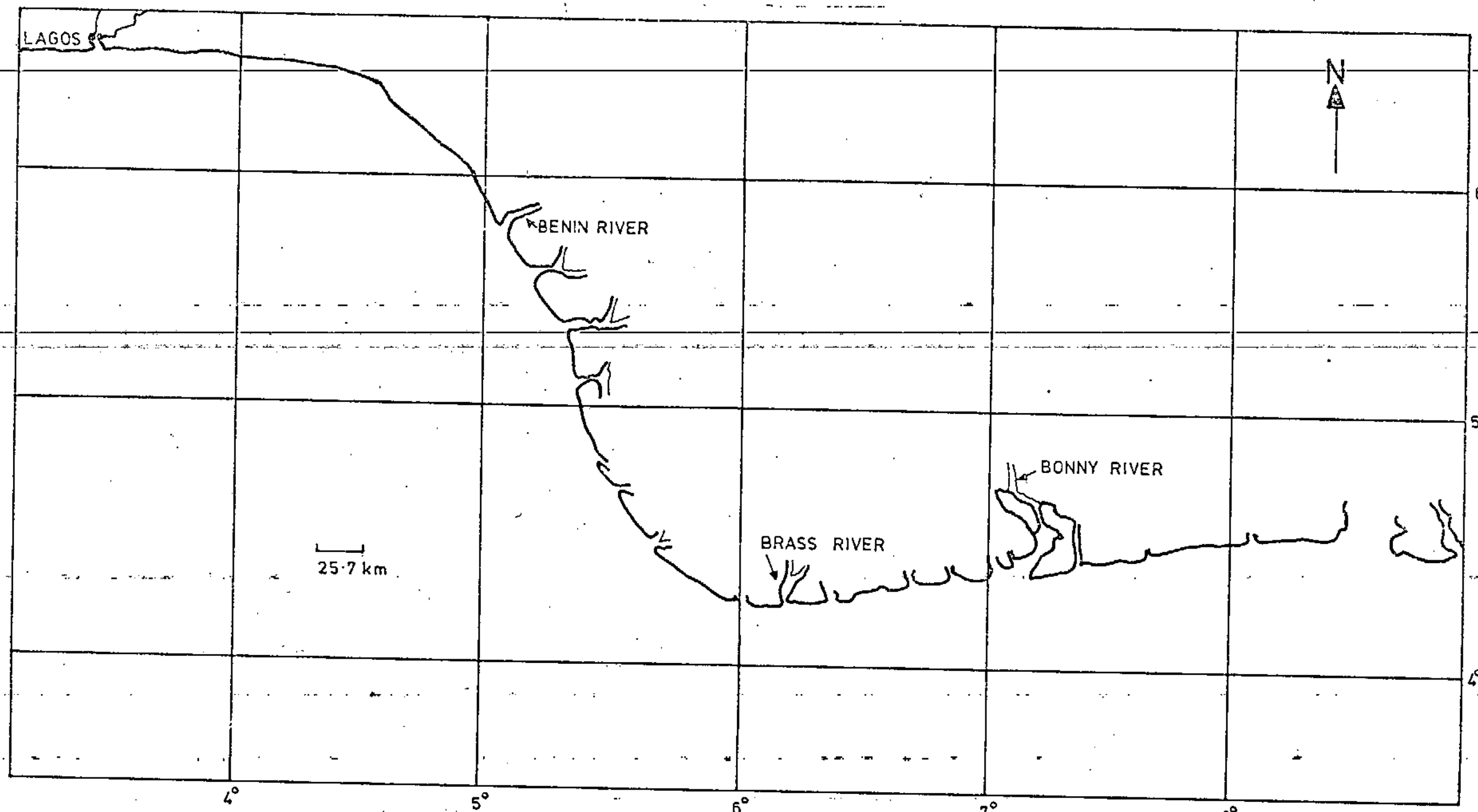


FIG. 1, Map of the Nigerian Coastline indicating the Sampling Stations.

examination under the binocular microscope and the maturity stage of the gonad was determined and recorded. The gonad was removed and its weight recorded to the nearest hundredth of a gram using a Sartorius sensitive balance.

Taxonomy and racial study

The meristic characters used were:

(i) Number of dorsal fin rays

(ii) Number of pectoral fin rays

(iii) Number of anal fin rays

(iv) Number of abdominal scutes

(v) Number of gill rakers on the right side of the lower portion of the anterior gill arch

(vi) Number of gill rakers on the left side of the lower portion of the anterior gill arch

(vii) Number of ventral fin rays

(viii) Number of vertebrae.

Where two rays had a common root, they were counted as one. This was the procedure adopted by Fagade (1969) and Ikusemiju (1973) for the meristic counts of fishes from Lagos and Lekki lagoons respectively. The pectorals were counted on the left side of the fish. The gill rakers on the lower part of the anterior gill arch were counted under magnification after removing the complete anterior gill arch from the fish. For the vertebral counts, the flesh around the skeleton was teased off and the skeleton was then thoroughly rinsed and dried before counts were made. The counts included the atlas and the urostyle.

Morphometric characters used were:

(i) Standard length

(ii) Head length

(iii) Body depth

(iv) Eye diameter

(v) Head depth

(vi) Snout length

(vii) Caudal peduncle length.

All the measurements were made on the left side of the fish. The standard length was measured from the tip of the snout to the structural base of the caudal fin, head length was measured from the tip of the snout to the projected most posterior margin of the opercular membrane. The measurement of the body depth was taken as the distance from just anterior to the first dorsal fin ray to a point vertically below it on the ventral surface.

Age determination

The Petersen's method, the opercular, the scale and the otolith check techniques were employed in order to be able to compare results. However, only the scale and the otolith check techniques were successfully applied. Because the scales of the fish were easily lost and thus most of the fish in the samples had few scales left on them by the time they were landed, the bulk of the work on ageing was done using the otolith check technique.

Scales were obtained from 25 fish. Samples of the scales were obtained on the left side of the fish from

1) the tail region of the fish

2) the hind trunk, behind the dorsal fin

3) the mid trunk, close to the insertion of the pectoral fins anterior to the dorsal fin.

These areas were chosen because they represent the 3 major sections of the fish namely the anterior, the middle and the posterior of the fish. Examination showed that apart from the fact that the scales near the pectorals were most available on the fish, they were those on which the growth marks were most visible. Therefore, for ageing the fish, scales were obtained from this region of the body. The scales were rubbed clean under tap water and they were then placed on a microscope slide and examined under a binocular microscope. The number of growth marks outside the nucleus was recorded and the distance from the centre of the nucleus to the farthest edge of the scale was noted. The position of the last annual ring was also recorded. The annual ring appeared as opaque zones and could even be seen with naked eyes when the scale was held against the source of light.

The opercular bones on either side of the fish were removed and they were cleaned of surrounding flesh by rinsing and rubbing with the fingers under running water. They were then examined under the binocular microscope.

Two hundred and seventy-six (276) otolith pairs were collected from fish caught between January and December 1979. The pairs of otoliths were removed from the otic capsules and kept in labelled envelopes for about 3 months to allow for adequate dehydration prior to examination; it was found during the course of the work that clearer rings were obtained when the otoliths were drier than when they were fresh and 'wet'. The length and depth of the otoliths from the left side of the fish were measured under a binocular microscope to the nearest tenth of a millimeter. A comparison of measurements from the left and right sides of the fish gave similar results.

The left otolith was placed on a metal spatula, convex side up and it was burnt in the flame of a methylated spirit lamp until it turned golden brown. The otolith often cracked through the nucleus but if kept in the flame for too long, it exploded. The otolith was burnt for 20 - 40 seconds depending on its size. A pin was pressed through its nucleus thus separating the otolith into fractures along the cracks. The fractured surfaces were examined under reflected light from a binocular microscope using xylene as a clearing agent. Occasionally continuations of zones on fractured surface were also traceable to the ventral and dorsal surfaces of the otolith. The number of dark zones as well as the position of the last zone relative to the edge of the otolith were recorded. Sometimes whole circles of dark zones could be clearly seen even on the concave and convex surfaces of the otolith. The total lengths of fish collected in each month of the period of study were used in computing the length frequency distribution for the species.

Food and feeding habits

The specimens for the food study of I. africana were caught off the Nigerian Coast between November 1978 and October 1980. Analysis of the food was undertaken using the volumetric, the numerical and the frequency of occurrence methods.

The stomach was removed from each fish by slitting the fish from throat to anus and then cutting off the intestine. Since the fish were preserved in formalin immediately they were caught, the stomach contents were assumed to be representative of the last meal of the fish.

Volumetric method

The stomach with its content was dropped into a 10 ml. measuring cylinder containing a known volume of water. The volume of the stomach and its content were then determined. The contents of the stomach were removed and poured into a petri-dish. The volume of the stomach was determined by water displacement method. By subtracting the volume of the stomach from the volume of the stomach and its food content, the volume of the food content was determined. The volume of each food item was then expressed as a percentage of the volume of all the food in the stomach.

Numerical method

The number of each type of food item in each stomach was recorded. The total number of individuals of a food item was then expressed as a percentage of the total number of food organisms found in all the fish examined.

Frequency of occurrence

This was taken as the number of stomachs in which each of the organisms occurred. The percentages of frequency of occurrence were calculated relative to the number of stomach containing food.

The merits and demerits of these methods have been examined by Hynes (1950), Hunt and Carbine (1950), Lagler (1956).

Plankton collection and analysis

For the collection of samples, a fine mesh plankton net with a glass jar at its cod end was attached to a towing warp and the fishing vessel was operated at about 1 - 1½ knots. In this way, surface horizontal plankton samples were collected over a period of 10 minutes. The plankton collections were preserved in 4% formalin.

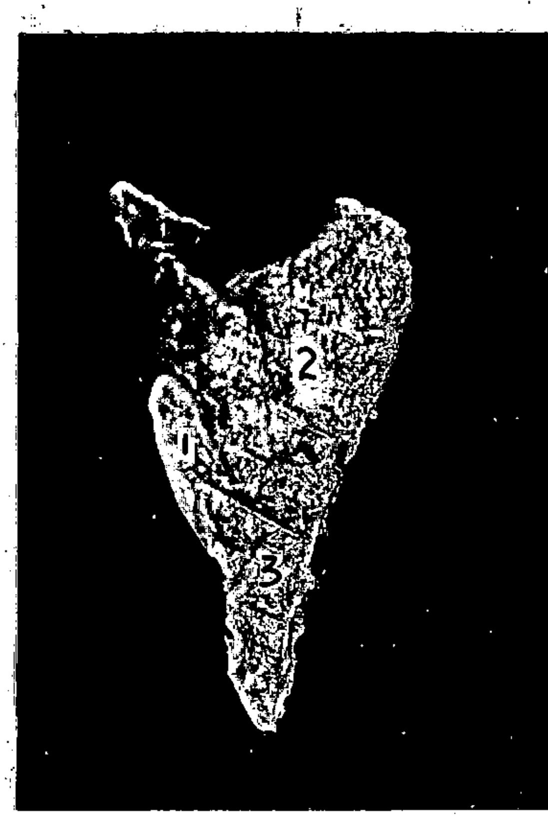
The plankton samples were analysed both quantitatively and qualitatively, the different components being determined and designated by their relative abundance in the sample.

Fecundity

In *I. africana*, the left gonad is smaller than the right one. A preliminary investigation was carried out to find out if the eggs in all the parts of the gonad were in the same maturity stage. The ovaries of a fish 17.9 cm total length was used for this exercise. The gonads were divided into 3 portions as shown in plate 1 and the sizes as well as the appearance of the eggs were noted. It was found that the eggs from the different portions of the ovary were in the same stage of maturity and size. For this reason, all the eggs in both ovaries of specimens used for the fecundity study were counted.

Fishes used for the fecundity study were in the late ripening stage. The gonads were removed from the fish and stored in specimen bottles containing 70% alcohol for preservation prior to fecundity determination. Each gonad was fully labelled denoting the fish length, fish weight and the gonad weight.

The gravimetric method was employed in fecundity determination. The alcohol was drained from the gonads using filter paper set in a funnel. The gonad was then weighed on a Sartorius sensitive balance. The ovary was opened up and the ovarian membrane and tissues between the eggs were removed. All the eggs were then weighed immediately. Three 0.05g samples were weighed and put in separate petri-dishes. The number of eggs in each of the petri-dishes was determined under a binocular microscope and the total number of eggs



Ovary of I. africana

contained in the ovary was determined by simple proportion. The average of the three values so obtained gave the fecundity estimate for that particular fish.

Fifty eggs from the ovary were lined up in five rows and their diameters were estimated using a micrometer eye piece which had been calibrated. The average diameter of the eggs in each fish was thus obtained.

Histology of gonads

The gonads of Specimens caught between July 1979 and July 1980 were used in studying the histology of the gonads of I. africana. The fish weight, fish length, sex, maturity stage and gonad weight were recorded for each fish. The gonad was fixed in Bouin's fluid. The composition of Bouin's fluid was a mixture of 1g picric acid, 1.5 ml of glacial acetic acid, 60 ml of 40% formaldehyde and 150 ml of ethanol (Pantin (1959)). After a period of 24 hours, the fixative was decanted and the gonad was dehydrated in 2 - 3 changes of 70% alcohol within 24 hours, 2 changes of 90% alcohol for 12 hours and finally absolute alcohol for 12 hours. Xylene was then used as a clearing agent for one hour after which the gonad was transferred to molten wax and allowed to stay in the oven for a while. The gonad was finally embedded in clean molten wax and left to set. Cross sections of the gonad were found to be best when the thickness of the sections was 10 U. The ribbons of cut sections were transferred to clean plain microscope slides. A few drops of 2% alcohol were then added and were left for a few minutes to straighten the sections. The ribbons were then transferred to warm water (about 40°C) to further straighten them. The sections were then removed from the water and mounted on plain microscope slides which had been previously rubbed with albumen (for preservation of sections) and marked with an appropriate index number. The slides were then placed on a hot plate for 20 minutes. At least two slides were prepared for each gonad.

Staining technique

The prepared slides were stained using the Erhlich's acid haematoxylin and eosin. The composition of the Erhlich's acid haematoxylin as described by Pantin (1959) is stated below:-

Haematoxylin	2g
Glacial acetic acid	10ml
Glycerol	100ml
Absolute alcohol	100ml
Water	100ml
Alum	excess

The Erlich's acid haematoxylin was prepared by dissolving the haematoxylin in the absolute alcohol, then adding the acid followed by glycerol and water and lastly excess alum. The mixture was allowed to ripen until it assumed a dark red colour.

The prepared slides were kept in xylene for 10 - 15 minutes and then transferred to 2 changes of absolute alcohol keeping them in each for 5 - 10 minutes. They were then kept for 1 minute each in 90% alcohol respectively and then in Erhlich's haematoxylin for 10 minutes. The haematoxylin was washed off in 70% alcohol and the slides were drawn through acid alcohol (1% Hcl in 70% alcohol) for 2 - 5 seconds. This was again washed off in 70% alcohol. The slides were kept in water for 10 - 15 minutes and then passed through 70% and 90% alcohol respectively and then into eosin where they were kept for 2 minutes. The slides were then transferred into 90% alcohol and then into absolute alcohol and finally into xylene from where they were removed for mounting using Canada balsam.

R E S U L T S

1. TAXONOMY

The taxonomy of I. africana was based on the meristic counts and morphometric measurements made from fishes caught off Lagos Coast. The dorsal fin ray counts ranged from 14 - 18 with a mean of 15.39 while the counts of the anal fin rays ranged between 41 and 49 with a mean of 46.27 and the pectoral fin rays ranged between 13 and 15 with a mean of 14.67. All the Specimens examined had 42 vertebrae and 6 ventral fin rays each. The abdominal scutes varied from 25 - 29 + 5 - 7 while the number of gill rakers on the lower portion of the anterior gill arch varied from 65 - 72 with a mean of 66.85. The meristic counts and morphometric data are shown in Appendices I and II respectively.

Figures 2 - 6 are illustrations of the distributions of the meristic counts of I. africana. The distribution of the abdominal scutes was dimodal with its modes at 31 and 33. The distributions of the dorsal fin rays, anal fin rays and the gill rakers conformed with the expected normal distribution. However, the distribution of the pectoral fin rays was not normal.

The total number of gill rakers on the lower anterior gill arch varied between 66 and 72 while the number of abdominal scutes varied from 30 - 35. However, there was no distinct linear variation in the numbers of gill rakers and number of abdominal scutes with increased fish size. Figs. 7 and 8 illustrate these respectively. However, the head length, head depth and body depth varied directly with increase in standard length of the fish. These are illustrated in Figs. 9 - 11.

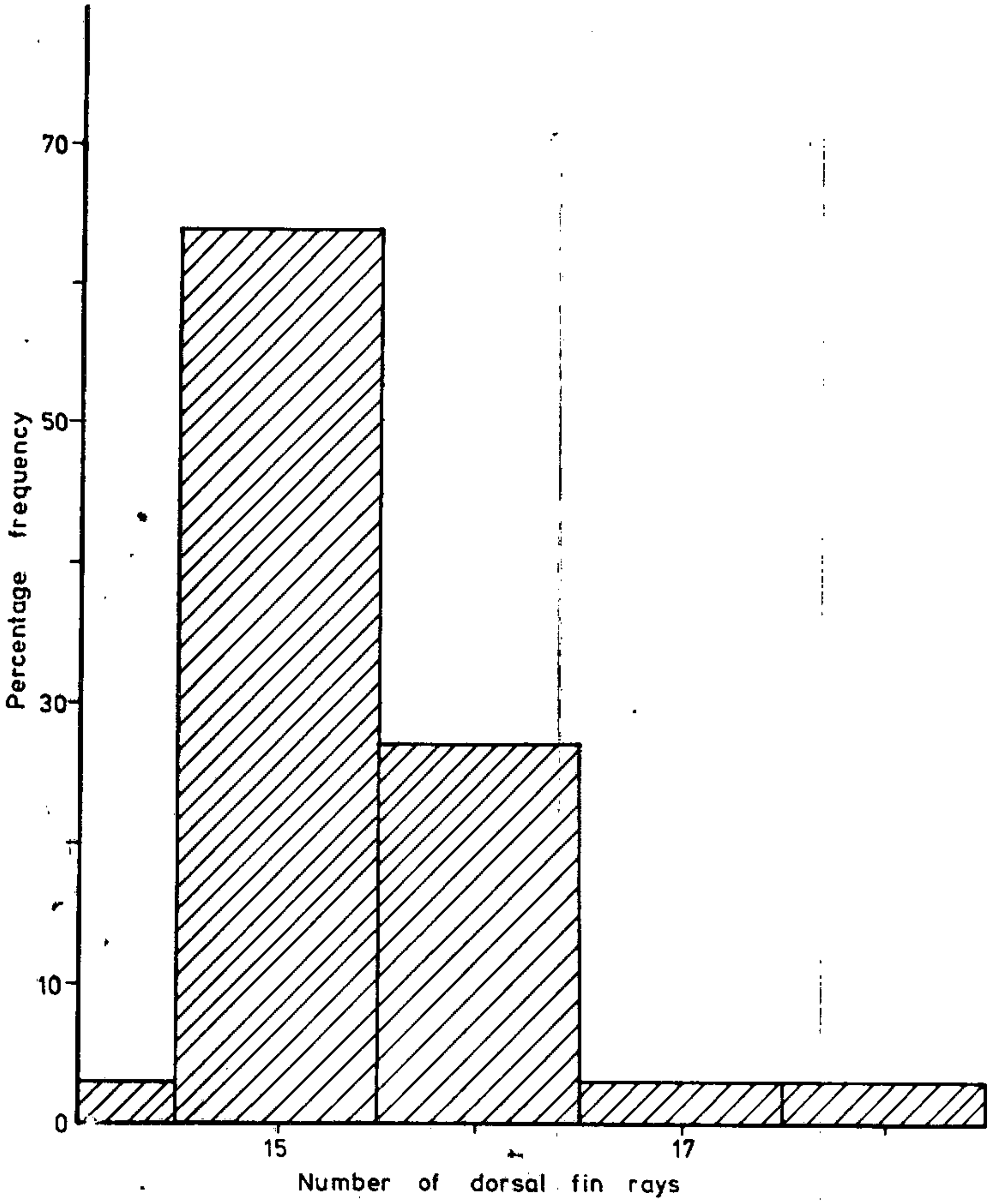


FIG. 2, Percentage distribution of dorsal fin rays in *I. africana*.

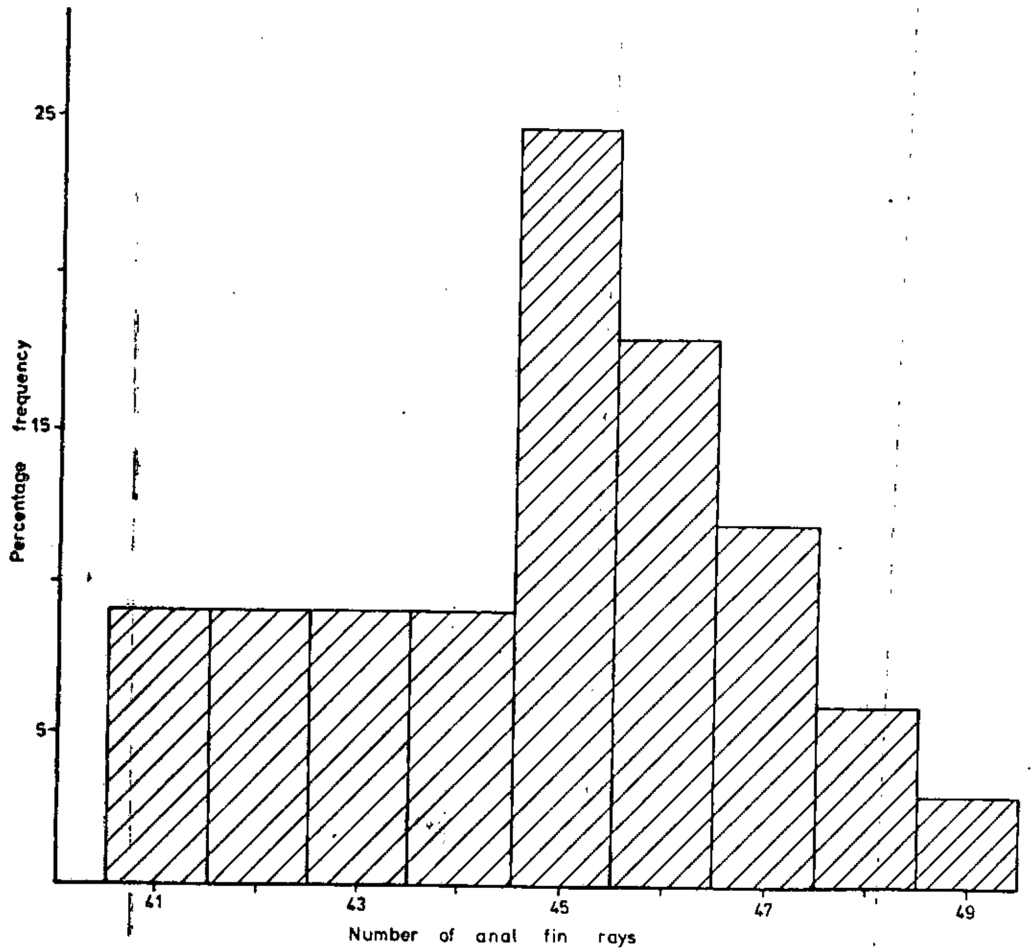


FIG. 3. Percentage distribution of anal fin rays in I. africana

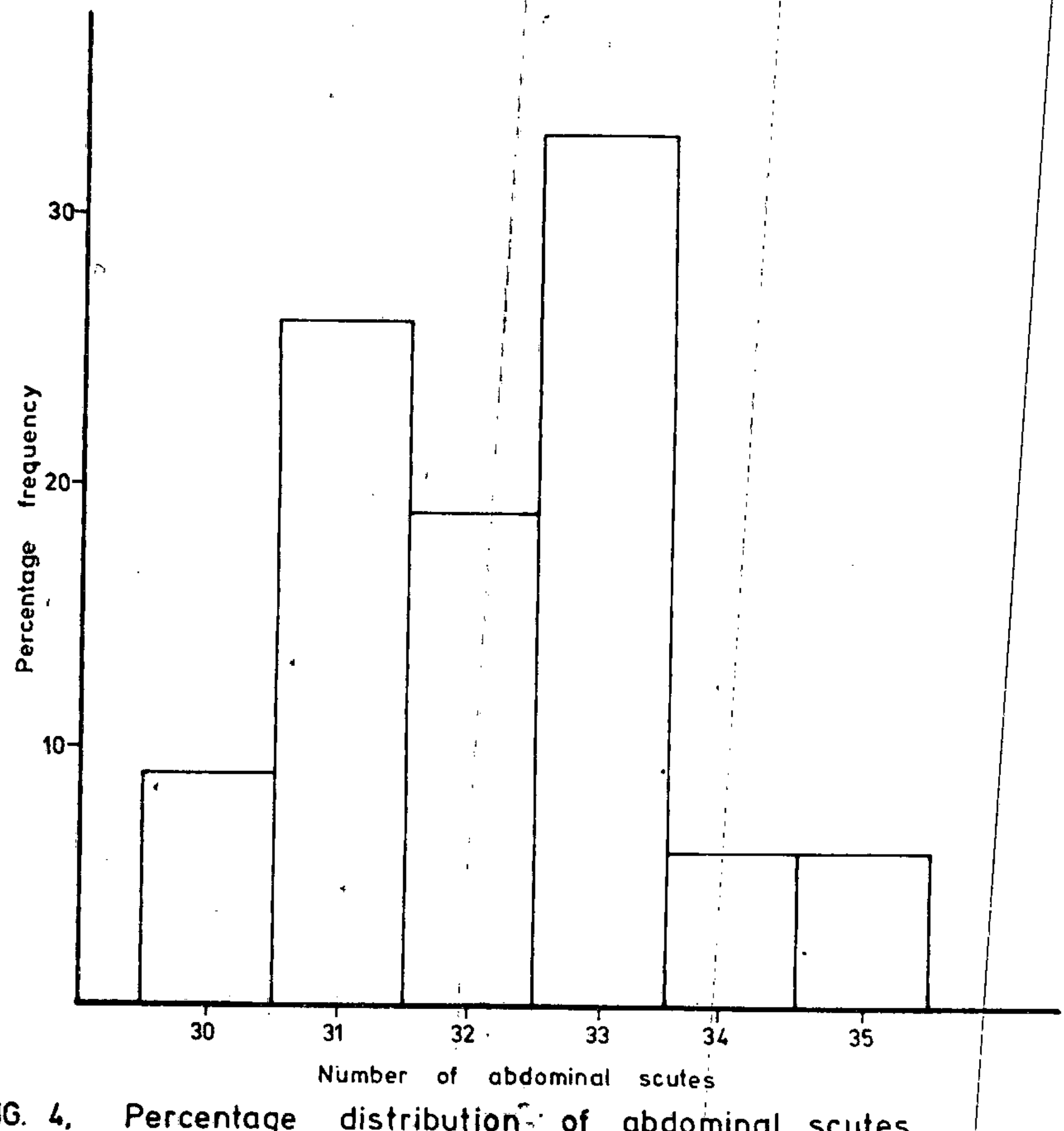


FIG. 4. Percentage distribution of abdominal scutes in *I. africana*

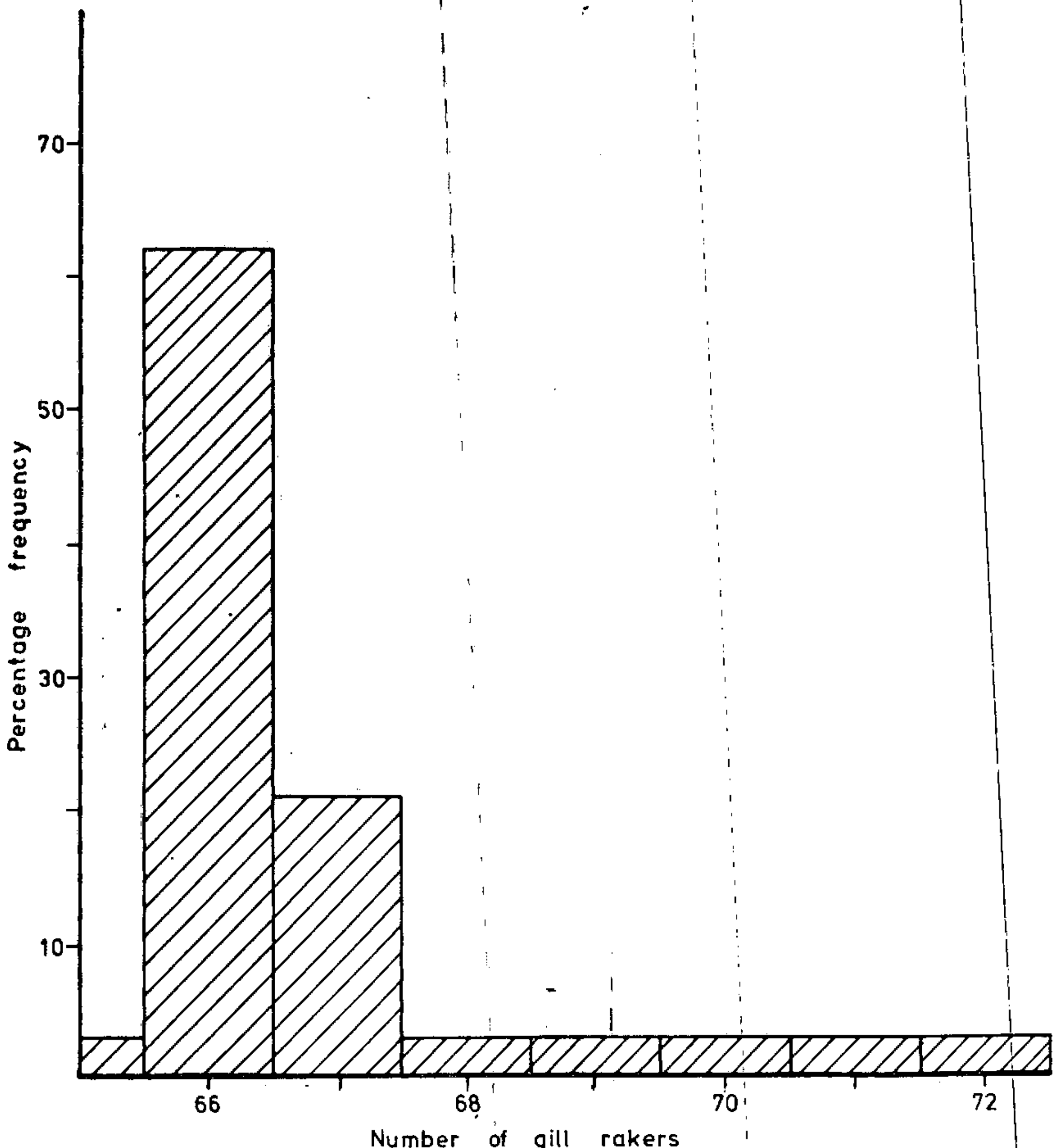


FIG. 5, Percentage distribution of gill rakers on the anterior gill arch in *I. africana*

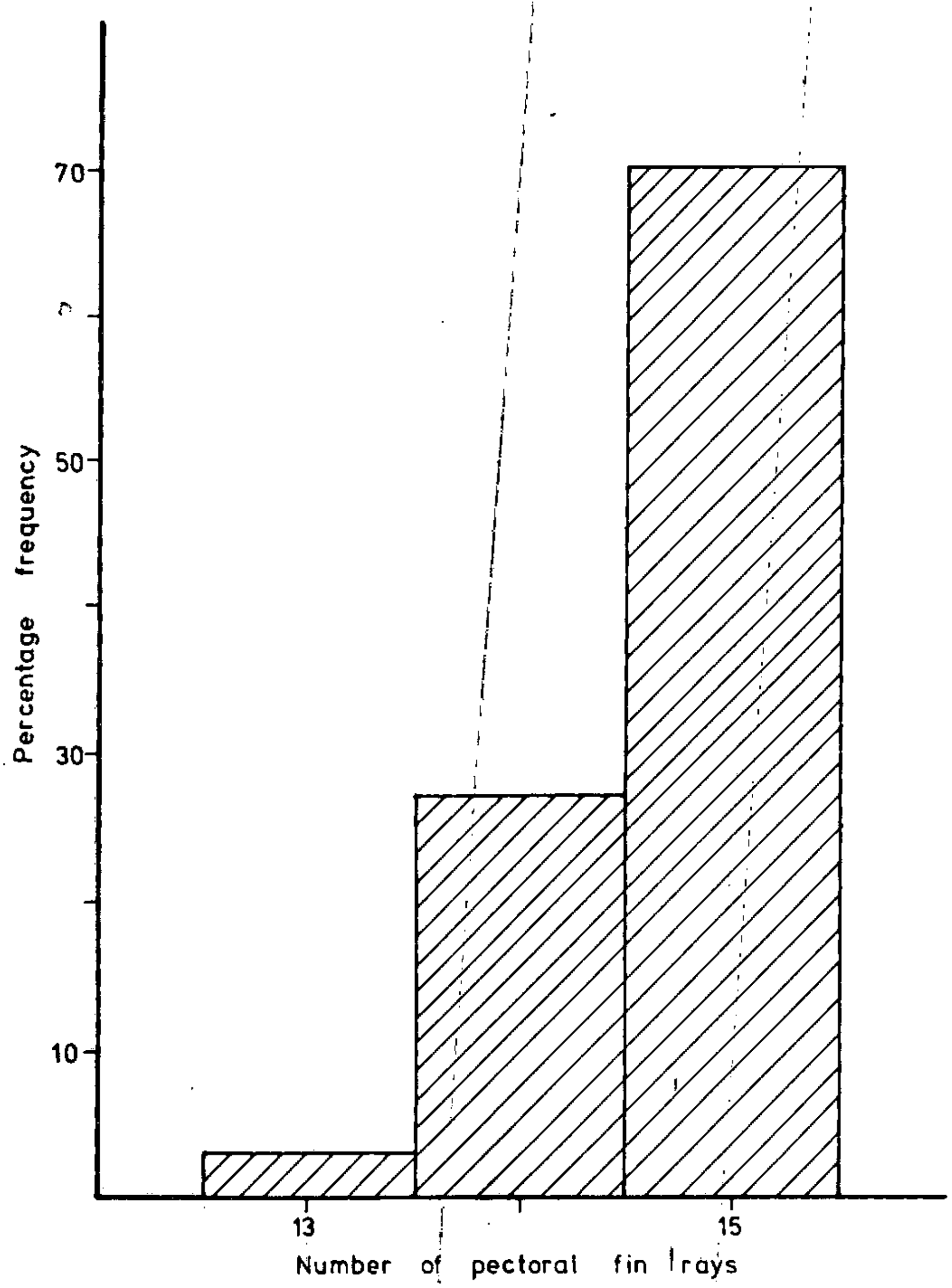


FIG. 6, Percentage distribution of pectoral fin rays in I. africana

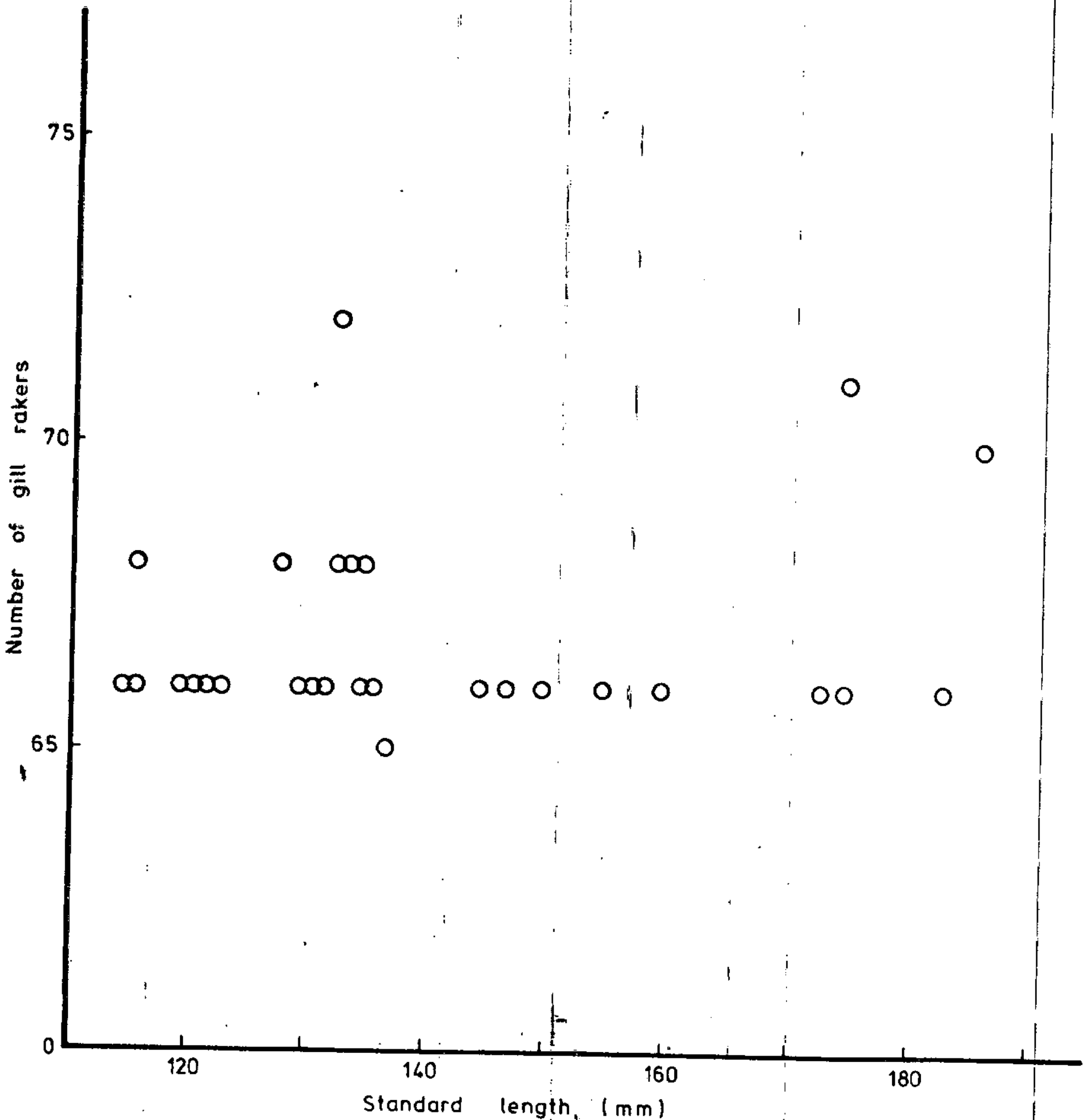


FIG. 7, Regression of number of gill rakers found on the anterior gill arch on the standard length in *I. africana*

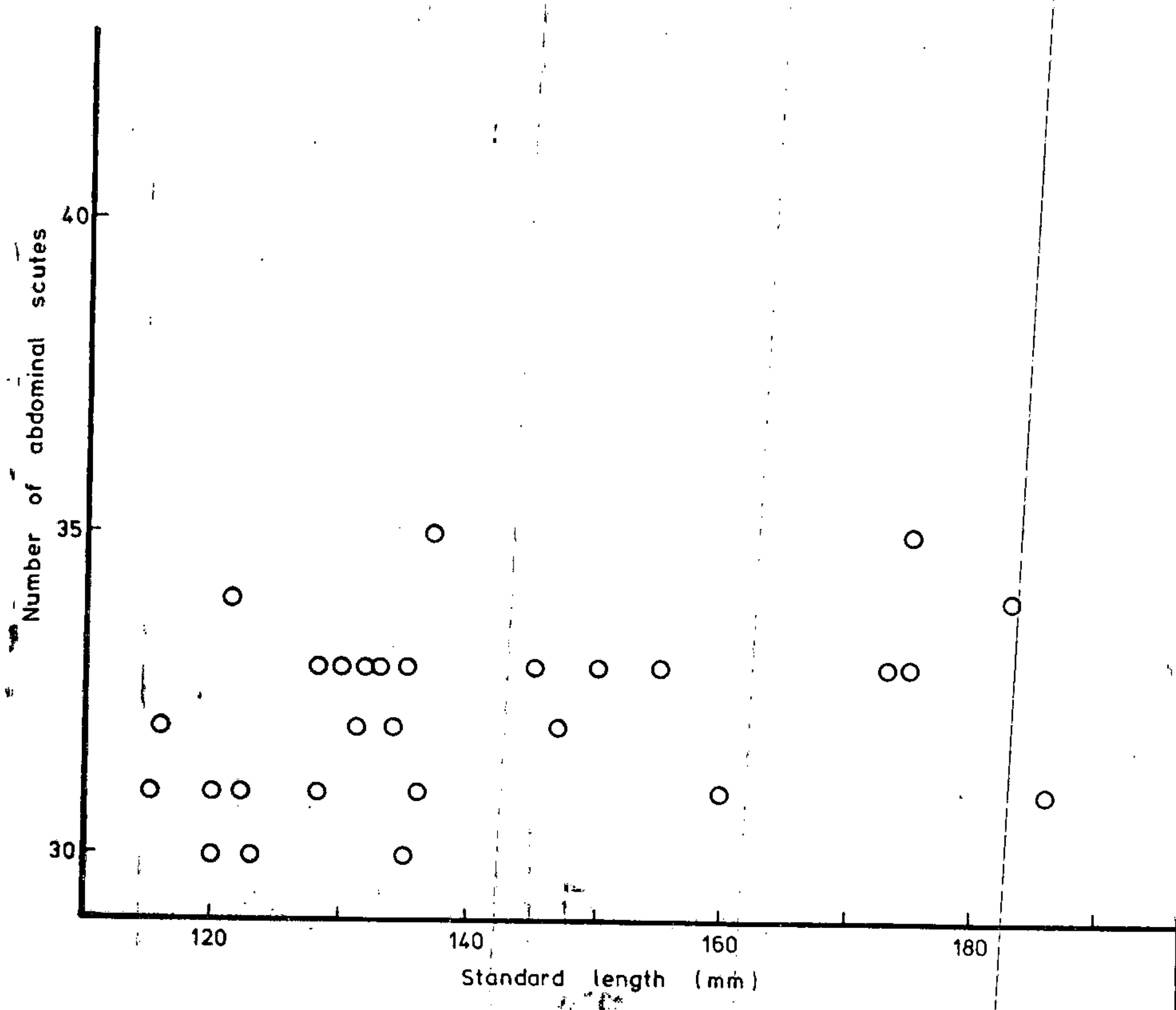


FIG. 8, Regression of number of abdominal scutes on the standard length in I. africana

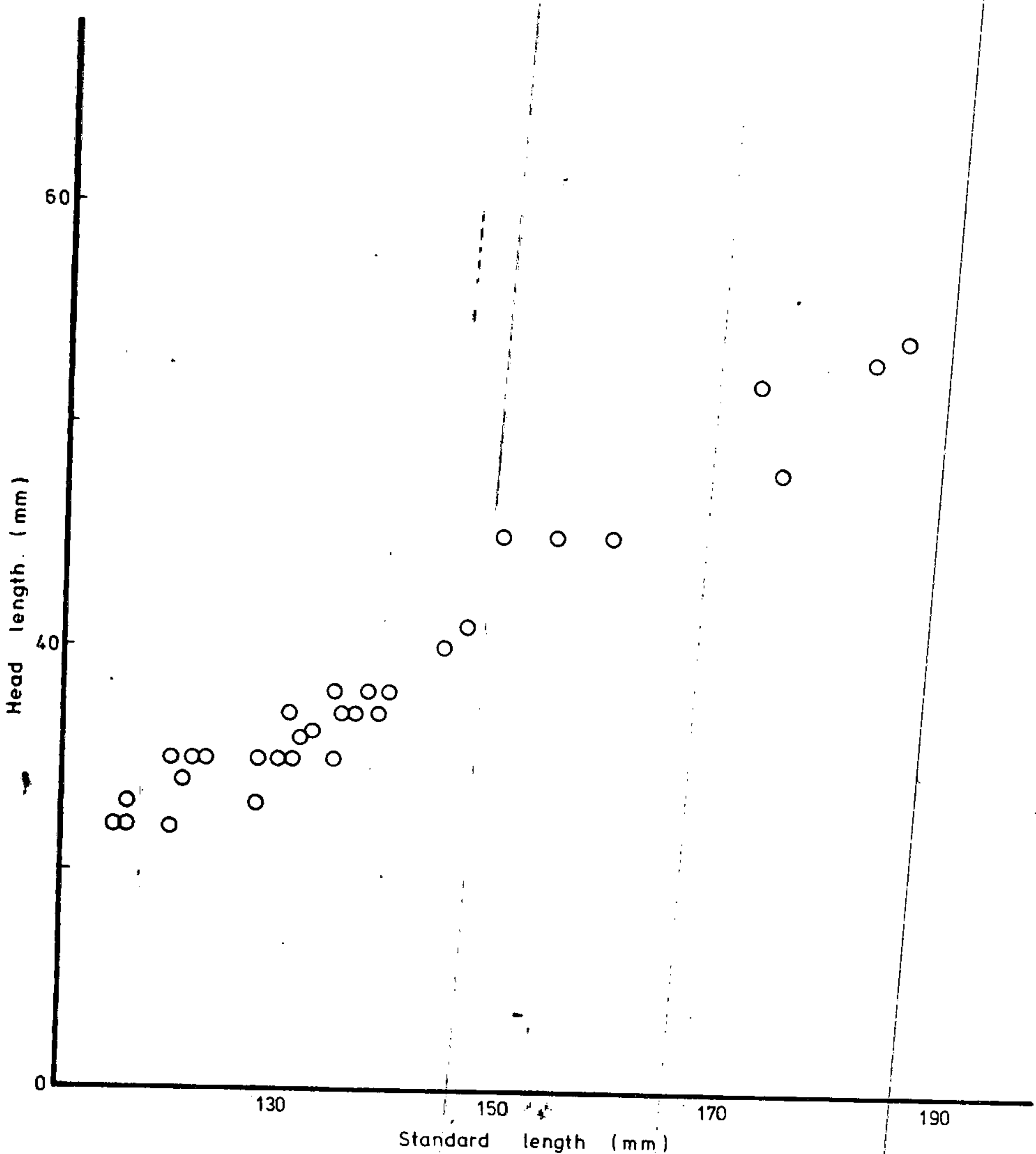


FIG. 9, Regression of head length on standard length in I. africana.

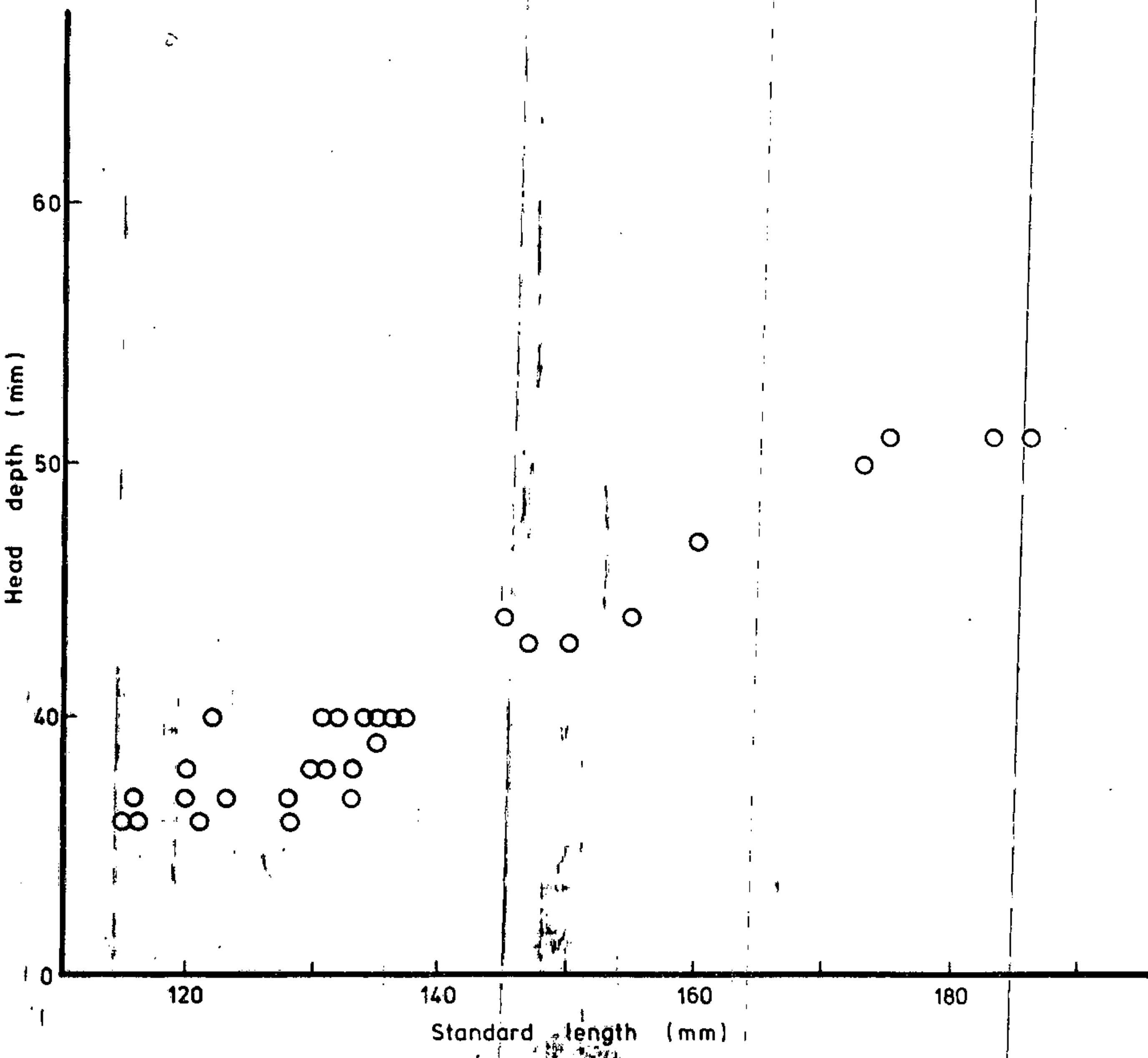


FIG. 10, Regression of head depth on standard length in in *I. africana.*

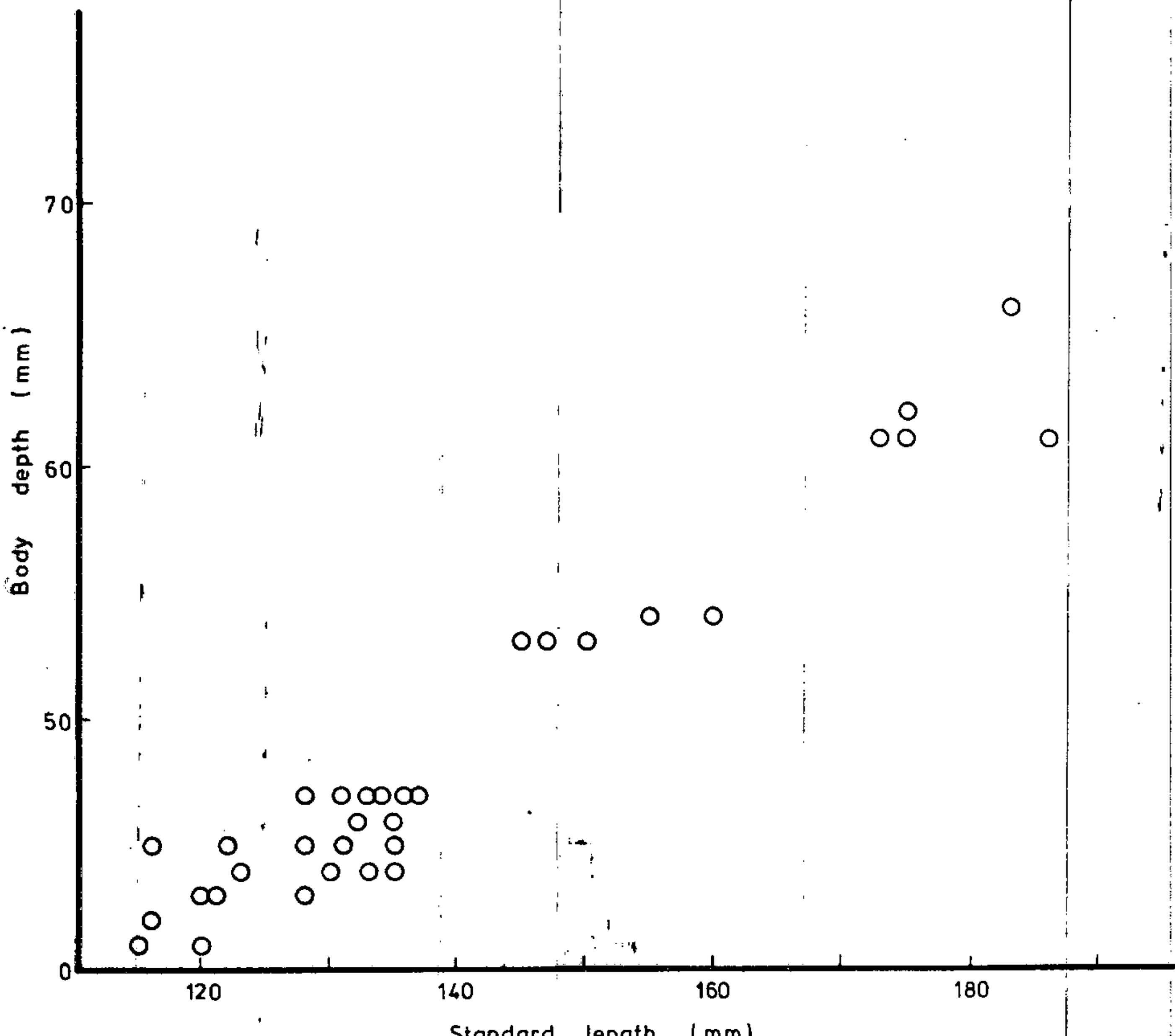


FIG. 11. Regression of body depth on standard length in *I. africana.*

Most meristic counts and morphometric ratios obtained in this study are comparable to those obtained by Fowler (1936). The values from this study and those of Fowler for the Congo River are presented in Tables 1 and 2 respectively.

Table 1. Comparison of meristic features of _I. africana_ off Lagos Coast with those off Congo River (Fowler, 1936)

Meristic characters	Lagos Coast	Congo River (Fowler, 1936)
Dorsal fin rays	III, 10 - 14, I	III, 12, 1 or III, 13, I
Anal fin rays	I or II or III, 39-45, I (41 - 49)	II, 43, I
Pectoral fin rays	13 - 15	
Abdominal scutes	25 - 29 + 5 - 8	25 - 27 + 6 - 8
Lateral median scales	40	40
Gill rakers	9 - 11 + 22 - 25	12 + 28

Table 2. Comparison of body proportions of *I. africana* from Lagos Coast with those off Congo River (Fowler, 1936)

Body ratio	Lagos Coast	Congo River (Fowler, 1936)
Standard length/Head length	3.33 - 3.88	3.50 - 3.67
Standard length/Body depth	2.71 - 3.02	2.88 - 3.00
Head length/Head depth	0.90 - 1.06	1.10 - 1.13
Head length/Snout length	3.50 - 3.90	3.50 - 4.00
Head length/Eye diameter	3.00 - 3.86	
Head length/Caudal peduncle length	2.86 - 3.53	3.00 - 3.13
Head depth/Eye diameter	3.14 - 3.70	

However, a major variation was in the number of gill rakers, the gill rakers on the anterior gill arch being more numerous in the specimens from the Congo. The proportion of head length in fish standard length was 3.33 - 3.88 while that of body depth in standard length was 2.71 - 3.02. Head of fish was about long as deep, the proportion of head depth in head length being 0.9 - 1.06. Snout length in head length was 3.5 - 3.9 while the proportion of eye diameter in head length was 3.0 - 3.86. Similarly, the proportion of eye diameter in head depth was 3.14 - 3.70. The body of the fish is compressed laterally the fish thus being thin. The lower profile was more convex than the upper profile in the anterior end of the fish.

The caudal peduncle was strongly compressed, it was as long as it was deep. Its length in the head length of the fish varied from 2.86 - 3.53.

The meristic counts made in this study were also comparable to those of Poll (1953) for specimens from South Atlantic waters and Tobor (1966) for off Lagos Coast. These are shown in Table 3.

Table 3. Meristic characters of Ilisha sp.

Meristic characters	South Atlantic (Poll, 1953)	Lagos Coast (Tobor, 1966)	Lagos Coast (Present study)
Dorsal fin rays	15 - 16	13 - 15	14 - 18
Anal fin rays	44 - 49	42 - 48	41 - 49
Ventral fin rays		6	6
Vertebrae		42	42
Abdominal scutes	30 - 35	27 - 33	30 - 35
Pectoral fin rays		14	13 - 15
Lateral median scales	40 - 42		40 - 42

2. DISTRIBUTION

Specimens of I. africana were obtained along the Nigerian Coast from off Lagos, off Benin River, off Brass River and off Bonny River.

(i) Bottom depth distribution

The distribution of this species in relation to to bottom depth was examined off the coast of Lagos. I. africana was encountered at depths of 5 - 25 fm (10 - 50m). However, the greatest abundance was between 10 - 15 fm (20 - 30m) while the least catch was at 20 - 25 fm (40 - 50m). Fig. 12 is a histogram of the distribution of the species with respect to depth. The percentage occurrence at 20 - 30m depth was 39% while it was 10% at 40 - 50m. At 10 - 20m it was 33% and at 30 - 40m it was 18%.

(ii) Other fish associates

Fish species commonly caught with I. africana included the croakers (Pseudotolithus spp), the grunter (Pomadasys jubelini (C & V)), the thread fin (Galeoides decadactylus (Bloch)), Chloroscombrus chrysurus (L), Vomer setapinnis (Mitchill), the big eye (Brachydeuterus auritus (Val.)) and the silver fish (Trichiurus lepturus (L)). From a depth of about 30m and at deeper depths, the marine catfish (Arius spp) were also commonly caught with I. africana.

(iii) Diurnal vertical migration

No catches of I. africana were made during the night time at depths of 10 - 50m. All the catches made at these depths were encountered during daylight hours.

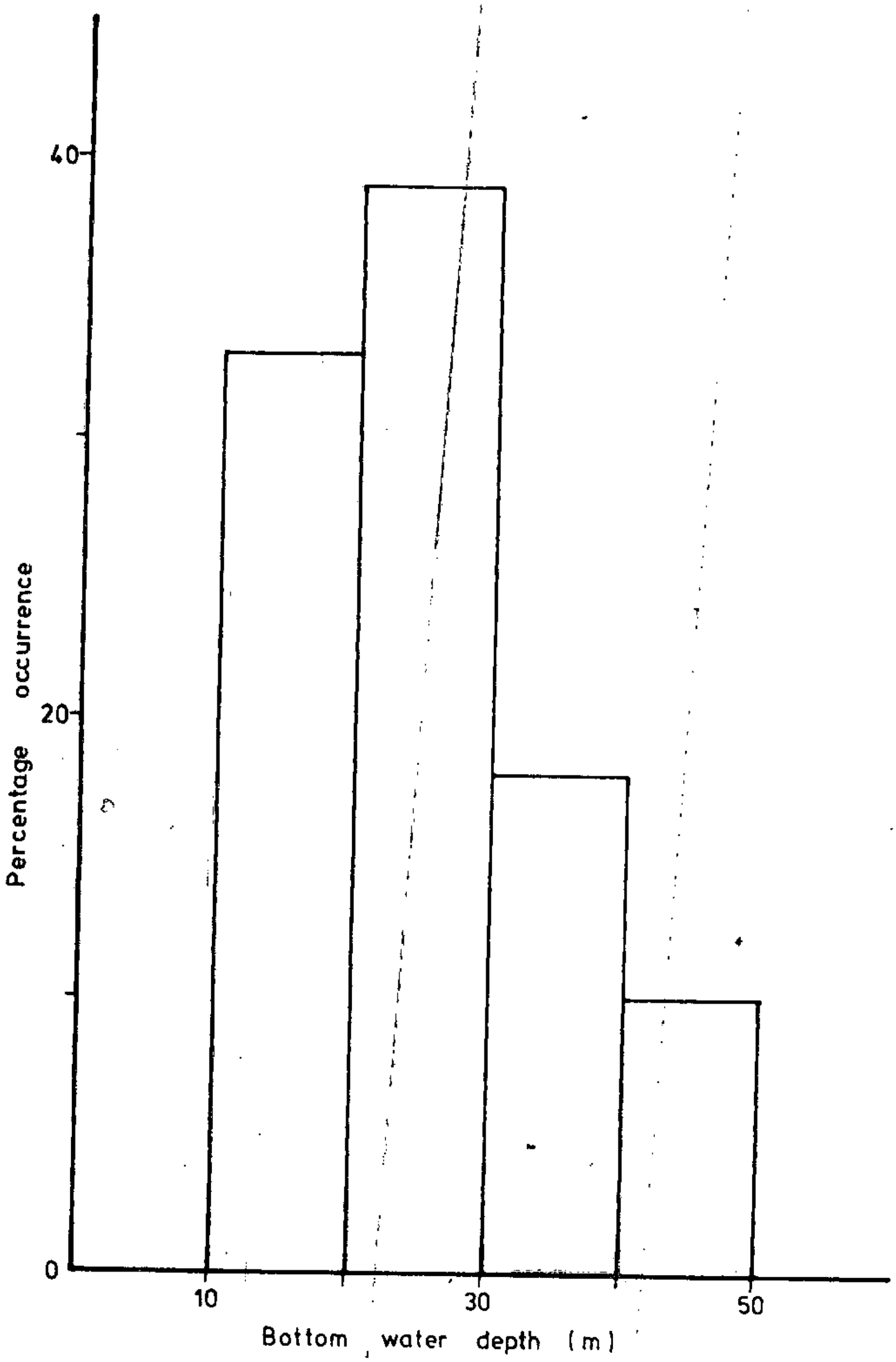


FIG. 12, Distribution of *I. africana* off Lagos coast at depths of 10 – 50 m.

3. AGE AND GROWTH

(i) Length frequency distribution

Two thousand, three hundred and eighteen (2,318) specimens of I. africana caught off Lagos Coast were examined for the length - frequency distribution. The smallest fish encountered was 4.2 cm while the largest fish was 28.7 cm. The size distribution of the species followed the expected normal distribution as shown in Figure 13a. Figures 13a - n show the monthly length frequency distribution for the fish between the months of November 1978 and November 1979. There were no distinct modes to indicate the various age groups among the specimens.

The length frequency distribution of I. africana in relation to depth was examined at 5m intervals between 10m and 50m. The results are presented in Figs. 14a - 14d. At the depth of 10 - 20m, the size range of I. africana caught was between 4 and 23cm. At the depth of 20 - 30m, the size range of fish was 9 - 26cm. Similarly at 30 - 40m, size range of fish was 11 - 26cm while at 40 - 50m, the size range of fish was 12 - 23cm.

(ii) Length - weight relationship

The relationship between the length and weight of fish was represented by the equation

$$W = a L^{b}$$

where W = weight of the fish

L = length of the fish

a and b = constants (Tesch, 1968).

The scatter diagram of the length - weight relationship for the male and female I. africana are presented in Figs. 15 and 16 respectively while Fig. 17 is the scatter diagram for the combined sexes.

The equations for the length - weight relationships for the Lagos Coast were:

Males: $W = .004498 L^{3.122}$

(correlation coefficient, r = 0.9986)

Females: $W = .004207 L^{3.155}$

(r = 0.9989)

Combined sexes: $W = .004335 L^{3.141}$

(r = 0.9989)

The values of the exponent b were 3.122, 3.155 and 3.141 for the male fish, female fish and the combined sexes respectively.

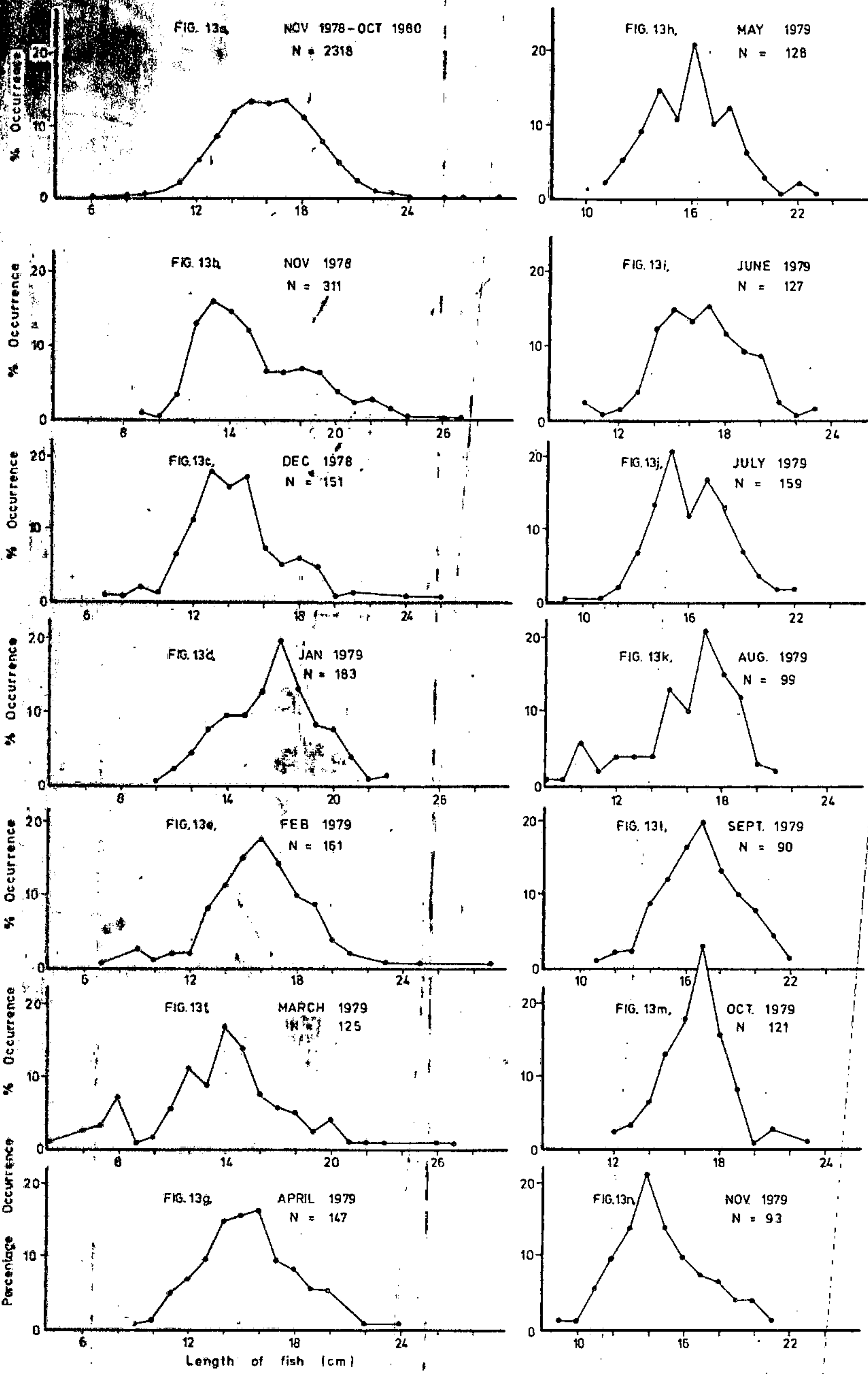


FIG. 13a – n, Length frequency distribution of I. africana off Lagos Coast.

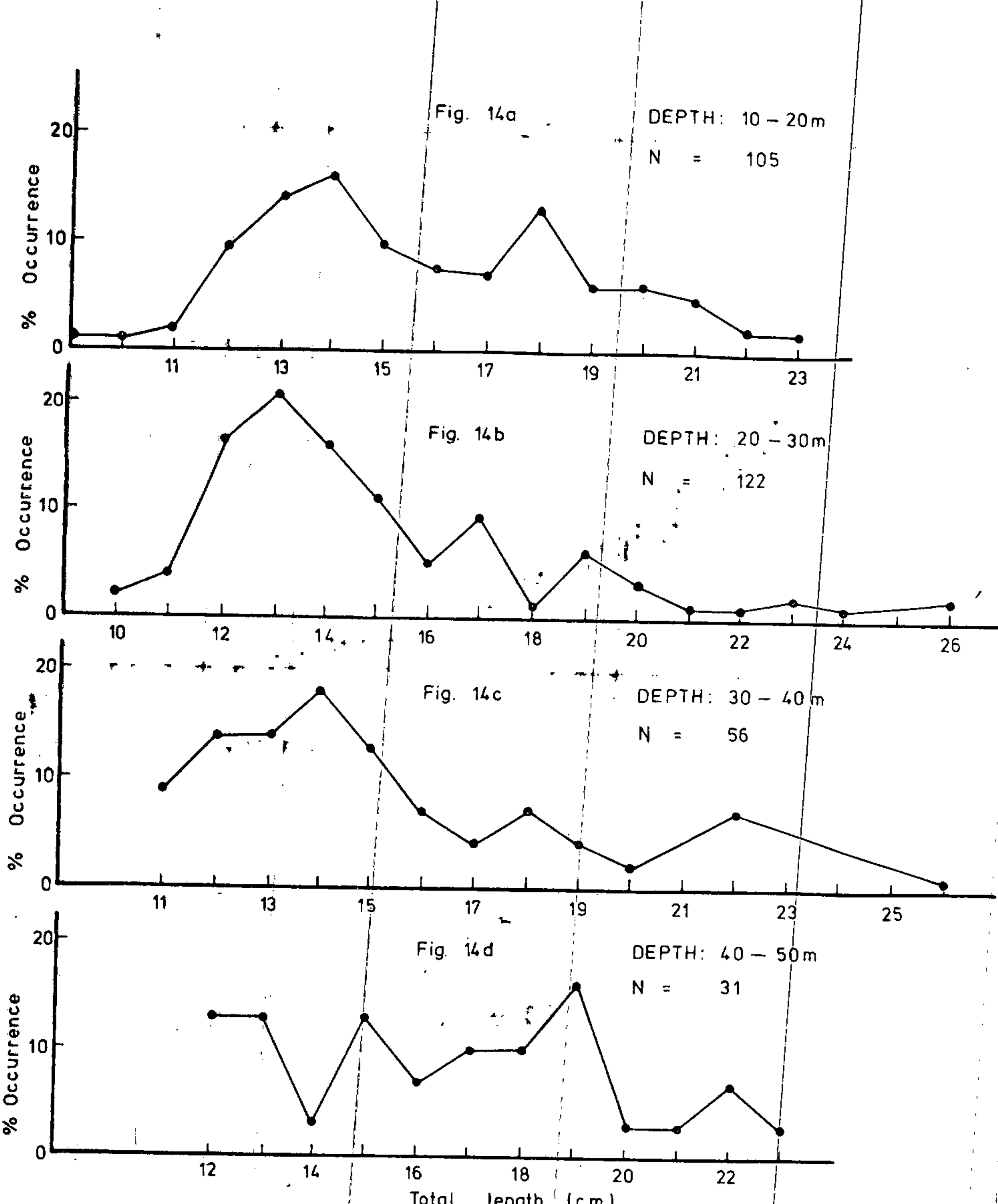


FIG. 14a — 14d. Length frequency distribution of <u>I. africana</u> in relation to depth.

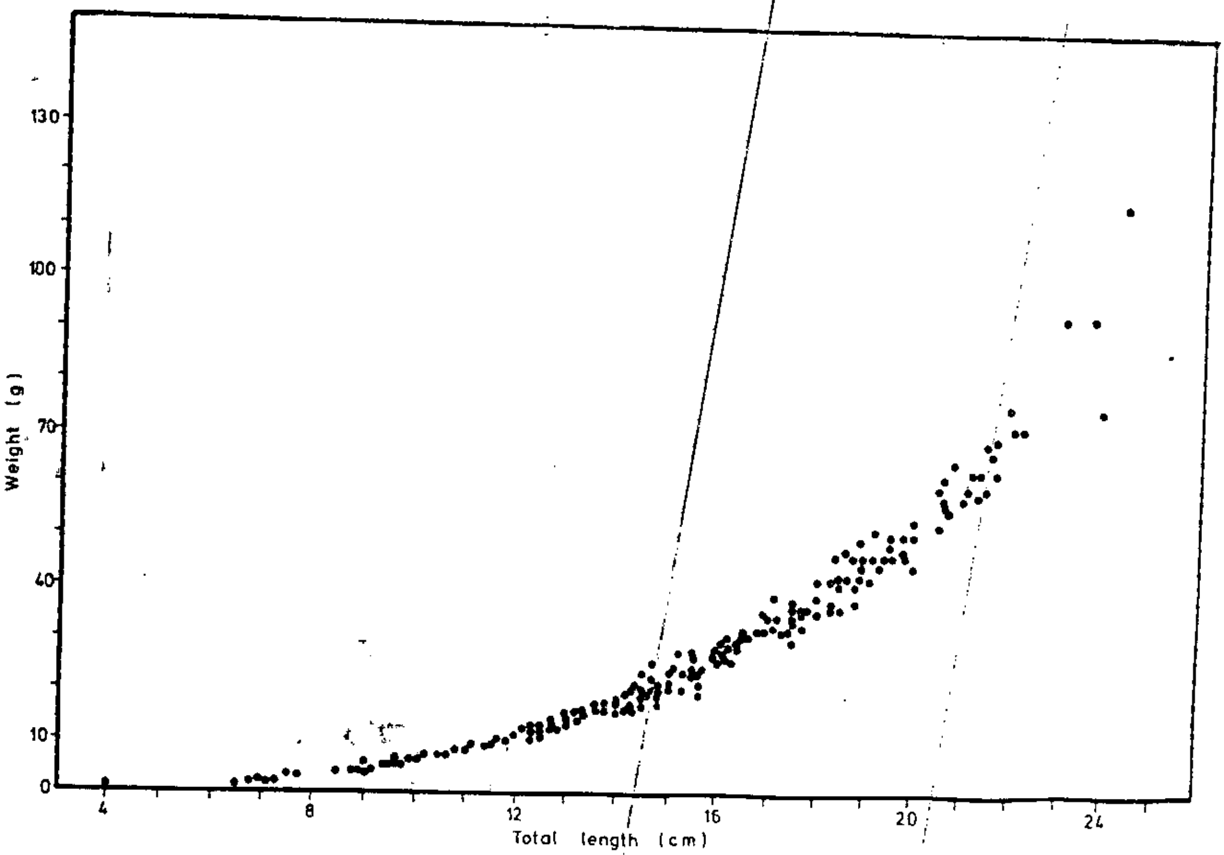


FIG. 15, Length - weight relationship in male I. africana caught off Lagos Coast.

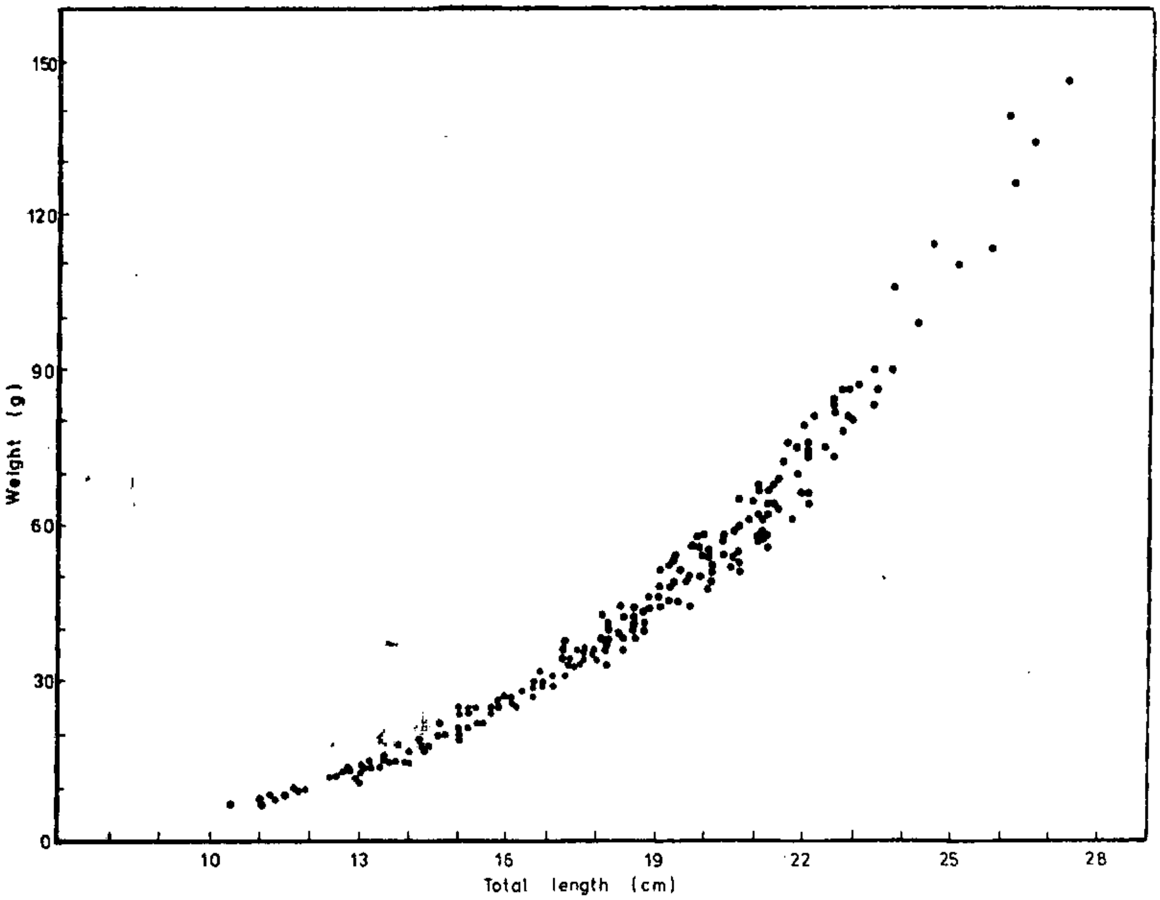


FIG. 16, Length – weight relationship in female I. africana caught off Lagos Coast.

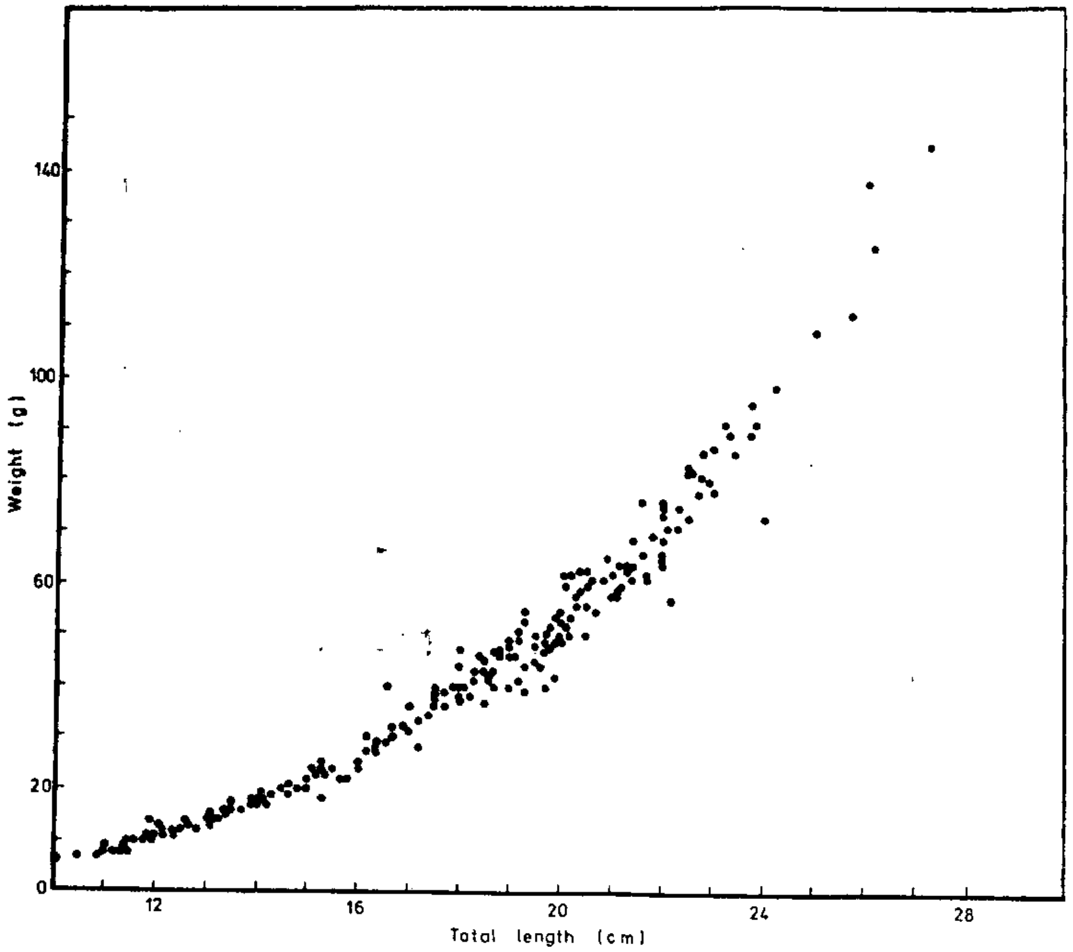


FIG. 17. Length - weight relationship for the combined sexes of I. africana caught off Lagos Coast.

The length - weight relationships for *I. africana* caught off Benin River, Brass River and Bonny River were also examined. The scatter diagrams of the length - weight relationships irrespective of sex for the three stations are shown in figs. 18, 19 and 20 respectively.

The equations for the length - weight relationship for the sample caught off Benin River were:

Males: $W = .003767\,L^{3.186}$

$(r = 0.986)$

Females: $W = .002323\,L^{3.366}$

$(r = 0.972)$

Combined sexes: $W = .003105\,L^{3.259}$

$(r = 0.982)$

The values of b exponent were 3.186, 3.366 and 3.259 for the male, female and the combined sexes respectively.

For the sample of *I. africana* caught off Brass River, the equations for the length - weight relationships were:

Males: $W = .005675\,L^{3.068}$

$(r = 0.980)$

Females: $W = .004969\,L^{3.110}$

$(r = 0.991)$

Combined sexes: $W = .005534\,L^{3.075}$

$(r = 0.988)$

The values of the exponent b were 3.068, 3.110 and 3.075 for the male fish, female fish and combined sexes respectively.

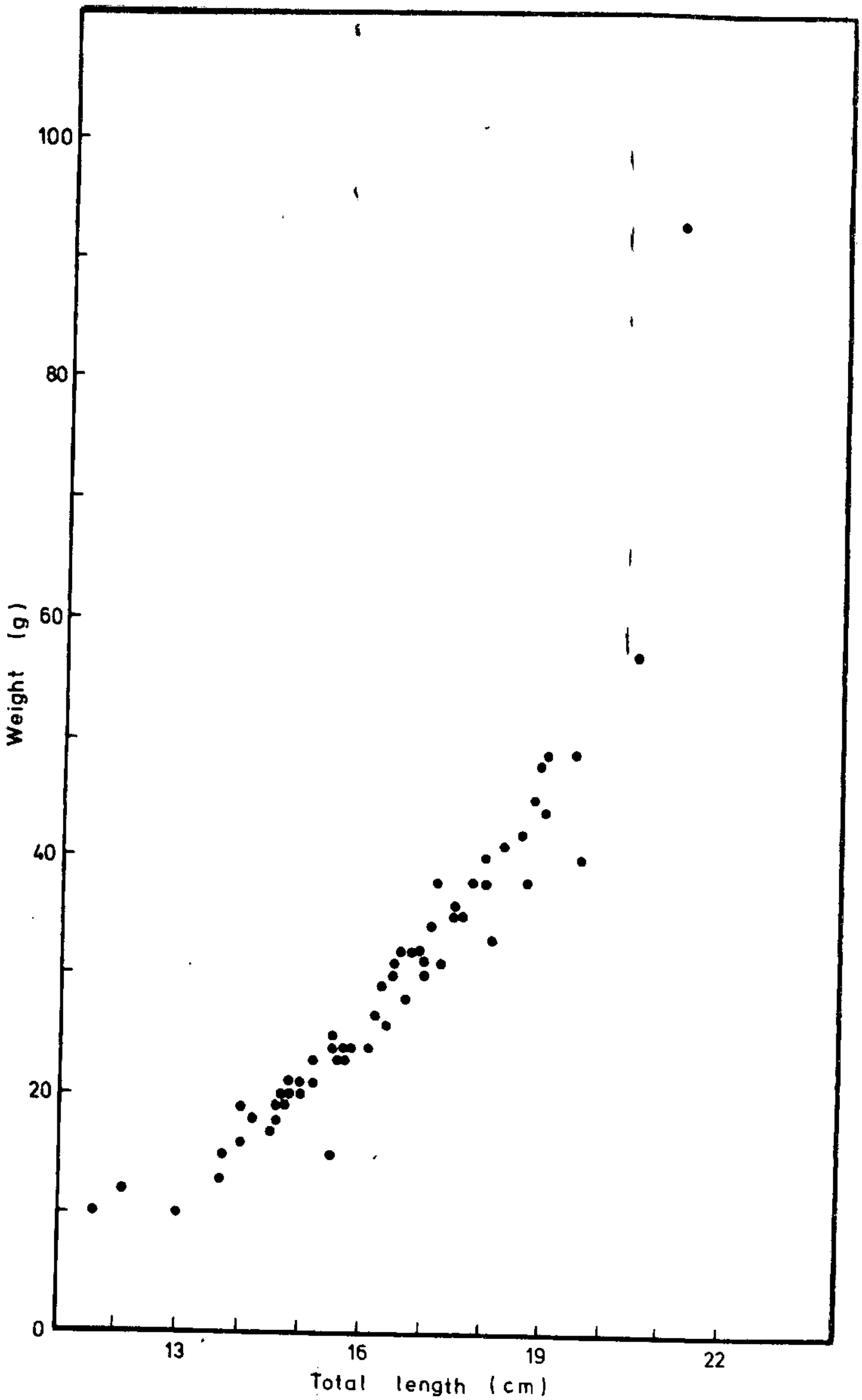


FIG. 18, Length - weight relationship in <u>I. africana</u> caught off Benin River.

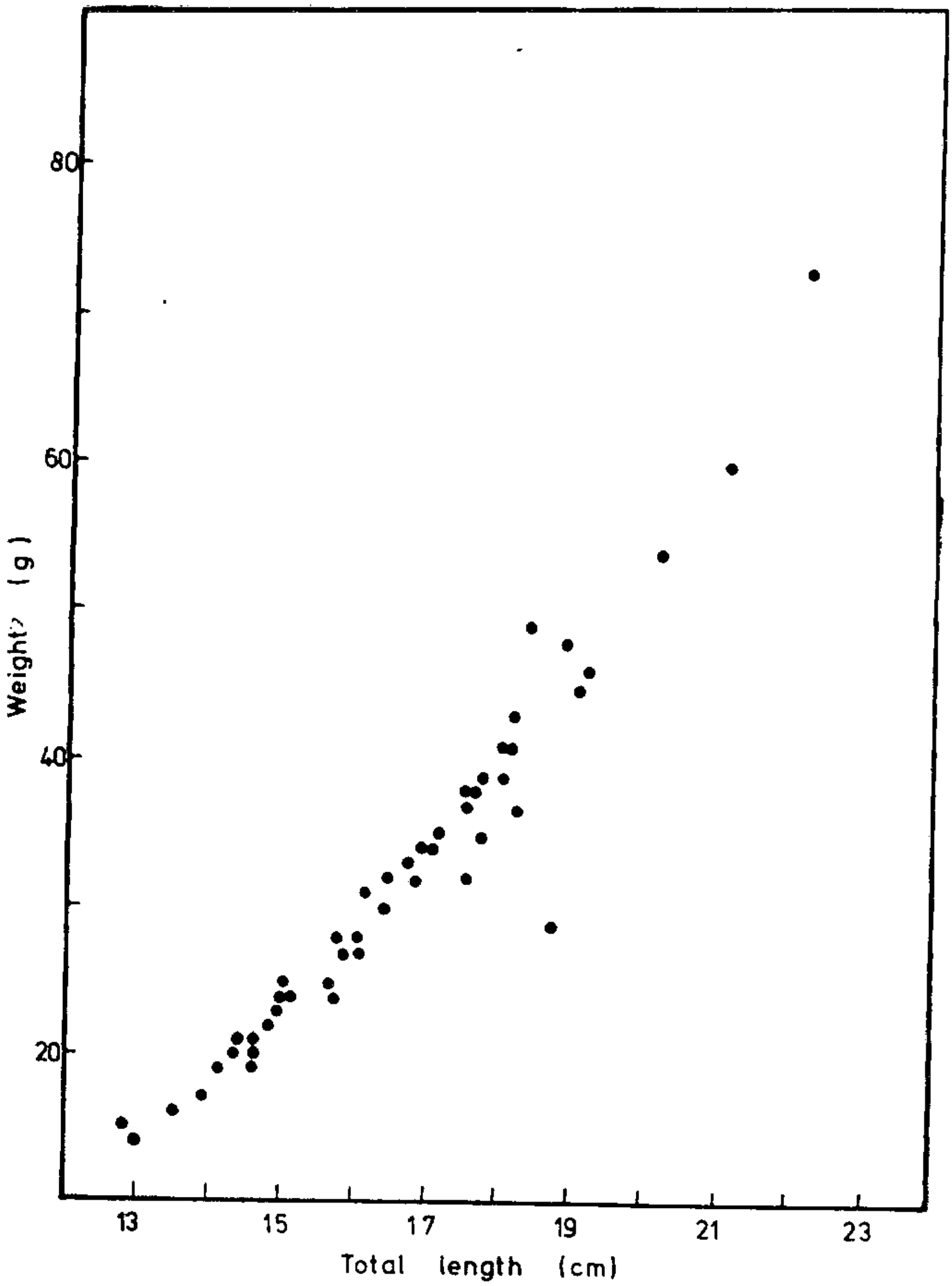


FIG. 19, Length - weight relationship in I. africana caught off Brass River.

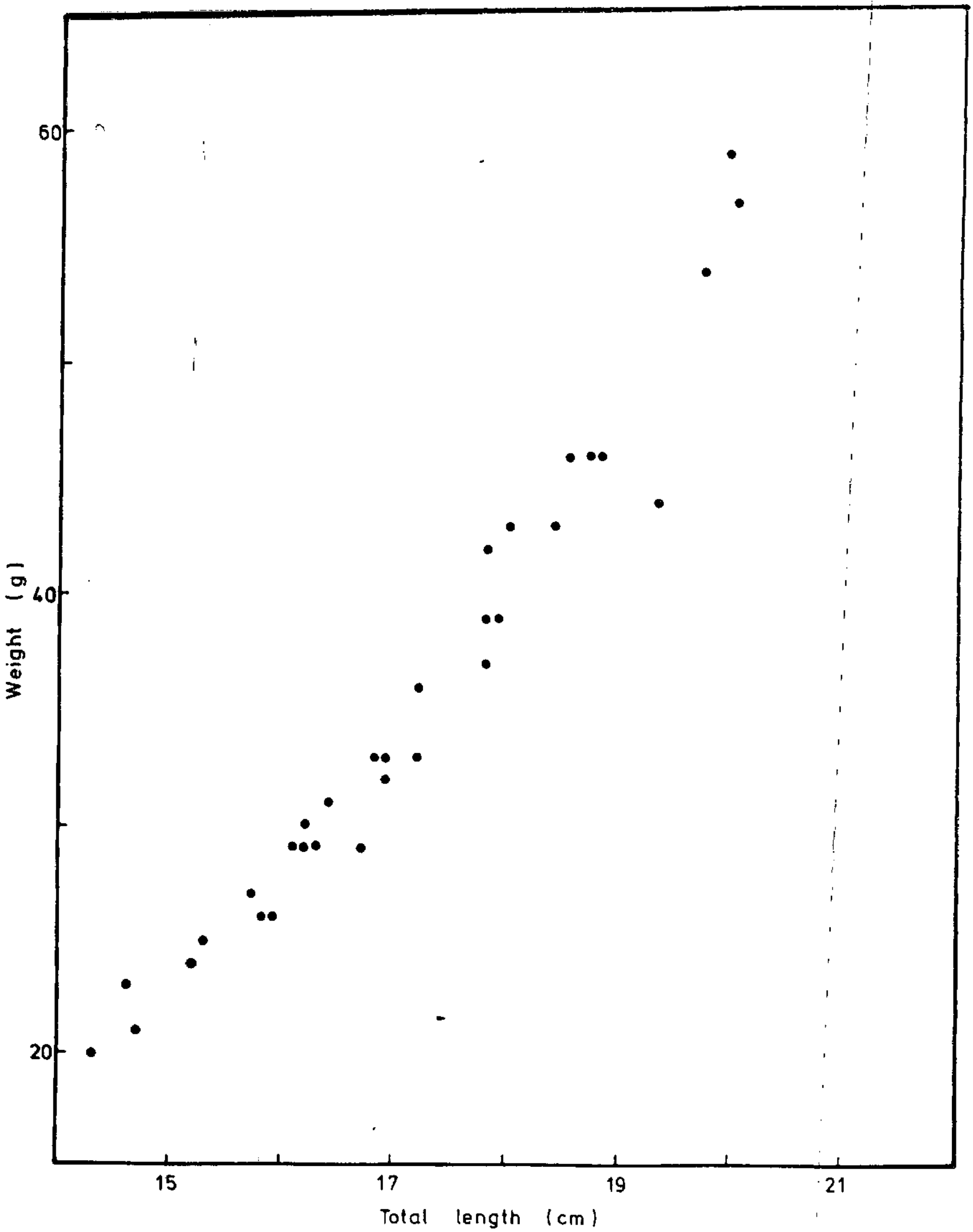
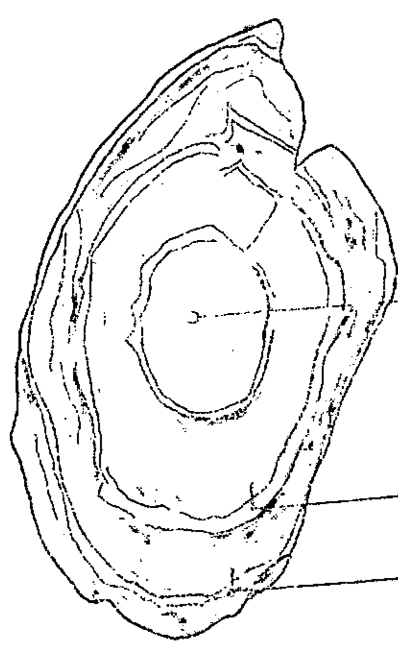


FIG. 20, Length – weight relationship in I. africana caught off Bonny River.

An otolith of I. Africana showing growth bands.

g1, g2 growth bands

n nucleus



LEFT OTOLITH (CONCACAVE SIDE UP) OF AN AGE II+ I. AFRICANA

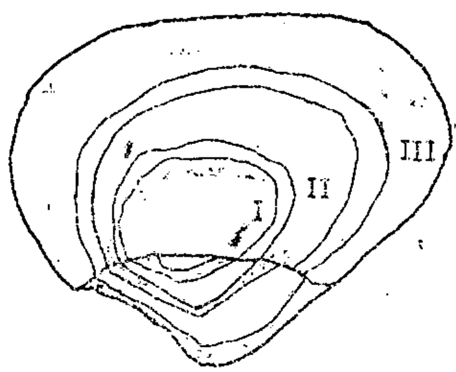


Diagram showing a scale of an Age III *I. africana*

The equations for the length - weight relationships for *I. africana* caught off Bonny River were:

Males: $W = .006412 \, L^{3.017}$

$(r = 0.980)$

Females: $W = .006653 \, L^{3.016}$

$(r = 0.985)$

Combined sexes: $W = .005546 \, L^{3.076}$

$(r = 0.985)$

(iii) Age determination

Scales from 25 fish and 276 pairs of otoliths were examined for age determination of this species. Only one band was found to be formed in each year of the fish life. In the burnt otolith, this appeared as a dark ring while on the scales it appeared as a transluscent ring. The occurrence of a dark band on the edges of otolith and a transluscent ring on the edge of a scale were only found in the fish which were in the ripe running stage or those that had just shed their eggs or milt and the gonads were flabby and possibly with empty space visible through the gonad walls. In specimens which had shed their eggs or milt for a fairly long period prior to being caught, the last dark band on the otolith were close to its edge.

The results of the age groups obtained by using the scale and otolith techniques were comparable and shown in Table 4. Results from the otolith technique however showed wider ranges for the sizes of fish belonging to the different age groups.

(iv) Age - length relationship

The age - length frequencies were considered separately for the male and female fish. The results show that fishes belonging to all

Table 4. Age groups in *I. africana* caught off Lagos Coast.

Age group (Years)	Size range (cm)	
	Scale technique	Otolith technique
0^+	11.0 - 13.3	6.0 - 14.7
1^+	14.0 - 16.5	13.0 - 18.0
2^+	16.1 - 18.5	16.0 - 19.8
3^+	19.0 - 22.0	17.2 - 22.0
4^+		22.0 - 24.5
5^+	26.1	27.2

ages were found throughout the year but fishes in the 1^+, 2^+ and 3^+ age groups were most commonly encountered in the catches. The maximum age group found in the species was 5^+ years. Fishes belonging to the 4^+ and 5^+ age groups were not common in the catches. Among the males the 0^+ age group constituted 26.3% while the 1^+, 2^+ and 3^+ age group constituted 27.5%, 29.4% and 14.4% while the 4^+ and 5^+ age group made up 2.5% and 0% of male fishes. Among the female fish, the 0^+, 1^+, 2^+, 3^+, 4^+ and 5^+ age groups contributed 11.3%, 34.0%, 34.0%, 17.9%, 1.9% and 0.9% respectively. Tables 5 and 6 show the age - length frequencies in the male and female fish respectively.

The relationship between the length and age of the fish was represented by the equation:

$$L = a + b \log A$$

where L = fish length

A = age of fish

a and b = constants

The equations for the length - age relationships were:

Males: $L = 15.008 + 12.113 \text{ Log } A$

(correlation coefficient, $r = 0.873$)

Females: $L = 14.767 + 13.343 \text{ Log } A$

($r = 0.843$)

(v) Otolith length - fish length relationship

The relationship between the otolith length and total length of fish was calculated separately for the males and females. The variations of otolith length with fish length are shown in Figs. 21 and 22 for the male and female fish respectively. The mathematical relationships between otolith lengths and fish lengths were calculated using the equation:

Table 5 Age – length frequencies in male *I. africana*

Fish length (cm)	0⁺ Years												1⁺ Years											
	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
0 – 4.9																								
5 – 9.9							2	1			1													
10 – 14.9	4		4		8	1	6	9	3		1	2	2		3			1	2	3			6	
15 – 19.9													2				2	2	13	1	2		2	3
20 – 24.9																								
25 – 29.9																								

Fish length (cm)	2⁺ Years												3⁺ Years							
	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A
0 – 4.9																				
5 – 9.9																				
10 – 14.9																				
15 – 19.9	6		3		1	1	10	9	5	9	1	2	3		1			2	2	
20 – 24.9													3		2		1	2	2	
25 – 29.9																				

Table 6 Age - length frequencies in female *I. africana*

Fish length (cm)	0+ Years J	F	M	A	M	J	J	A	S	O	N	D
0 - 4.9												
5 - 9.9							2	1			1	
10 - 14.9	2		1				1	1	1		1	1
15 - 19.9												
20 - 24.9												
25 - 29.9												

Fish length (cm)	1+ Years J	F	M	A	M	J	J	A	S	O	N	D
0 - 4.9												
5 - 9.9												
10 - 14.9	2		1		1		1	2		1	2	2
15 - 19.9	2		1		3		6	4	1	4	1	2
20 - 24.9												
25 - 29.9												

Fish length (cm)	2+ Years J	F	M	A	M	J	J	A	S	O	N	D
0 - 4.9												
5 - 9.9												
10 - 14.9	1		1				2					
15 - 19.9	4		2		2	2	9	4	3	3	1	2
20 - 24.9												
25 - 29.9												

Fish length (cm)	3+ Years J	F	M	A	M	J	J	A	S	O	N	D
0 - 4.9												
5 - 9.9												
10 - 14.9												
15 - 19.9	1		1			1	2	1		1		
20 - 24.9					1	1	5	2			1	2
25 - 29.9												

Fish length (cm)	4+ Years J	F	M	A	M	J	J	A	S	O	N	D
0 - 4.9												
5 - 9.9												
10 - 14.9												
15 - 19.9												
20 - 24.9						1						1
25 - 29.9												

Fish length (cm)	5+ Years J	F	M	A	M
0 - 4.9					
5 - 9.9					
10 - 14.9					
15 - 19.9					
20 - 24.9					
25 - 29.9					1

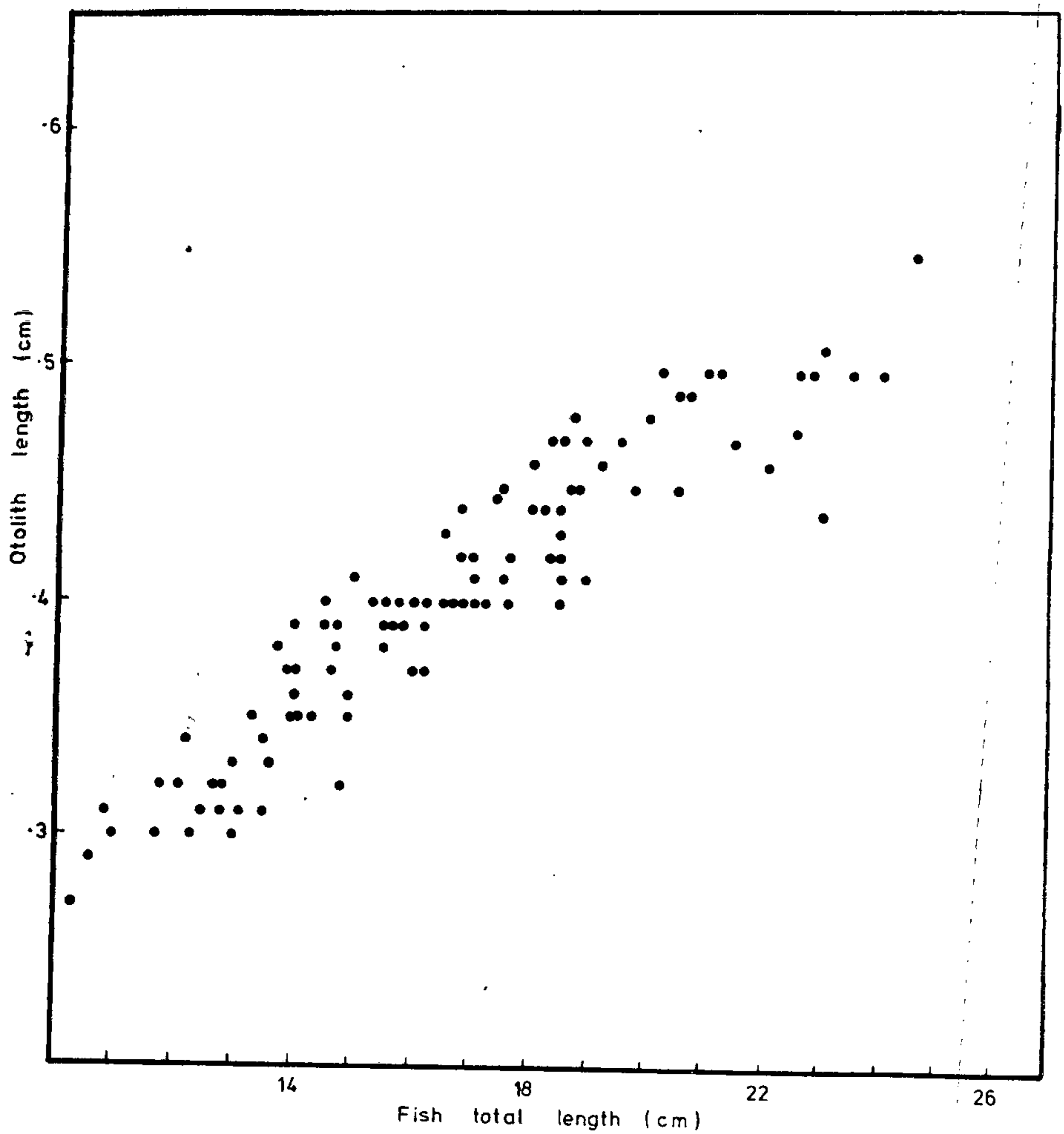


FIG. 21, Relationship between otolith length and fish length in male I. africana

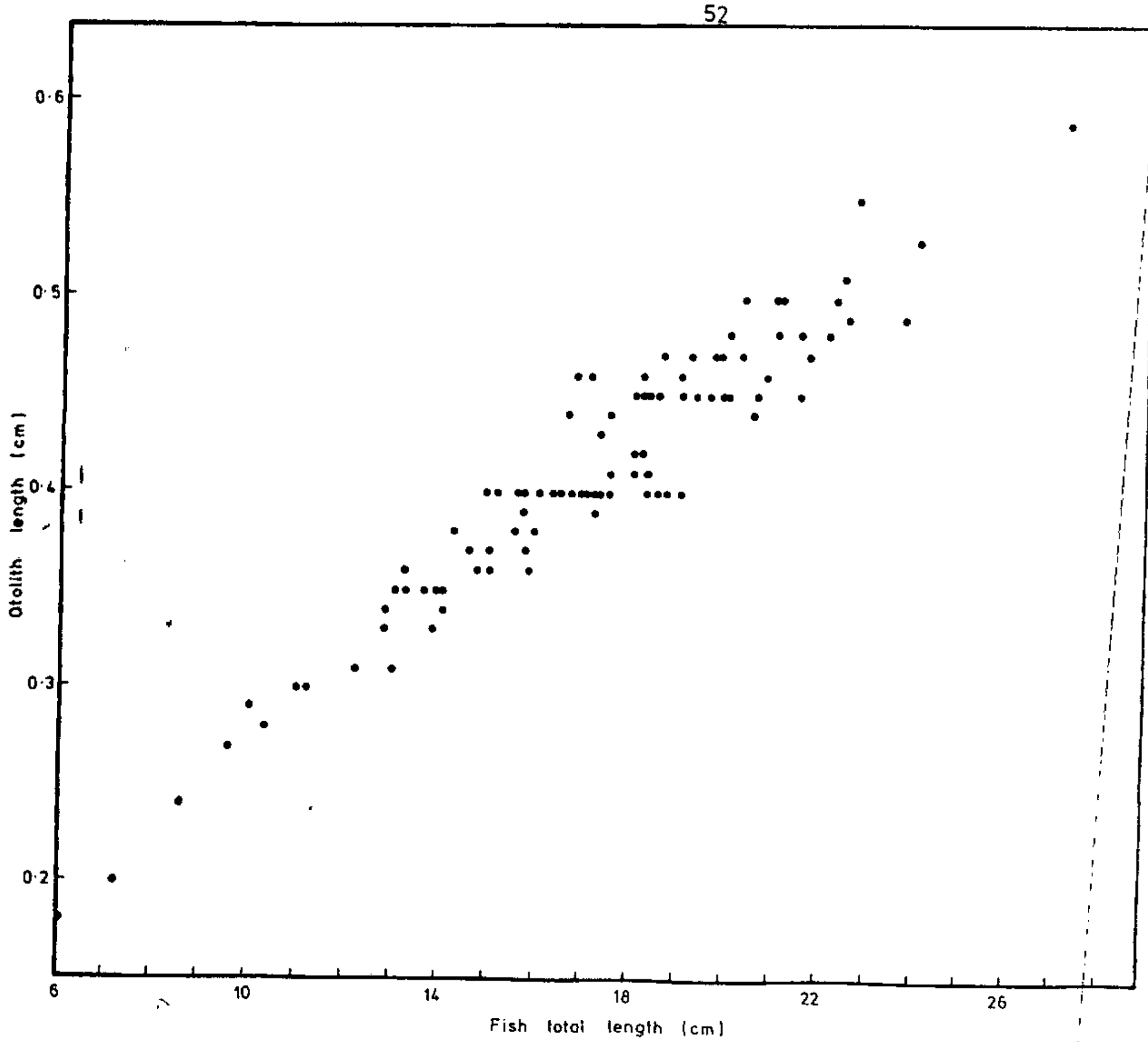


FIG. 22. Relationship between otolith length and fish length in female I. africana.

$$y = aL^b$$

where y = otolith length in mm

L = fish total length in cm

a and b = constants.

For the males,

$$y = 0.4853\,L^{0.752}$$

(r = 0.946)

For the females,

$$y = 0.5070\,L^{0.737}$$

(r = 0.956)

(vi) Otolith width - fish length relationship

The relationship between the otolith width and fish length was expressed by the formula:

$$y = aL^b$$

where y = otolith width

L = fish length

a and b = constants.

For the male fish,

$$y = 0.4519\,L^{0.595}$$

(r = 0.921)

and for the female fish,

$$y = 0.4603\,L^{0.592}$$

(r = 0.916)

Figures 23 and 24 are graphical representations of the relationships between the otolith width and fish length in the male and female <u>I. africana</u> respectively.

(vii) Scale length - fish length relationship

The relationship between the scale length and fish length was examined. It was found that the scale length increased with fish length

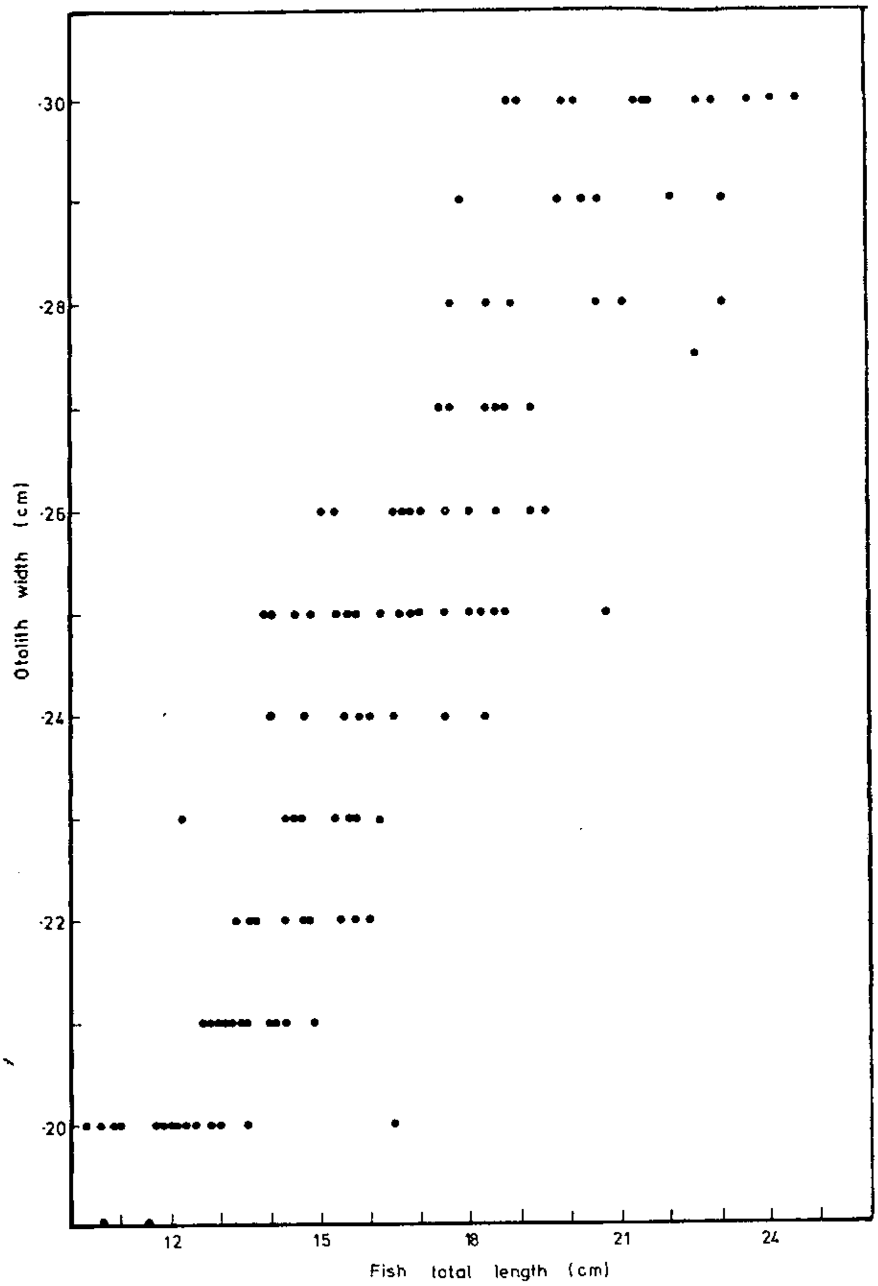


FIG. 23. Relationship between otolith width and fish length in male _I. africana._

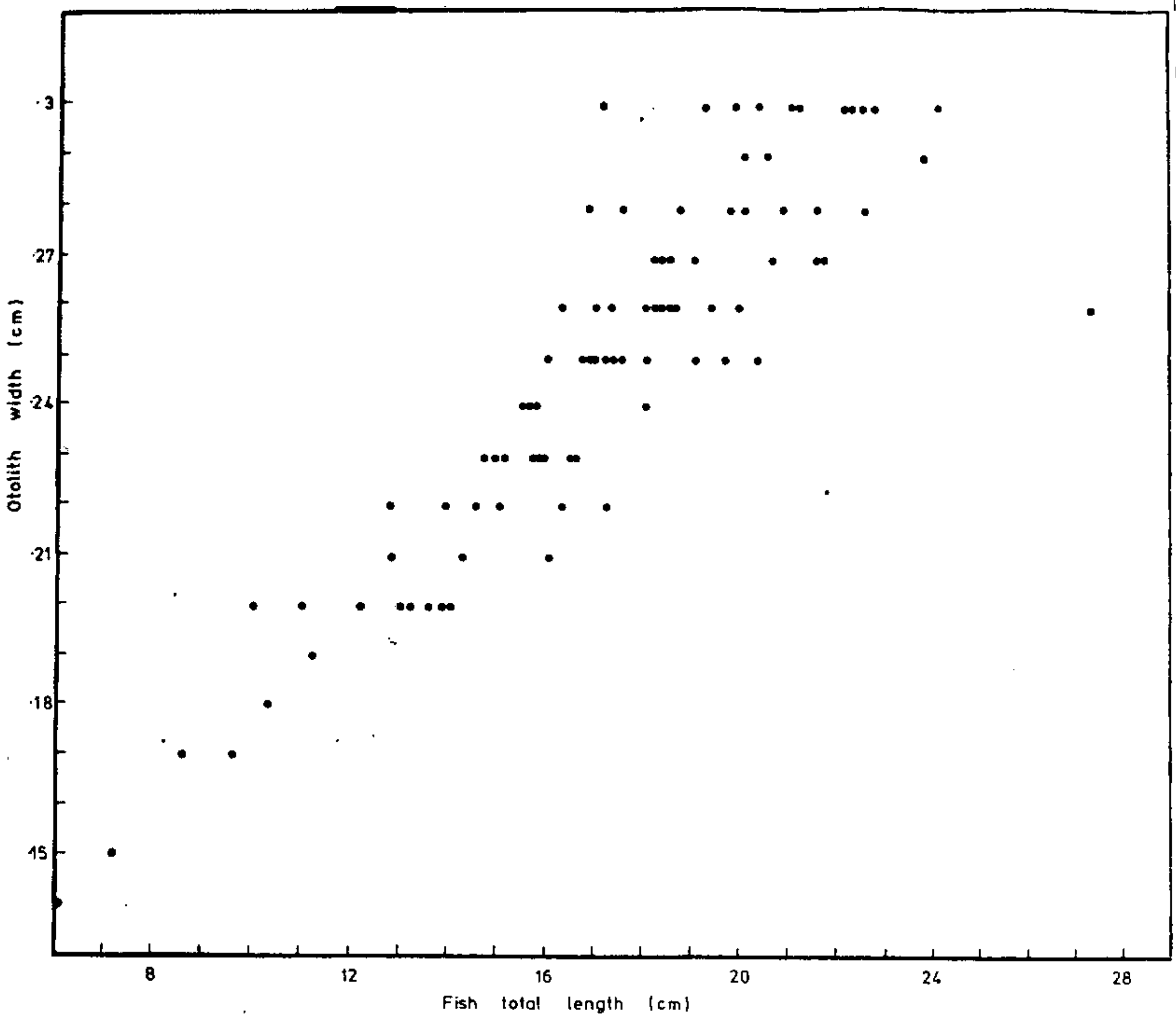


FIG. 24, Relationship between otolith width and fish length in female I. africana

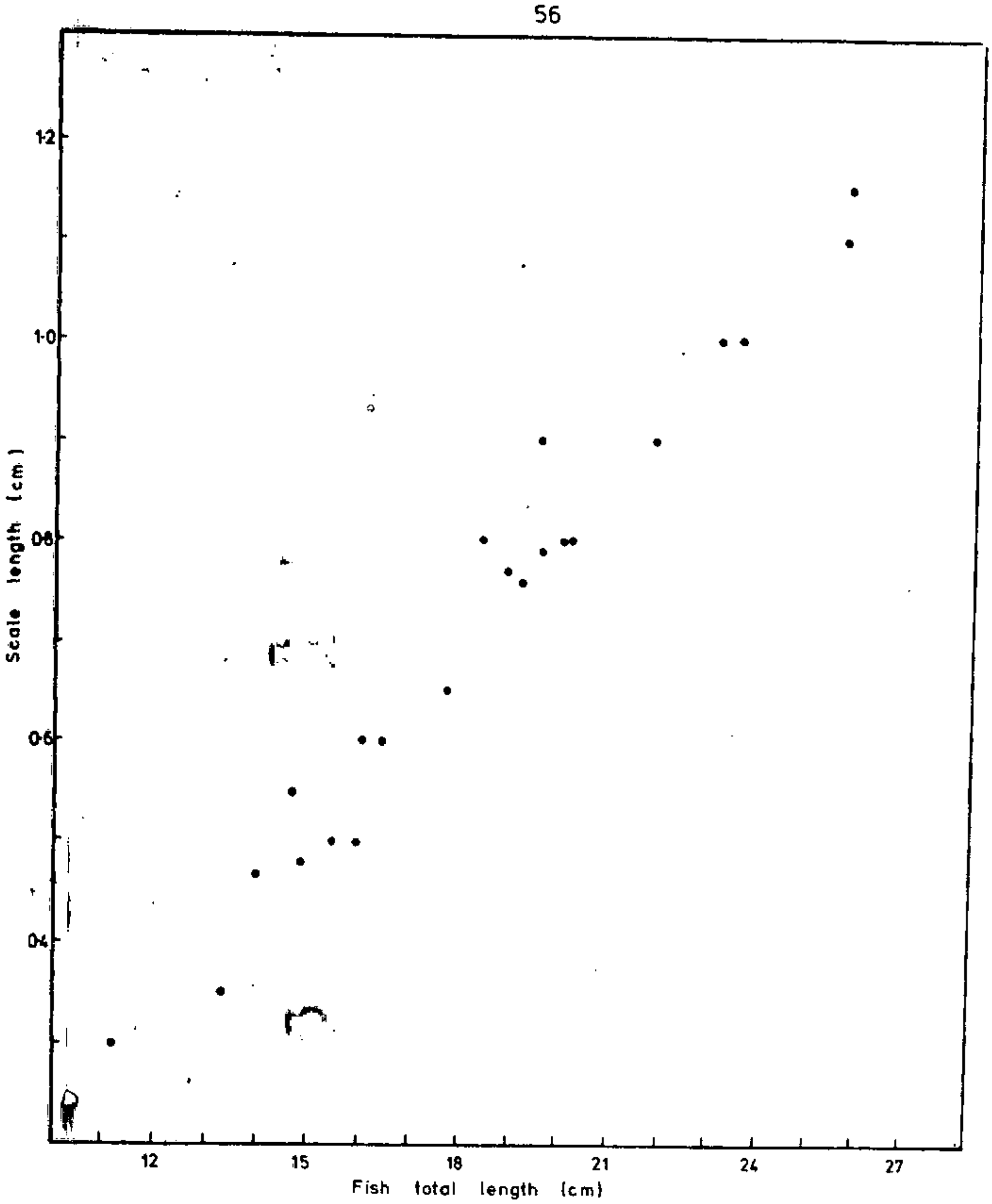


FIG. 25. Relationship between scale radius and fish length in _I. africana._

as indicated in Fig. 25. The relationship was described by the equation: $S_L = a + bL$

where

S_L = scale length in mm

L = fish length in cm

a and b = constants.

The equation obtained for scale length – fish length relationship in *I. africana* was

$$SL = -0.343 + 0.057 L$$

$$(r = 0.980)$$

(viii) Age – weight relationship

The age – weight frequencies were prepared separately for the male and female fish and are presented in Tables 7 and 8 respectively. Generally, the weights of the fishes increased with fish age, though there were overlaps in the weights of the various age groups. Among the males, fish in the 0^+ age group had weights in the range 0 – 30g, the 1^+ age group had weights ranging from 11 – 50g. Fish in the 3^+ and 4^+ age groups had weights ranging from 21 – 80g and 81 – 110g respectively. No male fish were encountered in the 5^+ age group. Among the females, fish in the 0^+ age group had weights between 0 – 20g, those in the 1^+ age group had weights ranging from 11 – 50g and those in the 2^+ age group had weight range of 11 – 60g. Fish in the 3^+, 4^+ and 5^+ age groups had weight ranges of 31 – 80g, 81 – 100g and 141 – 150g respectively.

The age – weight relationships are illustrated in Figs. 26 and 27 for the male and female fish respectively. The age – weight relationship was based on the equation:

as indicated in Fig. 25. The relationship was described by the equation: $S_L = a+bL$

where

S_L = scale length in mm

L = fish length in cm

a and b = constants.

The equation obtained for scale length - fish length relationship in *I. africana* was

$$SL = -0.343 + 0.057\,L$$

$$(r = 0.980)$$

(viii) Age - weight relationship

The age - weight frequencies were prepared separately for the male and female fish and are presented in Tables 7 and 8 respectively. Generally, the weights of the fishes increased with fish age, though there were overlaps in the weights of the various age groups. Among the males, fish in the 0^+ age group had weights in the range 0 - 30g, the 1^+ age group had weights ranging from 11 - 50g. Fish in the 3^+ and 4^+ age groups had weights ranging from 21 - 80g and 81 - 110g respectively. No male fish were encountered in the 5^+ age group. Among the females, fish in the 0^+ age group had weights between 0 - 20g, those in the 1^+ age group had weights ranging from 11 - 50g and those in the 2^+ age group had weight range of 11 - 60g. Fish in the 3^+, 4^+ and 5^+ age groups had weight ranges of 31 - 80g, 81 - 100g and 141 - 150g respectively.

The age - weight relationships are illustrated in Figs. 26 and 27 for the male and female fish respectively. The age - weight relationship was based on the equation:

$W = a + bA$

where W = fish weight (g)

A = Age of fish (years)

a and b = constants.

For the male fish,

$$W = 10.391 + 14.629A$$

$$(r = 0.874)$$

while for the female fish,

$$W = 5.447 + 17.694A$$

$$(r = 0.844)$$

(ix) Condition factor

The condition factors for *I. africana* were calculated using the formula,

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

where K = condition factor

W = weight in grams

L = total length of fish in cm.

The condition factor in relation to size, sexes and period of the year were examined. For the male fish, the K - values ranged from 0.38 - 0.77 while for the females, the K - values ranged from 0.44 - 0.85. For the combined sexes, the K - values ranged from 0.38 - 0.85. The K - values obtained for this species are shown in Tables 9 and 10. The specimens were divided into 5cm size groups in order to facilitate the examination of variation of K - values in relation to size. For the male fish in the size groups 6 - 10 cm, 11 - 15 cm, 16 - 20 cm and 21 - 25 cm, the mean K - values were 0.60, 0.64, 0.65 and 0.66 respectively while in the female fish, they were

Table 7. Age - weight frequencies in male *I. africana*

Weight in grams	Age in years 0+	1+	2+	3+	4+
0 - 10	12				
11 - 20	27	16	2		
21 - 30	3	23	8	1	
31 - 40		4	18	6	
41 - 50		1	14	4	
51 - 60				6	
61 - 70				3	
71 - 80				3	
81 - 90					1
91 - 100					
101 - 110					1

Table 8. Age - weight frequencies in female *I. africana*

Weight in grams	Age in years				
	0^+	1^+	2^+	3^+	4^+
0 - 10	8				
11 - 20	5	12	1		
21 - 30		13	7		
31 - 40		10	17	1	
41 - 50		1	8	6	
51 - 60			3	7	
61 - 70				6	
71 - 80				6	
81 - 90					1
91 - 100					1
101 - 110	-	-	-	-	-

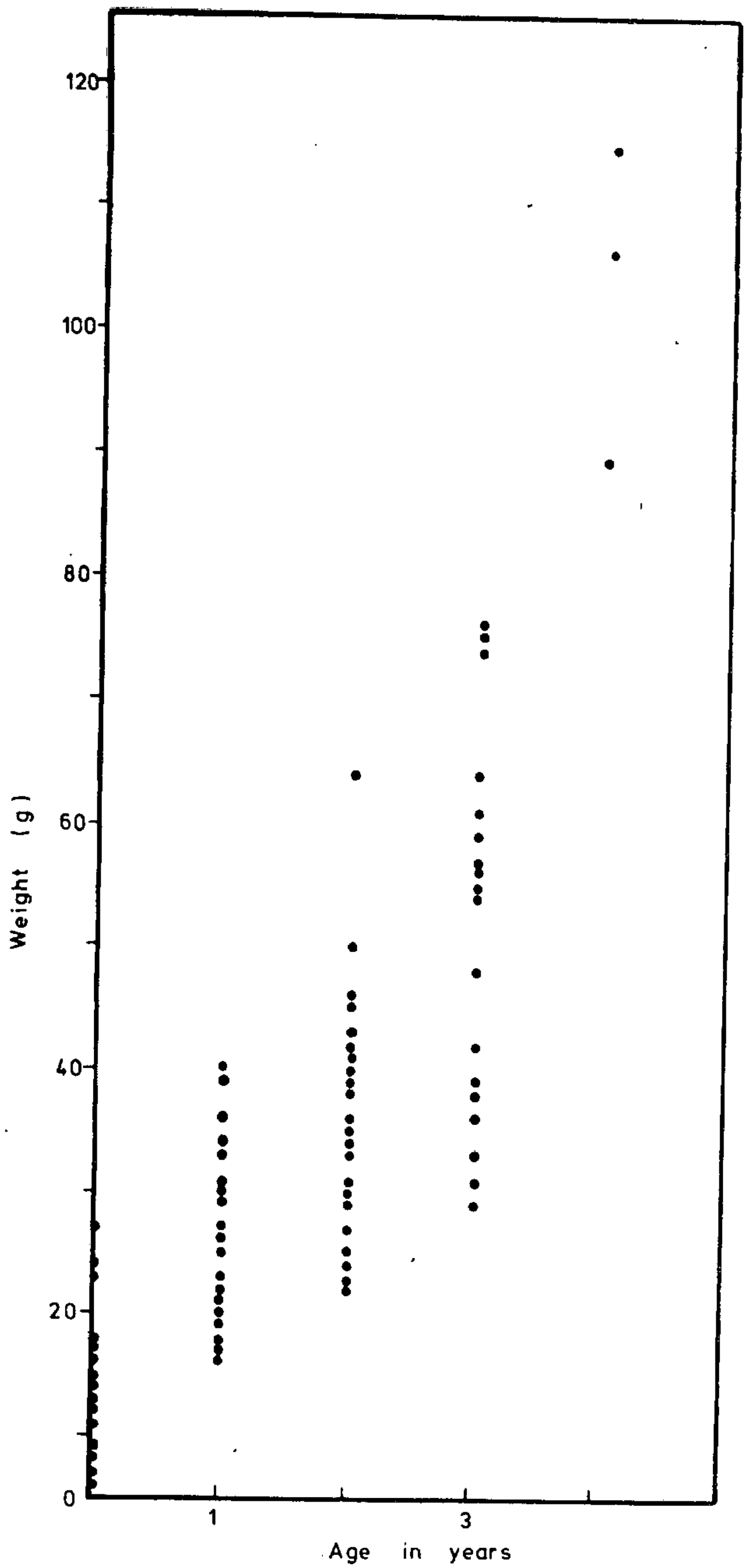


FIG. 26, Age – weight relationship in male <u>I. africana</u>

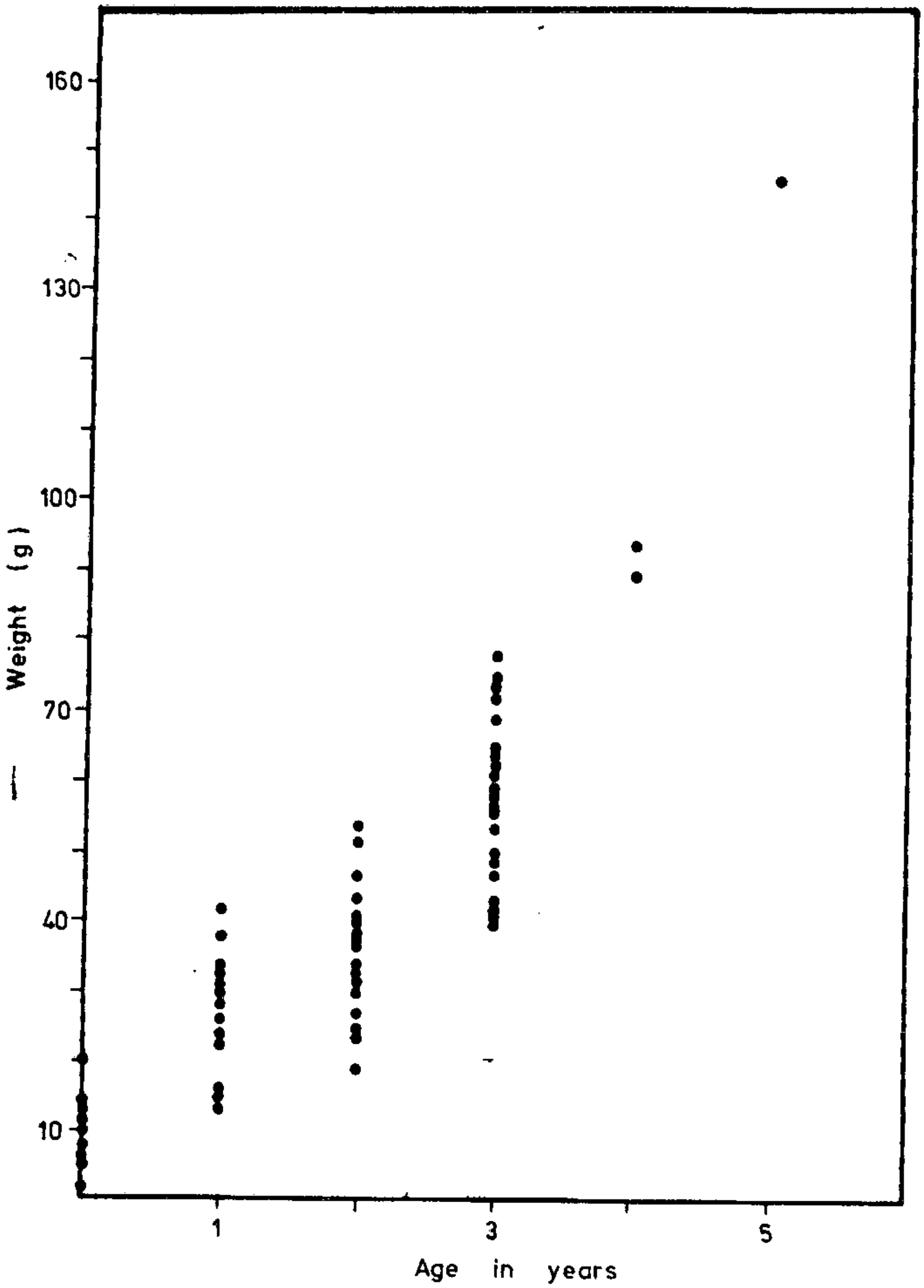


FIG. 27, Age - weight relationship in female I. africana.

0.59, 0.63, 0.66 and 0.66 for the 6 - 10 cm, 11 - 15 cm, 16 - 20 cm and 21 - 25 cm size groups respectively. In the female fish, the mean K - value for the fishes in the size group of 26 - 30 cm was 0.72. There were noticeable increase in mean K - values with increase in size group in both the male and female fish. In the male fish, the mean K - values increased from 0.60 in the 6 - 10 cm size group through 0.64 for the 11 - 15 cm size group, 0.65 for the 16 - 20 cm size group and 0.66 in the 21 - 25 cm size group. In the female fish, the mean K - values increased from 0.59 in the 6 - 10 cm size group to 0.63 in the 11 - 15 cm size group and 0.66 in the 16 - 20 cm and the 21 - 25 cm size groups and the highest mean K of 0.72 was obtained in the 26 - 30 cm size group. As shown in Table 9, the same trend of changes in condition factor with increase in size group was obtained for the sexes combined.

The seasonal variation in condition factors was also examined. On monthly basis, in the male fishes, the mean K - value decreased progressively from 0.66 in November, 1978 to 0.60 in May and then it increased to 0.66 in June followed by a decrease to 0.65 in July and August. There was a further decrease to 0.63 by September and then an increase to 0.69 in October. In November 1979, mean K was 0.64 while in December, it was 0.65. For the female fish, the mean K was 0.66 in November 1978. It decreased to 0.63 in December. In January 1979, it had increased to 0.67 but by February, it was 0.63 and 0.65 in March while it was 0.62 in April and May. It increased to 0.68 in June, while it was 0.66 in July, August and September and it further increased to 0.70 in October but again reduced to 0.64 in November. In December 1979, the mean K was 0.67. These results are presented in Table 10 and illustrated in Fig. 28. Figure 28 indicates a general

Table 9. Condition factor (K) in relation to size of *I. africana* from Lagos Coast

Total length (cm)	Males			Females			Combined Sexes		
	Number of Specimens	Range of K - values	Mean K - values	Number of specimens	Range of K - value	Mean K-value	Number of specimens	Range of K - value	Mean K-value
6 - 10	36	0.44 - 0.77	0.60	34	0.46 - 0.71	0.59	70	0.44 - 0.77	0.61
11 - 15	555	0.38 - 0.76	0.64	405	0.51 - 0.78	0.63	960	0.38 - 0.78	0.63
16 - 20	564	0.50 - 0.77	0.65	599	0.44 - 0.85	0.66	1163	0.44 - 0.85	0.66
21 - 25	39	0.55 - 0.77	0.66	81	0.59 - 0.79	0.66	120	0.53 - 0.79	0.66
26 - 30	-	-	-	7	0.67 - 0.72	0.72	7	0.67 - 0.72	0.72

Table 10. Monthly condition factor (K) for *I. africana* off Lagos Coast

Month	Male			Female			Combined sexes		
	Sample size	Range	Mean	Sample size	Range	Mean	Sample size	Range	Mean
Nov. 1978	141	0.53 - 0.78	0.66	171	0.53 - 0.76	0.66	312	0.53 - 0.78	0.66
Dec. 1978	67	0.54 - 0.72	0.63	81	0.51 - 0.73	0.62	215	0.51 - 0.73	0.63
Jan. 1979	95	0.53 - 0.77	0.64	110	0.53 - 0.77	0.67	205	0.53 - 0.77	0.66
Feb. "	83	0.50 - 0.74	0.62	76	0.55 - 0.77	0.63	159	0.50 - 0.77	0.60
Mar. "	66	0.44 - 0.77	0.63	59	0.46 - 0.78	0.65	125	0.44 - 0.78	0.61
Apr. "	96	0.51 - 0.69	0.60	54	0.51 - 0.78	0.62	150	0.51 - 0.78	0.61
May "	72	0.50 - 0.70	0.60	58	0.45 - 0.73	0.62	130	0.45 - 0.73	0.61
June "	71	0.57 - 0.75	0.66	53	0.58 - 0.75	0.68	124	0.57 - 0.75	0.64
July "	105	0.38 - 0.75	0.65	54	0.54 - 0.73	0.66	159	0.38 - 0.75	0.65
Aug. "	41	0.53 - 0.70	0.65	59	0.55 - 0.76	0.66	100	0.53 - 0.76	0.66
Sept. "	37	0.56 - 0.74	0.63	38	0.56 - 0.85	0.66	75	0.56 - 0.85	0.65
Oct. "	47	0.51 - 0.76	0.69	56	0.59 - 0.79	0.70	103	0.51 - 0.79	0.70
Nov. "	37	0.46 - 0.71	0.64	39	0.56 - 0.70	0.64	76	0.46 - 0.71	0.64
Dec. "	60	0.57 - 0.77	0.65	63	0.57 - 0.79	0.67	123	0.57 - 0.79	0.66

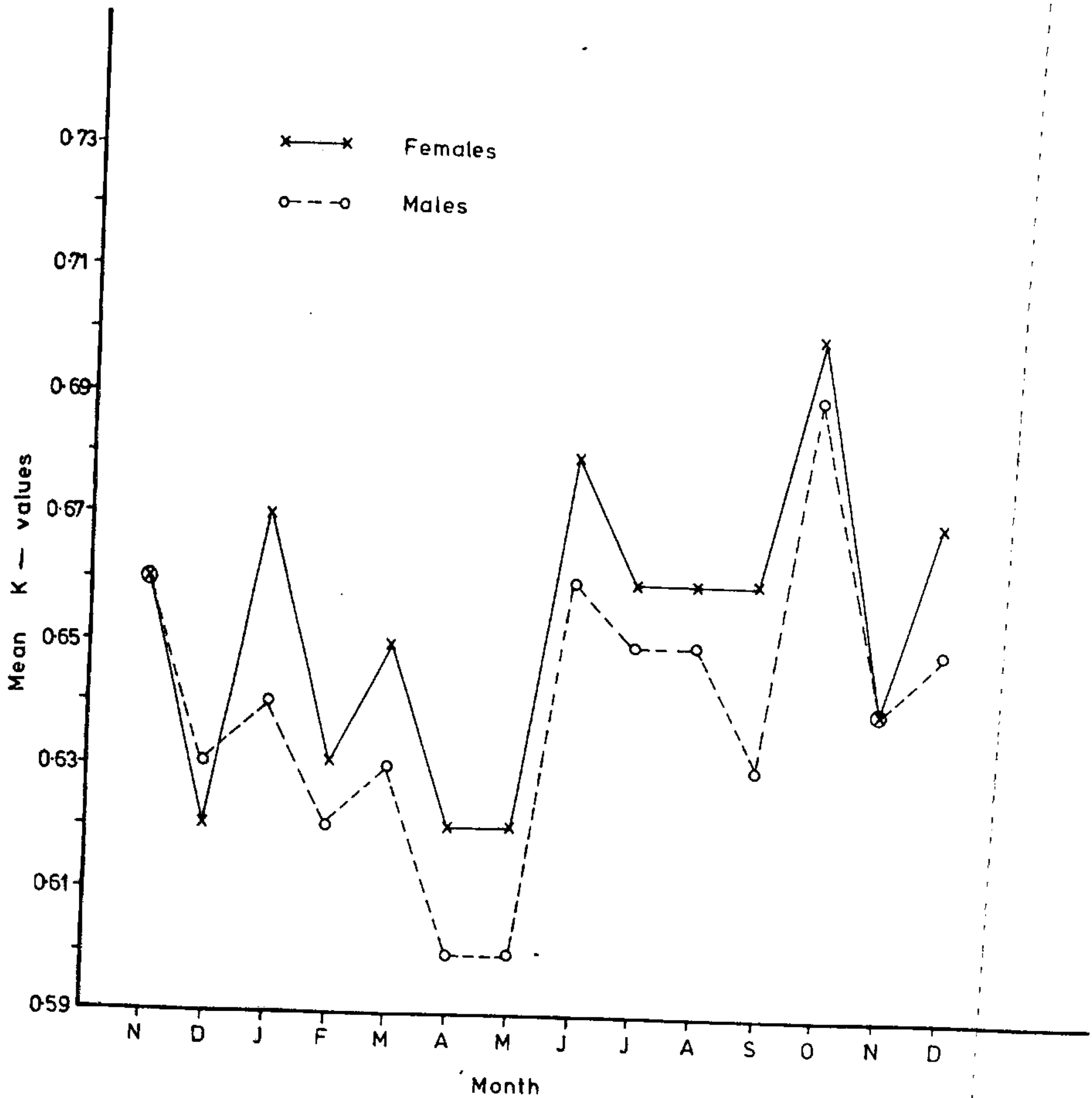


FIG. 28, Monthly variation in condition factor of I. africana caught off Lagos coast.

decreasing trend in the condition factor from November to May (dry season) and higher condition factors from June to October (rainy season).

Condition factors were also determined in fishes caught off Benin River, Brass River and Bonny River.

The sample caught off Benin River consisted of 49 males and 19 females. For the male fish, the range of K - values was 0.39 - 0.75 with a mean of 0.63 while for the females, the range of K - values was 0.57 - 0.97 with a mean of 0.66. Generally, the females had higher K - values than males. For the combined sexes, the K - values ranged from 0.39 to 0.97 with a mean of 0.64.

The condition factor was also considered relative to fish size. The size range of the male fish encountered in the catch was 11.6 - 20.5 cm while for the female fish, it was 14.8 - 21.2 cm. The fishes were divided into three 5 - cm size groups. The condition factor increased with fish size. For the male fish, the mean condition factors were 0.61 for the 11 - 15 cm size group, 0.64 for the 16 - 20 cm size group and 0.67 for the 21 - 25 cm size group. For the females, the mean condition factors were 0.62, 0.62 and 0.97 for the 11 - 15, 16 - 20 and 21 - 25 cm size groups respectively. Similarly, for the combined sexes, the mean condition factors were 0.61, 0.64 and 0.82. K - values thus increased with increase in size group of fish and it was relatively higher in females than males of the same size group, see Table 11.

For the 50 specimens of I. africana obtained off Brass River, the K - values ranged from 0.60 - 0.81. The mean K was 0.68. For the male fish, the range of K was 0.60 - 0.81 with a mean of 0.69 while for the female fish, the range of K - values was 0.61 - 0.75 with a mean of 0.68. The size range of fish used in the study was 14.1 - 22.1 cm.

Table 11. Condition factor (K) in relation to size of fish in *I. africana* caught off Benin River

Total length (cm)	Males			Females			Combined sexes		
	Number of specimens	Range of K - factor	Mean	Number of specimens	Range of K - factor	Mean	Number of specimens	Range of K - factor	Mean
11 - 15	20	0.57-0.69	0.61	5	0.59-0.65	0.62	25	0.57 - 0.69	0.61
16 - 20	28	0.39-0.75	0.64	13	0.57-0.72	0.64	41	0.39 - 0.75	0.64
21 - 25	1	0.67	0.67	1	0.97	0.97	2	0.67 - 0.97	0.82

Table 12. Condition factor (K) in relation to size of *I. africana* caught off Brass River

Total length (cm)	Males			Females			Combined sexes		
	Number of specimens	Range of K - factor	Mean	Number of specimens	Range of K - factor	Mean	Number of specimens	Range of K - factor	Mean
11 - 15	10	0.60-0.74	0.68	5	0.62-0.70	0.65	15	0.60 - 0.74	0.67
16 - 20	12	0.62-0.81	0.69	21	0.61-0.75	0.69	33	0.61 - 0.81	0.69
21 - 25	-	-	-	2	0.65-0.68	0.67	2	0.65 - 0.68	0.68

The mean condition factor increased with size group. In the male fish, the values were 0.68 and 0.69 in the 11 - 15 cm and 16 - 20 cm size groups. Similarly, in the female fish, the mean K - values were 0.65 and 0.69 for the 11 - 15 cm and 16 - 20 cm size groups. However, that of the 21 - 25 cm size group was 0.67. The condition factors with respect to size of fish are shown in Table 12.

The K - values of the 33 specimens obtained from Bonny River ranged from 0.61 - 0.75 with a mean of 0.69. For the male fish, the range of K was 0.62 - 0.71 with a mean of 0.68 while in the female fish, the range of K was 0.61 - 0.75 with a mean of 0.70. The size range encountered was 14.3 - 20.0 cm. In the male fish, while the mean K was 0.69 for the 11 - 15 cm size group, it was 0.68 in the 16 - 20 cm size group. Though, the mean K - values were higher in the females than in the males belonging to the same size group, the sample size was relatively small for any categorical inference to be drawn in relation to variation in K - values with respect to size group. The condition factors are shown in Table 13.

(x) von Bertalanffy growth parameters

Dickie (1968) and Gulland (1969) gave the von Bertalanffy growth equation as:

$$Lt = L\infty(1 - e^{-k(t-to)})$$

where

$L\infty$ = maximum size towards which the length of the fish is tending

K = a measure of the rate at which length approaches $L\infty$

to = a parameter indicating the hypothetical time at which the fish would have been zero size if it had always grown according to the equation above.

Table 13. Condition factor (K) in relation to size of *I. africana* caught off Bonny River

Total length (cm)	Males			Females			Combined sexes		
	Number of specimens	Range of K - factor	Mean	Number of specimens	Range of K - factor	Mean	Number of specimens	Range of K - factor	Mean
11 - 15	1	0.69	0.69	3	0.68-0.75	0.71	4	0.68 - 0.75	0.71
15 - 20	11	0.62 - 0.71	0.68	18	0.61-0.75	0.70	29	0.61 - 0.71	0.69

An algebraic method was used in the calculation of L_{oo}, K and t_o using the equations:

$$K = l_n \left(\frac{Lt - Lt - 1}{L_{t+1} - Lt}\right)$$

$$L_{oo} = L_t + \frac{(L_t + 1 - L_t)(L_t - L_{t-1})}{(L_t - L_t - 1) - (L_t + 1 - L_t)}$$

$$t_o = t + \frac{1}{K} l_n \left(\frac{L_{oo} - L_t}{L_{oo}}\right)$$

Age group	1^+	2^+	3^+
Mean length (cm)	15.5	17.7	19.7
Notation	L_{t-1}	L_t	L_{t-1}

Substituting values in the equations,

$$K = l_n \left(\frac{17.7 - 15.5}{19.7 - 17.7}\right)$$

$$= l_n\ 1.1$$

$$= 0.095$$

$$L_{oo} = 17.7 + \frac{(19.7-17.7)(17.7-15.5)}{(17.7-15.5)-(19.7-17.7)}$$

$$= 17.7 + \frac{4.4}{0.2}$$

$$= 39.7\text{cm}$$

Substituting the value of t = 1 in the equation for t_o,

$$t_o = 1 + \frac{1}{K} l_n \left(\frac{L_{oo} - L_t}{L_{oo}}\right)$$

$$= 1 + \frac{1}{K} l_n \left(\frac{39.7 - 15.5}{39.7}\right)$$

$$= 1 + \frac{1}{0.095} l_n \left(\frac{24.2}{39.7}\right)$$

$$= 1 + \frac{1}{0.095} (-0.4950)$$

$$= -4.1 \text{ years}$$

Thus the values of the theoretical maximum fish length L_{oo}, K and the theoretical age at which the size of the fish is zei are 39.7cm, 0.095 and - 4.21 years using the data obtained from the otolith,check technique.

Calculation of von Bertalanffy Parameters using data from the length frequency distribution (Fig.13b). Fig.13b was drawn using all the fish caught in the hauls made during November 1978. There were three distinct modes at 13cm, 18cm and 22cm. These modes were those for the 1 year, 2 year and 3 year age groups and they can be denoted as L_{t-1}, L_t and L_{t+1}.

Substituting the values in the equation.

$$K = l_n \left(\frac{L_t - L_{t-1}}{L_{t-1} - L_t} \right)$$

$$K = \ln \left(\frac{18 - 13}{22-18} \right)$$

$$= \ln \frac{5}{4}$$

$$= 0.2231$$

Substituting fish length values into the equation for L_{oo},

$$L_{oo} = 18 + \frac{(22-18)(18-13)}{(18-13)-(22-18)}$$

$$= 18 + 20$$

$$L_{oo} \simeq 38.0\text{cm}$$

Substituting the values into the equation for t_o,

$$t_o = 1 + \frac{1}{0.2231} l_n \left(\frac{38.0-13}{38} \right)$$

$$= 1 + \frac{1}{0.2231} l_n\ 0.6579$$

$$= 1 + \frac{1}{0.2231} (-0.4187)$$

$$= 1 - 1.88$$

$$t_o = -0.88 \text{ year}$$

Using data from the length frequency distribution graph, the theoretical maximum length L_{oo}, rate at which this size is attained K and the hypothetical time at which the size of the fish will be zero t_o are thus 38.0cm, 0.2231 and -0.88 year respectively.

4. FOOD AND FEEDING HABITS

For the Lagos Coast, 2,215 specimens of I. africana were analysed for the food and feeding habits. Of this number, 83 (3.7%) had empty stomachs.

(i) Summary of food items

Crustaceans constituted the most important group of food of I. africana. By the numerical method, crustaceans constituted 90.5% of all the food items and occurred in 80.3% of the stomachs containing food. By the volumetric method, they accounted for 33.4% of the food in the stomachs. The other important food organisms were the fish, fish larvae, fish scales and eggs which constituted 5.4% by the numerical method and 8.7% by the volumetric method. Fishes occurred in 17.7% of the stomachs. The nematodes were also an important group in the stomach contents, constituting 2.1% and 7.8% by number and occurrence respectively. However by volume, they made up only 0.5% of the total stomach contents. The molluscs constituted 1.0% by number, 1.4% by volume but occurred in 4.5% of the stomachs. Other less important groups of food organisms were the urochordates, the insects, coelenterates, chaetognaths, annelids and phytoplanktons.

A summary of the stomach contents of I. africana off Lagos Coast is presented in Table 14. Among the crustaceans, the shrimps were the most frequently encountered food items, occurring in 27.4% of stomachs with food. By volume also, they were the most important food item constituting 21.3% of the total food. However, by the numerical method, they were the third most important (16.5%), the lucifer being most numerous (22.7%) while the calanoids were second in importance (18.6%, by number). The lucifer however constituted only 2.4% by volume and 5.7% by occurrence while the calanoids constituted 1.4% by volume and 8.9% by occurrence. The amphipod was also an important food item, constituting 10.5% by number, 10.7% by occurrence but 1.1% by volume. Crustacean larvae, consisting of caridean larvae, penaeid larvae, anomuran larvae, pagurid larvae and the brachyuran larvae together constituted 8.8% by number and 3.6% by volume while they occurred in 12.9% of the stomachs. The brachyuran larvae were the most important crustacean larvae. The other less important crustaceans were the cladocera, cyclopoida, harpacticoida, mysidacea, isopoda, ostracoda, euphausiids and the mantis shrimps and larvae.

Fish and fish larvae constituted 2.6% by number, 7.5% by volume and occurred in 11.1% of the stomachs.

Though the molluscs were relatively unimportant in the diet of this species, the opisthobranchs, the prosobranchs and Sepia sp constituted 0.5%, 0.2%, 0.2% respectively by number and 0.6%, 0.1% and 0.7% respectively by volume while their occurrence were 2.2%, 1.0% and 1.0% respectively. The lamellibranch larvae were insignificant in the diet of I. africana.

Among the phytoplanktons, the diatoms were the most important by number (0.6%) and by occurrence (1.7%). However, they contributed only 0.1% of the food by volume. Trichodesmium sp had an occurrence of 0.8%, a volume of 0.2% and by number, they accounted for 0.3% of the food items. The flagellates and algae were very insignificant in the diet of I. africana. Also, the Siphonophores, chaetognaths, nereids, polychaetes, tunicates and insects, though they formed part of the food of the fish, they were relatively unimportant accounting for 0.01% - 0.09% of the food items.

Table 14. Summary of the food items of 2,215 *I. africana* caught off Lagos Coast

ood item	Frequency method		Numerical method		Volumetric method	
	Number	%	Number	%	Volume(cc)	%
CRUSTACEA						
Cladocera	12	0.56	22	0.16	2.7	0.06
Calanoida	189	8.86	2,614	18.60	61.1	1.38
Cyclopoida	19	0.89	35	0.25	0.9	0.02
Harpacticoida	4	0.19	4	0.03	0.02	0.004
Mysidacea	82	3.85	244	1.74	35.0	0.79
Amphipoda	227	10.65	1,481	10.54	49.6	1.12
Isopoda	18	0.84	20	0.14	5.8	0.13
Euphausiacea	27	1.27	36	0.26	12.8	0.29
Ostracoda	2	0.09	2	0.01	0.04	0.001
Caridean larvae	22	1.03	35	0.25	0.4	0.09
Penaeid larvae	2	0.09	2	0.01	15.5	0.35
Anomuran larvae	21	0.98	31	0.22	4.4	0.1
Pagurid larvae	41	1.92	56	0.4	11.5	0.26
Brachyuran larvae	190	8.91	1,112	7.91	123.2	2.78
Crustacean appendages	127	5.96	1,489	10.60	89.0	2.01
Shrimps	585	27.44	2,317	16.49	944.0	21.31
Mantis shrimps	22	1.03	27	0.19	14.2	0.32
Lucifer	122	5.72	3,193	22.72	106.3	2.4

(Contd.)

Table 14 (Contd.)

Food item	Frequency method		Numerical method		Volumetric method	
	Number	%	Number	%	Volume(cc)	%
PISCES						
Fish	200	9.38	320	2.26	320.3	7.23
Fish larvae	36	1.69	40	0.30	13.3	0.30
Fish scale	127	5.96	350	2.49	49.6	1.12
Fish eggs	15	0.70	52	0.37	10.4	0.01
NEMATODA	167	7.83	292	2.08	20.4	0.46
MOLLUSCA						
Prosobranchs	22	1.03	34	0.24	4.0	0.09
Opisthobranchs	46	2.16	65	0.46	25.7	0.58
Lamellibranchs	5	0.23	5	0.04	0.4	0.01
Sepia sp	22	1.03	29	0.21	30.6	0.69
PHYTOPLANKTON						
Diatoms	36	1.69	85	0.6	4.0	0.1
Flagellates	5	0.23	4	0.03	0.4	0.01
Algae	5	0.23	26	0.19	1.3	0.029
Trichodesmium sp.	17	0.83	40	0.30	6.6	0.15
ANNELIDA						
Nereid larvae	4	0.19	8	0.06	1.3	0.03
Polychaete larvae	4	0.19	4	0.03	0.4	0.01
ARTHROPODA						
Insecta	5	0.23	13	0.09	0.4	0.01
UROCHORDATA						
Tunicate larvae	3	0.14	3	0.02	0.4	0.01

(Contd.)

Table 14 (Contd.)

Food item	Frequency method		Numerical method		Volumetric method	
	Number	%	Number	%	Volume(cc)	%
COELENTERATA						
Siphonophores	1	0.05	1	0.01	0.04	0.001
CHAETOGNATHA						
Sagitta larvae	1	0.05	1	0.01	0.04	0.001
UNIDENTIFIED MASS	1,353	63.43	-	-	2456.0	55.44

(ii) Feeding in relation to size

The fish were divided into two size groups to facilitate the comparison of their food habits in relation to size. The first group comprised of the small fish (3.0 - 14.9cm total length) while the second group consisted of the larger fish (15.0 - 26.9cm total length). Both size groups fed on the same types of food items. However, the importance of the food items varied in their diets. The crustaceans were the most important group of food in both size groups. Details of feeding in relation to size are presented in Table 15 and illustrated in Figures 29a and 29b. In the smaller fishes, the crustaceans constituted 94.4% by number and 29.9% by volume. The frequency of occurrence of the crustaceans was 89.8% in this category. In the bigger fishes, crustaceans accounted for 74.5% by the occurrence, 86.7% by the numerical and 36.0% by the volumetric methods. However, the larger crustaceans were of greater importance in the diet of the bigger fishes. The shrimps for example constituted 27.2% numerically, 26.5% by volume and 34% by occurrence method in the larger specimens whereas in the smaller fishes, the shrimps made up only 5.1% numerically, 12.9% by volume and 16.7% by occurrence. Similarly, the mantis shrimps, in the bigger fishes accounted for 1.4% by occurrence, 0.3% by numerical method and 0.5% by volumetric method while in the smaller fishes, they constituted only 0.5% by occurrence, 0.07% by numerical method and 0.1% by volumetric method. Lucifer was found in greater abundance in the bigger fishes, constituting 29.1% against 16% in the smaller fishes. Other crustaceans which were of importance in the diet of the bigger fishes were the euphausiids, the isopods and the mysids. Conversely, the smaller crustaceans were more important in the diet of the smaller fishes than that of the bigger fishes. The crustacean larvae constituted 9.3% by number, 4.7% by volume and they had an occurrence of 17.5% in the smaller fishes whereas in the bigger fishes the occurrence was 10.2% the volume was 3.2% while numerically, they made up 8.1% of the food. Similarly, the calanoids and amphipods had greater percentages in the smaller fishes. Here, the calanoids had an occurrence of 17.2%, 35.1% by number and 3.3% by volume whereas, in the bigger fishes, the respective percentages were 3.7%, 3.1% and 0.2%. The amphipods constituted 14.5% by occurrence, 17.1% by number and accounted for 1.0% by volume of the food of the smaller specimens. In the bigger fishes, the respective percentages were 8.3%, 4.4% and 0.7%. Though cladocera, cyclopoida, harpacticoida and ostracoda were of little importance in the diet of I. africana, they were more important in the diet of the smaller fishes.

The fishes were of greater importance in the diet of the larger specimens accounting for 20.4% by occurrence, 8.2% by number and 10.0% by volume. In the smaller fishes, however, they constituted 2.5% by number, 6.5% by volume, but occurred in 13.4% of the specimens.

Among the molluscs, Sepia sp. though few in number, were of greater importance in the diet of the larger fishes. In the larger specimens, they had an occurrence of 1.6% and constituted 1.0% by volume and 0.4% by number. In the smaller fishes, however, the occurrence of Sepia sp. was 0.1% and they constituted 0.02% and 0.1% of the food by number and volume respectively. However, the opisthobranchs and lamellibranchs which are smaller molluscs were of greater importance in the diet of the smaller fishes.

The tunicates and sinophores were only found in the stomachs of the smaller fishes while only one Sagitta sp. was found in the bigger size group. The phytoplankton was of about equal importance in the

Table 15. Summary of the food of *I. africana* off Lagos Coast in percentages by size group

Size group	3.0 - 14.9 cm			15.0 - 26.9 cm		
Number of fish examined	833			1,382		
Number of empty stomachs	20			63		
	F^1	N^1	V^1	F^2	N^2	V^2
CRUSTACEA						
Cladocera	0.86	0.22	0.08	0.38	0.1	0.05
Calanoida	17.22	35.06	3.27	3.71	3.13	0.21
Cyclopoida	1.97	0.47	0.05	0.23	0.04	0.002
Harpacticoida	0.49	0.06	0.01	-	-	-
Mysidacea	3.57	1.01	0.97	4.02	2.42	0.68
Amphipoda	14.51	17.10	1.75	8.27	4.40	0.73
Isopoda	0.62	0.07	0.03	0.99	0.21	0.19
Euphausiacea	0.86	0.10	0.29	1.52	0.40	0.29
Ostracoda	0.12	0.02	0.003	0.08	0.01	0.0004
Caridean larvae	1.72	0.38	0.10	0.61	0.12	0.08
Penaeid larvae	-	-	-	0.15	0.03	0.06
Anomuran larvae	1.60	0.32	0.24	0.61	0.12	0.03
Pagurid larvae	2.71	0.53	0.26	1.44	0.28	0.26
Brachyuran larvae	11.44	8.08	4.08	7.35	7.76	2.78
Crustacean appendages	6.64	9.85	1.96	5.53	11.29	2.04
Shrimps	16.73	5.11	12.85	34.04	27.17	26.54

(Contd.)

Table 15 (Contd.)

Size group	3.0 - 14.9 cm			15.0 - 26.9 cm		
Number of fish examined	833			1,382		
Number of empty stomachs	20			63		
	F^1	N^1	V^1	F^2	N^2	V^2
Mantis shrimps	0.49	0.07	0.10	1.36	0.30	0.45
Lucifer	8.24	15.95	3.64	4.17	29.08	1.63
PISCES						
Fish	5.66	0.68	5.0	9.94	3.13	8.00
Fish larvae	1.23	0.32	0.49	3.71	0.90	0.79
Fish scale	5.54	1.33	0.94	6.22	3.57	1.29
Fish eggs	0.98	0.12	0.03	0.53	0.61	0.002
NEMATODA	6.89	1.16	0.50	8.42	2.94	0.44
MOLLUSCA						
Prosobranchs	2.21	0.43	0.10	0.30	0.07	0.08
Opisthobranchs	3.08	0.53	0.63	1.59	0.40	0.05
Lamellibranchs	0.62	0.07	0.003	-	-	-
<u>Sepia</u> sp	0.12	0.02	0.13	1.59	0.39	1.04
PHYTOPLANKTON						
Diatoms	1.23	0.18	0.03	0.68	0.46	0.03
Flagellates	0.49	0.06	0.03	-	-	-
Algae	0.37	0.13	0.03	0.15	0.23	0.03
<u>Trichodesmium</u> sp.	1.23	0.32	0.13	0.53	0.25	0.03
ANNELIDA						
Nereid larvae	0.25	0.03	0.003	0.15	0.08	0.05
Polychaete larvae	0.37	0.04	0.03	0.08	0.01	0.002

(Contd.)

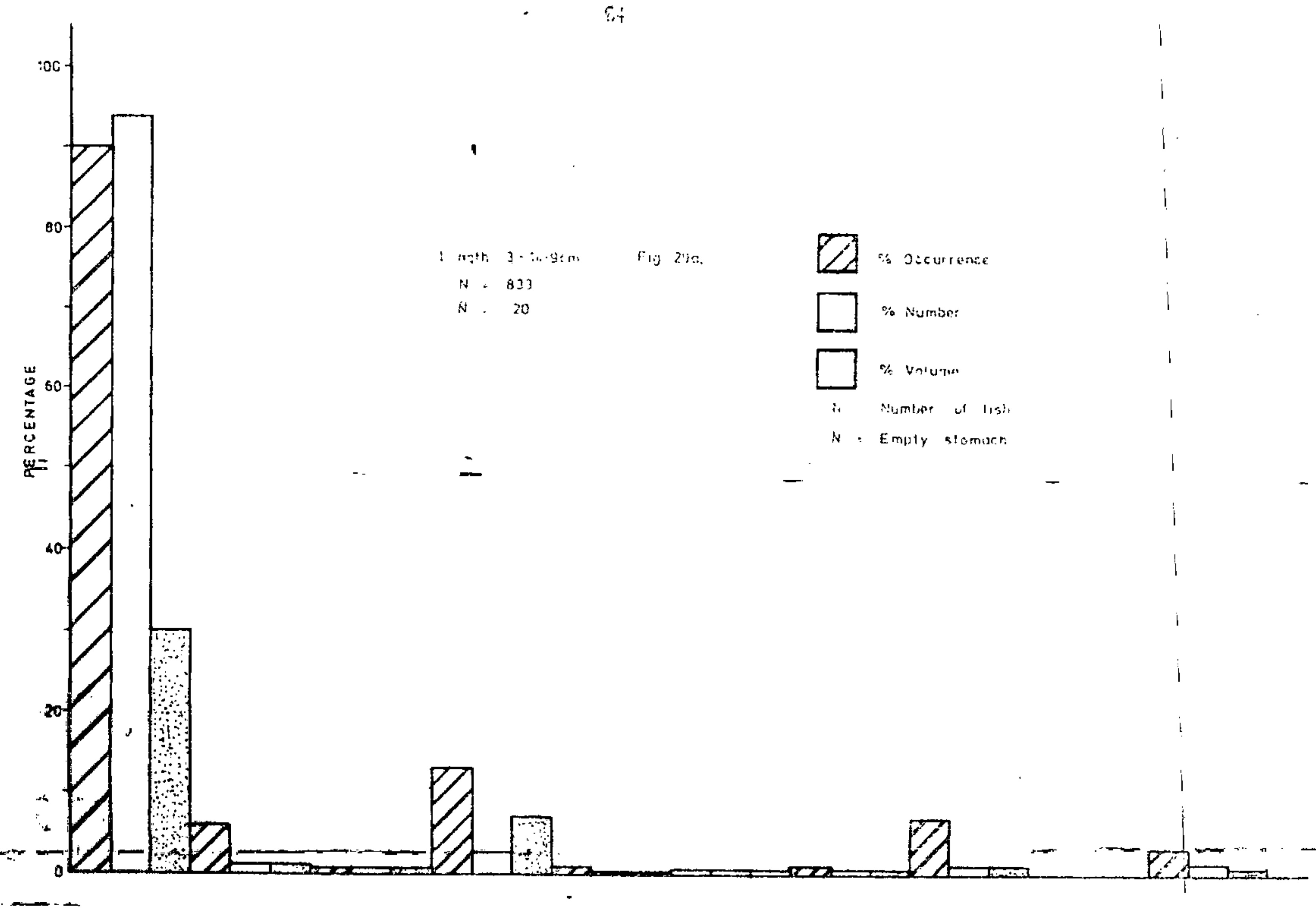
Table 15 (Contd.)

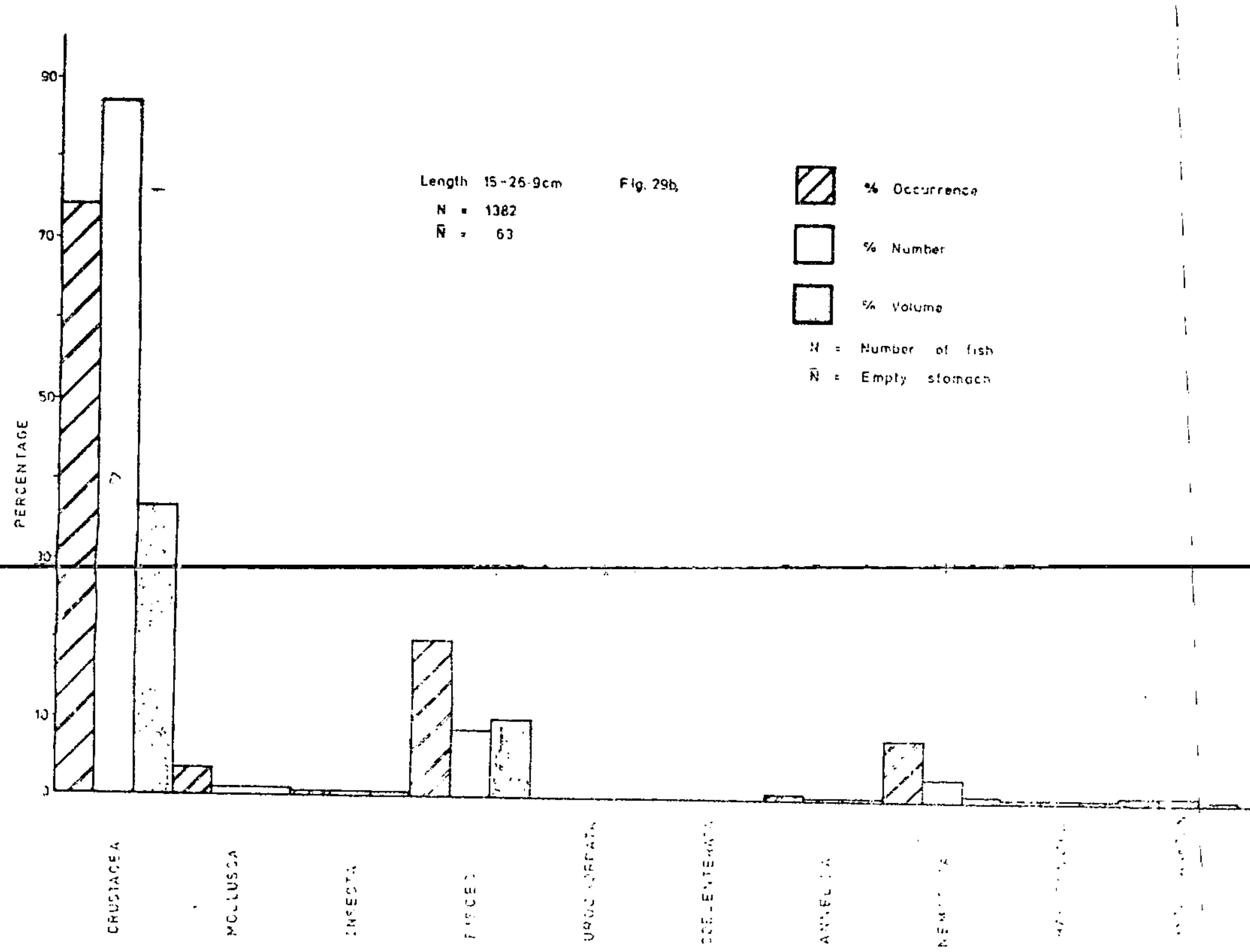
Size group Number of fish examined Number of empty stomachs	3.0 - 14.9 cm 833 20			15.0 - 26.9 cm 1,382 63		
	F^1	N^1	V^1	F^2	N^2	V^2
ARTHROPODA						
Insecta	0.25	0.12	0.008	0.23	0.07	0.42
UROCHORDATA						
Tunicate larvae	0.37	0.04	0.03	-	-	-
COELENTERATA						
Siphonophores	0.12	0.02	0.003	-	-	-
CHAETOGNATHA						
<u>Sagitta</u> larvae	-	-	-	0.08	0.01	0.002
UNIDENTIFIED MASS	71.2	-	62.22	59.97	-	51.75

F = occurrence

N = Number

V = Volume





FIGS 29a and 29b. Relative importance of the Stomach contents in the diet of *I. africana* in relation to size stomachs of both size groups of fish constituting 6.9% and 8.4% by occurrence in the smaller and larger fishes respectively, 1.2% and 2.9% respectively by number and 0.5% and 0.4% respectively by volume.

(iii) Feeding in relation to depth

For the purpose of comparing feeding of I. africana in relation to water depth, specimens collected from 10 - 20m and 40 - 50m were examined.

A greater variety of food organisms was encountered in the diet of I. africana from the shallow waters than from the deeper waters. In the shallow waters, twenty different types of food items were encountered of which ten were crustaceans while in the deeper waters, only twelve types of food items were found in the stomachs and seven of these were crustaceans. A summary of the food of I. africana in relation to water depth is shown in Table 16 and illustrated in figures 30a and 30b. The crustaceans in the shallow water constituted 68.8% by number and 70.1% by volume while in the deeper waters, they accounted for 60.1% and 45.3% by number and volume respectively. The shrimp was an important food item at both the shallow and deep water. Though the calanoids and amphipods were important in the diets of fishes from both the shallow and deeper waters, their occurrence were higher in fish from the shallow water, accounting for 32.4% and 10.8% respectively compared to the respective occurrence of 12.5% and 9.4% in the deeper waters. By volume, the calanoids and the amphipods respectively constituted 14.3% and 0.4% in the shallow waters and 1.3% and 0.4% respectively in the deeper waters. However, the amphipods were more numerous in diet of fishes from the deeper waters, contributing 10.7% while in the diet of fishes from the shallow waters, they constituted 3.1%.

stomachs of both size groups of fish constituting 6.9% and 8.4% by occurrence in the smaller and larger fishes respectively, 1.2% and 2.9% respectively by number and 0.5% and 0.4% respectively by volume.

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For the purpose of comparing feeding of *I. africana* in relation to water depth, specimens collected from 10 - 20m and 40 - 50m were examined.

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Fish, fish larvae, fish scales and eggs were important in the food of fishes from both the shallow and deeper waters. In the diet of fishes from the shallow waters, the occurrence was 24.5%, numerically they contributed 18.6% and by volume 5.6% while in the diets of I. africana from the deeper waters, the occurrence was 15.7%, number was 26.7% and by volume they constituted 14.0%.

The molluscs, mostly larvae had a higher occurrence in the stomachs of fishes from the shallow waters. The occurrence of cephalopod was recorded only in the fishes from the shallow waters. The incidence of urochordates, annelids, nematodes, insecta and diatoms were recorded in the fishes from the shallow waters only while a small number of flagellates and Trichodesmium sp. were encountered in the fishes from the deeper waters.

(iv) Monthly variation in food habit

The seasonal variation in the stomach contents of I. africana was examined. The results are shown in tables 17, 18 and 19. Crustaceans were important in the diet of this species throughout the year. By the numerical method, they contributed 51.6 - 97.7% of the monthly food while by volume, they accounted for 16.3 - 81.9% of the monthly stomach contents. Fish, fish larvae, fish scales and eggs contributed 0.8 - 36.5% by number of the monthly food while by volume, they accounted for 2.0 - 32.3% of the food. They occurred in the diet of this species throughout the year. The molluscs accounted for only 0 - 3.0% by number while contributing 0 - 6.0% by volume. The tunicates, sinophores, nereid larvae, polychaete larvae and Sagitta larvae were incidental in the diet of I. africana. The tunicates and sinophores occurred in the diet of the fish in November only while nereid larvae were found in December. Sagitta larvae occurred in February and polychaete larvae were

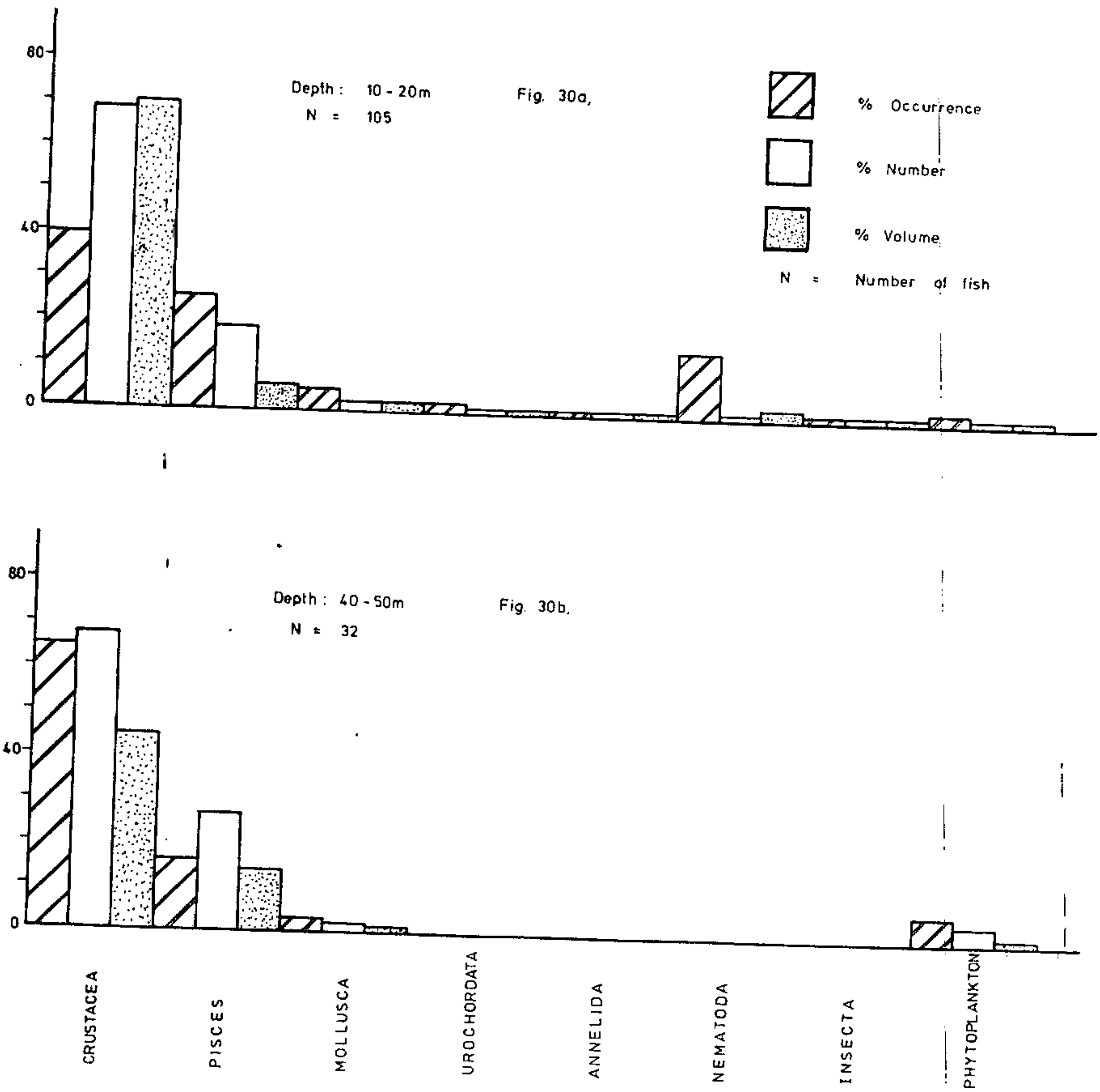
Table 16. Analysis of stomach contents of *I. africana* by water depth (expressed in percentage)

Depth (m)	10 - 20			40 - 50		
Sample size	105			32		
% Empty stomachs	2.9			15.6		
	F^1	N^1	V^1	F^2	N^2	V^2
CRUSTACEA						
Calanoida	32.35	31.74	14.25	12.5	10.67	1.31
Amphipoda	10.78	3.06	0.42	9.4	10.67	0.43
Shrimps	50.98	26.20	50.35	28.10	28.00	34.93
Isopoda	4.90	0.96	0.17	-	-	-
Mysidacea	4.90	0.96	0.58	3.10	2.67	0.34
Lucifer	4.90	2.29	1.35	-	-	-
Euphausiacea	3.92	0.76	0.46	3.10	4.00	1.55
Brachyuran larvae	18.63	0.76	1.87	6.20	2.07	0.11
Anomuran larvae	4.90	1.34	0.13	-	-	-
Caridean larvae	3.92	0.76	0.42	-	-	-
Cladocera	-	-	-	3.10	9.33	6.64
PISCES						
Fish	8.83	2.49	4.68	4.34	6.29	7.54
Fish larvae	3.92	0.76	0.42	1.96	0.38	0.22
Fish scales	6.86	7.46	0.15	9.40	20.00	6.28
Fish eggs	4.90	7.84	0.30	-	-	-

(Contd.)

Table 16 (Contd.)

Depth (m)	10 - 20			40 - 50		
Sample size	105			32		
% Empty stomachs	2.9			15.6		
	F^1	N^1	V^1	F^2	N^2	V^2
MOLLUSCA						
Opisthobranchs	2.90	0.76	0.20	3.10	1.33	0.02
Cephalopoda	1.96	1.15	1.74	-	-	-
NEMATODA						
Nematodes	14.71	0.48	1.74	-	-	-
PHYTO PLANKTON						
Diatoms	1.96	0.38	0.001	-	-	-
Flagellates	-	-	-	3.10	3.07	0.69
Trichodesmium sp	-	-	-	3.10	1.33	0.34
UROCHORDATA						
Tunicate larvae	1.96	0.38	0.03	-	-	-
ANNELIDA						
Polychaete larvae	0.98	0.89	0.55	-	-	-
ARTHROPODA						
Insecta	0.98	0.57	0.03	-	-	-
Unidentified mass	42.16	-	20.21	46.90	-	39.60



FIGS. 30a and 30b, Variation in stomach contents of I. africana with water depth.

part of the diet from November to January. The phytoplanktons were also of limited importance in the diet of the fish contributing 0 - 2.7% by number and 0 - 0.25% by volume. They occurred in the diet of the fish from November to December, February to March and May.

By the numerical method of analysis, the calanoids were the most important food item in November and December 1978. They accounted for 23.4% and 58.5% of the total food respectively. By volume, these food items accounted for 8.4% in November and 12.3% in December while by occurrence, they contributed 23.4% and 64.9% respectively. In subsequent months, the respective percentage contributions were very low ranging between 0 - 2.5%, 0 - 0.9% and 0 - 6.5%.

In November, though the shrimps were the second most important food item by the numerical method (21.0%), they were the most important by the volumetric and occurrence methods, contributing 38.4% and 33.7% respectively. They were fairly important in the diet in December contributing 12.3% by volume and 20.1% by occurrence. However, they were relatively unimportant numerically contributing only 1.3%. In January and June to October, they were the most important food in the diet of *I. africana*, accounting for 34.7 - 97% of the food of the fish. By occurrence method, the shrimps were also important in January, February, April, June to October, accounting for 39.0%, 29.1%, 25.4%, 19.2%, 18.1%, 33.7%, 55.3% and 93.9% respectively of the food. By the volumetric method, the percentages of the shrimps in the diet of the fish were respectively 16.0%, 15.2%, 18.5%, 15.6%, 14.3%, 30.7%, 50.6% and 81.7%.

The amphipods had a high occurrence of 12.5 - 49.4% between November 1978 and February 1979 but thereafter their occurrence was low (0 - 6.3%). Numerically, their percentages were high in December

1978 and January 1979 (30.1% and 23.4% respectively) but relatively low in the other months (0 - 6.2%). By volume, the percentages were low in all the months with a range of 0 - 7.1%. Both the calanoids and amphipods were absent in the diet of the fish in July and October 1979.

By the numerical method of analysis, the fish and fish larvae were appreciably important in the diet of the fish only in January contributing 13.4% of the fish food. However, by volume, they were relatively more important contributing between 11.7% and 30.6% in five months of the year and an occurrence of 7.7% to 40.4% in six months of the year. Fish and fish larvae were the most frequently occurring food in January contributing 40.4%. The occurrence was also fairly high in December and February (17.5%) as well as in May (21.8%). By number, the percentages were fairly high in January and June (13.4% and 14.6% respectively). The fish and fish larvae formed a substantial volume of the fish diet from December to February, May and June accounting for 14.4%, 24.5%, 11.1%, 30.6% and 11.7% respectively of the volume of the fish food. Fish formed part of the diet of the specimens in all months of the year and in June and July, fishes and shrimps were the dominant food of I. africana.

From February to May, the importance of the lucifers in the diet of I. africana was noticeable. By number, they accounted for 71.4% of the fish food in February, placing the shrimps second in importance with 12.4%. Similarly, by occurrence, they were the second most important food item accounting for 20.8% of the fish food. In March and May, the lucifers had the highest percentage by occurrence, the numerical and the volumetric methods of analysis. These were 25.2%, 46.2% and 7.8% respectively in March and 21.1%, 77.4% and 15.2%

respectively in May.

The mysids were fairly important in the diet of the fish in some months of the year. By occurrence, they contributed 13.0% and 15.0% of the food in February and March and 4.5%, 14.7% and 10.8% in February, March and August using the numerical method. By the volumetric method, they contributed 6.4% of the food in March, 1979. By all the methods of analysis, they were the second most important food item in March while in August, they were the second most important by occurrence and numerical methods. In February the mysids were the third most important food item by number accounting for 45% of the food.

The brachyuran larvae were very important in the diet of this species by occurrence between March and May as well as in September, accounting for 13.4%, 56.5%, 14.3% and 11.8% in the respective months. By number, this food item constituted 9.3%, 38.8% and 16.1% in March, April and June while in April, a relatively high volumetric percentage of 32.4% was obtained.

When the feeding habit in the rainy season (May to October) and the dry season (November to April) were compared, it was found that *I. africana* fed on a wider variety of food items during the dry season than in the rainy season. Food items such as cyclopoida, harpacticoida, ostracoda, caridean larvae, penaeid larvae, opisthobranchs, lamellibranchs, sinophores, nereid larvae, *sagitta* larvae, flagellates, algae and *Trichodesmium* were only encountered in the diet of the fish during the dry season of the year. Cladocera and pagurid larvae were only incidental in the diet of the fish during the rainy season in July and September respectively.

Though some zooplanktons occurred in the diet of the fish in both the dry and the rainy seasons, their percentages were higher in the dry seasons. By occurrence, the percentage of the calanoids ranged from 1.5 - 64.9% in the dry season in comparison to 0 - 2.3% in the rainy season. By the numerical method, the range during the dry season was 9.1 - 58.5% while during the rainy season, it was 0 - 3.9%. By the volumetric method, the values ranged between 0.1% and 12.3% in the dry season while in the rainy season, it ranged between 0% and 1.0%. For the amphipods and mysids respectively their occurrence ranged from 2.2 - 49.4% and 0.7 - 15.0% in the dry season while it was 0 - 6.0% and 0 - 6.8% respectively in the rainy season. Similarly, the occurrence of the brachyuran larvae in the dry season ranged from 1.3% - 56.5% while in the rainy season it ranged from 1.3% - 14.3%. The occurrence of lucifer in the diet ranged from 0 - 28.6% in the dry season and 0 -21.1% in the rainy season.

The importance of the shrimps was spread over the whole year, but it became more conspicuous in the rainy season when other food items were of less importance. The occurrence of shrimps in the diet of the fish ranged between 5.5 - 39% during the dry season while it ranged between 9% and 93.0% during the rainy season. By the numerical method and the volumetric method, the percentages ranged from 1.3% - 34.7% and 2.9% - 38.4% respectively in the dry season while in the rainy seasons, they respectively ranged from 2.8% - 97.0% and 5.1 - 81.8%.

The importance of fishes was also spread through the dry and rainy seasons. The occurrence of fish and fish larvae ranged from 2.4% to 40.4% in the dry season and 1.1% to 21.8% in the rainy season while by number, they ranged from 0.3 - 13.4% in the dry season and 0.7 - 14.6% in the rainy season. By volume, the percentages ranged from 1.0% to 24.5% in the dry season and 0.9% to 30.6% in the rainy season.

Table 17 Monthly variation in the food items of *I. africana* by percent occurrence

Month	N	D	J	F	M	A	M	J	J	A	S	O
Number of fish	320	154	151	160	128	148	133	128	163	101	76	98
Food items												
CRUSTACEA												
Cladocera	13.2	2.6	-	0.65	0.79	-	-	-	0.65	-	-	-
Calanoida	23.4	64.9	4.26	6.49	1.57	1.45	2.30	0.8	-	2.17	1.3	-
Cyclopoida	0.33	9.1	2.13	0.65	-	-	-	-	-	-	-	-
Harpacticoida	0.33	1.9	-	-	-	-	-	-	-	-	-	-
Mysidacea	3.63	3.2	2.13	12.99	14.96	0.72	6.8	0.8	-	3.26	-	-
Amphipoda	12.54	49.4	38.30	20.78	6.3	2.17	6.0	0.8	-	3.26	1.3	-
Isopoda	3.3	0.7	-	2.60	0.79	-	1.5	-	-	-	1.3	-
Euphausiacea	2.31	-	-	7.79	4.72	-	-	0.8	-	1.09	-	-
Ostracoda	-	-	0.71	-	0.79	-	-	-	-	-	-	-
Caridean larvae	1.32	8.4	0.71	3.25	-	-	-	-	-	-	-	-
Penaeid larvae	-	0.7	0.71	0.65	0.79	-	-	-	-	-	-	-
Anomuran larvae	1.65	3.2	-	1.95	3.15	2.17	5.3	-	-	-	-	-
Pagurid larvae	-	10.4	0.71	3.90	2.36	5.07	1.5	-	-	-	1.30	-
Brachyuran larvae	9.57	16.8	2.13	1.3	13.37	56.51	14.3	2.4	1.29	2.17	11.8	2.00
Crustacean appendages	5.28	1.9	10.64	-	-	44.20	3.8	-	0.65	-	3.9	-
Shrimps	33.66	20.1	39.01	29.07	5.51	25.36	9.0	19.2	18.06	33.70	55.30	93.90
Mantis shrimps	-	-	1.42	4.55	3.15	-	2.3	0.8	-	-	3.9	1.0
Lucifer	2.31	1.3	3.55	28.57	25.20	-	21.1	-	-	-	2.60	-
MOLLUSCA												

(Contd.)

N 320	D 154	J 151	F 160	M 128	A 148	M 133	J 128	J 163	A 101	S 76	O 98
0.66	11.7	-	1.30	-	-	-	-	-	1.09	2.6	-
3.3	8.4	0.71	14.29	-	-	-	-	-	-	-	-
-	3.9	-	2.6	-	-	-	-	-	-	-	-
0.99	-	6.38	0.65	-	-	4.5	1.6	-	1.09	-	-
0.66	1.3	-	1.30	-	-	-	-	-	1.09	-	-
7.91	16.8	39.72	16.23	2.36	4.34	21.05	12.8	7.74	1.09	5.30	9.2
1.0	0.7	0.71	1.3	-	-	0.75	-	-	-	-	-
9.57	13.6	17.02	3.25	7.8	2.90	5.3	1.6	9.03	3.26	-	2.0
2.97	-	-	1.95	0.79	-	0.75	-	-	-	-	-
1.32	-	-	-	-	-	-	-	-	-	-	-
0.33	-	-	-	-	-	-	-	-	-	-	-
-	1.3	-	-	-	-	-	-	-	-	-	-
0.33	1.9	0.71	-	-	-	-	-	-	-	-	-
0.99	12.3	12.77	9.74	7.87	0.72	4.5	4.0	6.45	1.09	2.60	-

(Contd.)

Month	N	D	J	F	M	A	M	J	J	A	S	O
Number of fish	320	154	151	160	128	148	133	128	163	101	76	98
Food items												
CHAETOGNATHA												
Sagitta larvae	-	-	-	0.65	-	-	-	-	-	-	-	-
PHYTOPLANKTON												
Diatoms	-	-	-	-	-	-	0.75	-	-	-	-	-
Flagellates	0.33	0.7	-	-	-	-	-	-	-	-	-	-
Algae	+	-	-	-	-	-	-	-	-	-	-	-
Trichodesmium	0.33	3.9	-	2.6	2.36	-	-	-	-	-	-	-
UNIDENTIFIED MASS	31.35	61	61.7	55.19	81.89	34.06	64.7	74.4	79.35	33.70	43.4	28.6

\+ minute trace

Table 18 Monthly variation in food items of *I. africana* by number (in percentage)

Month	N	D	J	F	M	A	M	J	J	A	S	O
Number of fish	320	154	151	160	128	148	133	128	163	101	76	98
Food items												
CRUSTACEA												
Cladocera	0.92	0.13	-	0.04	0.29	-	-	-	1.26	-	-	-
Calanoida	23.44	58.51	2.49	0.93	0.58	0.09	3.86	1.46	-	1.44	0.43	-
Cyclopoida	0.09	0.67	1.05	0.04	-	-	-	-	-	-	-	-
Harpacticoida	0.09	0.08	-	-	-	-	-	-	-	-	-	-
Mysidacea	1.74	0.16	0.52	4.51	14.74	0.04	1.00	0.43	-	10.79	-	-
Amphipoda	6.23	30.10	23.43	2.47	2.60	0.19	0.57	0.73	-	5.04	0.43	-
Isopoda	1.01	0.03	-	0.18	0.29	-	0.14	-	-	-	0.43	-
Euphausiacea	0.82	-	-	0.64	2.31	-	-	0.43	-	0.72	-	-
Ostracoda	-	-	0.13	-	0.29	-	-	-	-	-	-	-
Caridean larvae	0.37	0.43	0.13	0.21	-	-	-	-	-	-	-	-
Penaeid larvae	-	0.03	0.13	0.04	0.29	-	-	-	-	-	-	-
Anomuran larvae	0.64	0.13	-	0.18	3.18	0.14	0.57	-	-	-	-	-
Pagurid larvae	-	0.75	0.26	0.25	1.73	0.51	0.14	-	-	-	0.43	-
Brachyuran larvae	5.40	1.42	0.52	0.11	9.25	38.75	4.22	16.06	1.26	1.44	5.64	0.50
Crustacean appendages	10.99	0.08	7.07	-	-	52.21	1.72	-	2.51	-	3.48	-
Shrimps	20.97	1.26	34.69	6.26	3.76	6.22	2.79	56.9	46.54	74.10	71.30	96.98
Mantis shrimps	-	-	0.26	0.43	1.45	-	0.2	0.43	-	-	1.3	0.17
Lucifer	1.56	0.05	1.05	71.41	46.24	-	77.41	-	-	-	9.13	-

(Contd.)

Month	N	D	J	F	M	A	M	J	J	A	S	O
Number of fish	320	154	151	160	128	148	133	128	163	101	76	98
Food items												
MOLLUSCA												
Prosobranchs	0.37	0.62	-	0.01	-	-	-	-	-	0.72	0.87	-
Opisthobranchs	1.01	0.62	0.13	1.04	-	-	-	-	-	-	-	-
Lamellibranchs	-	0.19	-	1.22	-	-	-	-	-	-	-	-
Sepia sp	1.65	-	1.18	0.04	-	-	0.79	1.46	-	0.72	-	-
ARTHROPODA												
Insecta	0.37	0.22	-	0.07	-	-	-	-	-	0.72	-	-
PISCES												
Fish	2.74	0.59	12.17	0.75	-	-	4.87	14.6	7.55	0.72	5.65	1.51
Fish larvae	0.37	0.43	1.18	0.43	-	-	0.2	-	-	-	-	-
Fish scales	7.51	2.05	9.42	0.21	6.07	0.51	1.0	2.92	28.93	2.88	-	0.84
Fish eggs	4.12	-	-	0.14	0.29	-	0.14	-	-	-	-	-
UROCHORRATA												
Tunicates	0.92	-	-	-	-	-	-	-	-	-	-	-
COELENTERATA												
Siphonophores	0.09	-	-	-	-	-	-	-	-	-	-	-
ANNELIDA												
Nereid larvae	-	0.05	-	-	0.87	0.28	-	-	-	-	-	-
Polychaete larvae	0.09	0.08	0.13	-	-	-	-	-	-	-	-	-
NEMATODA												
Nematodes	4.49	0.59	4.06	0.86	4.91	0.04	0.64	3.65	11.94	0.72	0.87	-

(Contd.)

Month	N	D	J	F	M	A	M	J	J	A	S	O
Number of fish	320	154	151	160	128	148	133	128	163	101	76	98
Food items												
CHAETOGNATHA												
Sagitta larvae	-	-	-	0.04	-	-	-	-	-	-	-	-
PHYTOPLANKTON												
Diatoms	2.01	-	-	-	-	-	0.07	-	-	-	-	-
Flagellates	0.18	0.05	-	-	-	-	-	-	-	-	-	-
Algae	0.46	-	-	-	-	-	-	-	-	-	-	-
Trichodesmium	0.09	0.65	-	0.29	0.87	-	-	-	-	-	-	-

Table 19 Monthly variation in food items of *I. africana* by percentage volume

Month Number of fish Food items	N	D	J	F	M	A	M	J	J	A	S	O
CRUSTACEA												
Cladocera	0.96	0.05	–	0.26	0.04	–	–	–	0.06	–	–	–
Calanoida	8.35	12.33	0.07	0.28	0.05	0.87	1.04	0.02	–	0.11	0.04	–
Cyclopoida	+	0.11	0.17	+	–	–	–	–	–	–	–	–
Harpacticoida	+	0.05	–	–	–	–	–	–	–	–	–	–
Mysidacea	0.48	0.16	0.58	2.86	6.36	0.07	0.84	0.08	–	1.90	–	–
Amphipoda	0.57	7.06	1.28	4.22	0.92	0.07	0.20	+	–	0.11	0.01	–
Isopoda	0.25	0.01	–	0.88	0.12	–	0.75	–	–	–	0.07	–
Euphausiacea	0.54	–	–	0.77	1.75	–	–	0.08	–	0.05	–	–
Ostracoda	–	–	+	–	0.02	–	–	–	–	–	–	–
Caridean larvae	0.22	0.50	0.03	0.15	–	–	–	–	–	–	–	–
Penaeid larvae	–	0.01	0.21	0.01	0.04	–	–	–	–	–	–	–
Anomuran larvae	0.07	0.16	–	0.32	0.1	0.08	0.11	–	–	–	–	–
Pagurid larvae	–	0.56	0.21	0.82	0.48	1.51	0.51	–	–	–	0.01	–
Brachyuran larvae	0.97	1.4	0.07	0.03	1.48	32.40	2.06	0.30	0.1	0.12	0.49	0.10
Crustacean appendages	1.61	0.85	4.59	–	–	18.79	0.43	–	0.64	–	1.48	–
Shrimps	38.38	12.28	15.95	15.24	2.87	18.52	5.08	15.62	14.28	30.70	50.64	81.70
Mantis shrimps	–	–	0.64	1.25	2.06	–	0.44	0.16	–	–	1.0	0.1
Lucifer	0.79	0.05	0.59	12.38	7.76	–	15.23	–	–	–	1.21	–

(Contd.)

D 154	J 151	F 160	M 128	A 148	M 133	J 128	J 163	A 101	S 76	O 98
	–	0.04	–	–	–	–	–	0.01	0.13	–
	0.03	2.25	–	–	–	–	–	–	–	–
	–	0.45	–	–	–	–	–	–	–	–
	2.94	0.63	–	–	6.01	0.97	–	0.54	–	–
	–	0.04	–	–	–	–	–	0.54	–	–
	23.18	9.82	1.04	2.22	28.55	11.71	6.29	0.87	3.72	2.01
	1.28	1.25	–	–	2.06	–	–	–	–	–
	1.14	0.14	1.34	0.94	1.66	0.09	4.11	1.74	–	–
	–	0.01	0.08	–	0.03	–	–	–	–	–
	–	–	–	–	–	–	–	–	–	0.25
	–	–	–	–	–	–	–	–	–	–
	–	–	–	–	–	–	–	–	–	–
	0.02	–	–	–	–	–	–	–	–	–
	0.16	0.15	1.83	0.73	0.24	0.01	0.76	0.01	0.03	–

(Contd.)

Month	N	D	J	F	M	A	M	J	J	A	S	O
Number of fish	320	154	151	160	128	148	133	128	163	101	76	98
Food items												
CHAETOGNATHA												
Sagitta larvae	-	-	-	0.01	-	-	-	-	-	-	-	-
PHYTOPLANKTON												
Diatoms	0.08	-	-	-	-	-	0.01	-	-	-	-	-
Flagellates	0.1	0.01	-	-	-	-	-	-	-	-	-	-
Algae	+											
Trichodesmium	0.05	0.18	-	0.24	0.12	-	-	-	-	-	-	-
UNIDENTIFIED MASS	36.68	45.09	46.85	45.49	70.71	23.80	34.74	70.95	73.83	62.87	41.16	15.84

\+ Minute trace

(v) Feeding in relation to fauna

Surface plankton samples were obtained from Lagos Coast at the locations where the fish specimens were collected. The plankton samples consisted of crustaceans, annelids, chaetognaths, molluscs, insects, phytoplankton, fish eggs, scales and fish larvae. A summary of the species encountered in the plankton hauls with an index of their relative abundance is given in Table 20.

A comparison of the food of the fish with the plankton samples showed that I. africana fed on the plankton available in its environment. The calanoids which were very abundant in the plankton sample formed a common food of the fish. Similarly, the lucifers and diatoms which were also abundant in the plankton were frequently encountered in the stomachs of the fish. Amphipods, caridean larvae, bruchyuran larvae, euphausiids and lamellibranchs were common in plankton samples and they were also commonly encountered in the stomachs of the fishes. Zooplankton such as harpacticoids, ostracods, polychaete larvae, chaetognaths, and gastropod larvae occurred only occasionally in plankton samples. These zooplankton were only sparingly encountered in the diet of I. africana. Phytoplankton such as flagellates and Trichodesmium sp were of occasional occurrence in the plankton samples as well as the food of the fish. Similarly, insects were only incidental in the plankton sample as well as stomach content of I. africana. Though shrimps, fish and fish larvae formed major food items in I. africana, they were only encountered occasionally in the plankton samples. Fish eggs were occasionally encountered in plankton samples and in the diet of the fish while fish scales were commonly encountered.

Table 20. Plankton encountered off Lagos Coast

Plankton	Index of abundance
Calanoids	Very abundant
Diatoms	Abundant
Lucifer	Abundant
Amphipoda	Common
Cyclopoida	Common
Cladocera	Common
Caridean larvae	Common
Brachyuran larvae	Common
Fish scales	Common
Euphausiids	Common
Lamellibranchs	Common
Harpacticoida	Occasional
Ostracoda	Occasional
Fish eggs	Occasional
Polychaete larvae	Occasional
Chaetognatha	Occasional
Flagellate	Occasional
Trichodesmium sp	Occasional
Echinoderm larvae	Occasional
Fish larvae	Occasional
Shrimps	Occasional
Gastropod larvae	Occasional
Insecta	Occasional

(vi) Feeding in relation to other species

The feeding habits of Brachydeuterus auritus (Val), Vomer setapinnis (Mitchill) and Galeoides decadactylus (Bloch) which were abundant species caught along with I. africana, were examined to determine the similarities and differences in their diets. Similarly, the stomach contents of Sardinella eba (C.V), a clupeid occuring together with I. africana were also examined. All the specimens used in this study were caught in December 1978.

The crustaceans, molluscs and fishes formed the major food of I. africana and S. eba. The former however fed on some food items which did not appear in the diet of S. eba. These included shrimps, nematodes, crustacean larvae, insects, mysids, cyclopoida, harpacticoida, lucifer, nereid larvae, polychaete larvae and Trichodesmium sp. Among the crustaceans, the calanoids served as the favourite food item of the two fish species. In the stomach of I. africana, this food item had an occurrence of 64.9% and 58.8% by number. In S. eba, it constituted 79.6% by number and occurred in 50% of the stomachs.

The food of B. auritus consisted of diatoms, crustaceans, fishes and insects with the crustaceans and fishes forming the major food items. Fish contributed 28.6% by occurrence and 25% by number to the diet of B. auritus while the crustaceans constituted 57.1% by occurrence and 69.4% by number. The calanoids contributed 30.1% by number and occurred in 21.4% of the stomachs. The diatoms accounted for 16.6% by number and 7.1% by occurrence.

The food of V. setapinnis were crustaceans, fishes and nematodes while G. decadactylus fed on crustaceans, fishes and molluscs. In V. setapinnis the crustaceans made up 42.8% of the fish food by occurrence and 76.8% by number, while in G. decadactylus, they were found in all fish examined and they contributed 85.1% of the fish food. In V. setapinnis the fishes had an occurrence of 42.9% and made up 5.4% of the food items by number. In G. decadactylus, they had an occurrence of 33.3% and made up 7.4% of the total food. Thus, crustaceans and fishes were important and common food items to all the fishes examined.

Though, the calanoids formed the most important crustacean in the diets of all the fishes, there were other crustaceans or other food items which were characteristic of diets of one or more fishes. Mantis shrimp and diatoms were peculiar in the diet of B. auritus alone while foraminifera and lobsters were found only in the food of G. decadactylus. Nematodes and amphipods were found in only V. setapinnis and I. africana while gastropods were found only in Sardinella and Ilisha. Cyclopoida, harpacticoida, mysids, anomuran larvae, pagurid larvae, lucifer, nereid larvae, polychaete larvae and Trichodesmium sp were only found in the diet of I. africana. Also, insects, penaeid larvae and caridean larvae were found only in the diets of B. auritus and I. africana while the shrimps formed an important and common food of B. auritus, G. decadactylus and I. africana, having an occurrence of 7.1%, 100.0% and 20.1% respectively and the respective percentage by number being 25.0%, 74.1% and 1.3%. Table 21 summarises the food and feeding relationships of B. auritus, V. setapinnis, G. decadactylus, Sardinella and I. africana

(vii) Food habits of I. africana from off Benin River

The stomach of 68 I. africana caught off Benin River were analysed for feeding habits to compare these with the food of I. africana caught off Lagos Coast.

I. africana caught off Benin River fed on crustaceans, fish and

Table 21. Food and feeding relationships of B. auritus (Val), V. setapinnis (Mitchill), G. decadactylus (Bloch), S. madarensis and I. africana caught off Lagos Coast

Fish species	B. auritus		V. setapinnis		G. decadactylus		S. madarensis		I. africana	
Analysis	O	N	O	N	O	N	O	N	O	N
Calanoid	21.43	33.33	28.57	73.21	-	-	50.0	79.58	64.9	58.51
Amphipoda	-	-	14.29	3.57	-	-	50.0	14.08	49.4	30.10
Isopoda	-	-	-	-	-	-	25.0	0.70	0.70	0.03
Shrimps	7.14	25.0	-	-	100	74.07	-	-	20.1	1.26
Brachyuran larvae	7.14	2.78	-	-	33.33	11.11	25.0	3.52	16.8	1.42
Mantis shrimp	7.14	2.78	-	-	-	-	-	-	-	-
Penaeid larvae	7.14	2.78	-	-	-	-	-	-	0.7	0.03
Caridean larvae	7.14	2.78	-	-	-	-	-	-	8.4	0.43
Cyclopoida	-	-	-	-	-	-	-	-	9.1	0.67
Harpacticoida	-	-	-	-	-	-	-	-	1.9	0.08
Mysidacea	-	-	-	-	-	-	-	-	3.2	0.16
Anomuran larvae	-	-	-	-	-	-	-	-	3.2	0.13
Pagurid larvae	-	-	-	-	-	-	-	-	10.4	0.75
Lucifer	-	-	-	-	-	-	-	-	1.3	0.05
Fish	28.57	25.0	42.86	5.36	33.33	7.41	25.0	0.70	17.5	1.02
Fish scales	-	-	28.57	16.07	-	-	-	-	13.6	2.05
Nematodes	-	-	14.29	3.57	-	-	-	-	12.3	0.59
Gastropoda	-	-	-	-	-	-	50.0	1.41	24.0	1.43
Lobster	-	-	-	-	16.67	3.7	-	-	-	-
Foraminifera	-	-	-	-	16.67	3.7	-	-	-	-
Diatoms	7.14	16.6	-	-	-	-	-	-	-	-

(Contd.)

Table 21 (Contd.)

Fish species	B. auritus		V. setapinnis		G. decadactylus		S. maderensis		I. africana	
Analysis	O	N	O	N	O	N	O	N	O	N
Trichodesmium	-	-	-	-	-	-	-	-	3.9	0.65
Nereid larvae	-	-	-	-	-	-	-	-	1.3	0.05
Polychaete larvae	-	-	-	-	-	-	-	-	1.9	0.08
Insecta	1.2	3.2	-	-	-	-	-	-	1.3	0.02
Unidentified mass	64.29	-	71.4	-	-	-	50.0	-	61.0	-

fish larvae, fish scales, molluscs and nematodes. A summary of the food organisms is presented in Table 22. The crustaceans were the most important food item. By number, they constituted 59% and 19.0% by volume of the fish food. The fish, fish larvae and fish scales were next in importance constituting 37.7% of the food by number and 11.8% by volume. The nematodes occurred in 8.6% of the stomachs and they constituted 2.5% of the stomach contents by number and 0.6% by volume while the molluscs occurred in 2.9% of the stomachs and constituted 0.8% of the food by number and 0.1% by volume. By occurrence and volume the shrimps were the most important crustacean occurring in 14.3% of the stomachs and constituting 9.8% of the food by volume. However, crustacean larvae, though they had an occurrence of 8.6% and constituted only 4.4% of the food of the fish by volume, by number, they constituted 26.2%. Crustacean appendages occurred in 8.6% of the stomachs, constituted 10.7% of the food by number and 3.0% by volume. Mysids had an occurrence of 5.7% and by number and volume, they contributed 2.5% and 1.3% respectively. The amphipods had an occurrence of 2.9% and by volume and number, they contributed 0.03% and 2.5% of the fish food respectively. The mantis shrimps occurred in 2.9% of the stomachs and constituted 0.8% of the fish food by number and 0.6% by volume. The fish, fish larvae and fish scales had an occurrence of 2.9%, 5.7% and 22.9% respectively. By number, they contributed 0.8%, 5.7% and 31.2% respectively to the food of *I. africana* while their contributions by volume were 2.5%, 2.2% and 7.1% respectively.

(viii) Food of *I. africana* from off Brass River

The food of 50 *I. africana* caught off Brass River consisted of

Table 22. Summary of the food of *I. africana* caught off Benin River

Food items	Occurrence (%)	Number (%)	Volume (%)
CRUSTACEA			
Shrimps	14.29	16.59	9.84
Crustacean larvae	8.57	26.23	4.37
Crustacean appendages	8.57	10.66	2.96
Amphipods	2.86	2.46	0.03
Mysids	5.72	2.46	1.27
Mantis shrimp	2.86	0.82	0.56
PISCES			
Fish	2.86	0.82	2.54
Fish larvae	5.72	5.74	2.23
Fish scales	22.86	31.15	7.07
MOLLUSCA			
Prosobranchs	2.86	0.82	0.14
NEMATODA			
Nematodes	8.57	2.46	0.62
UNIDENTIFIED MASS	82.86	-	68.38

crustacea, fish larvae, fish scales, fish eggs, molluscs and nematodes. However, the crustaceans were the most important group of food constituting 55.23% by number and 29.6% of the food by volume. The fish, fish larvae, fish scales and fish eggs were next in importance contributing 38.81% by number and 22.5% by volume. The molluscs which were represented by Sepia sp occurred in 6.1% of the stomachs and by number and volume, contributed 3.0% and 4.2% respectively. The nematodes similarly had an occurrence of 6.1% and contributed 3.0% by number but by volume they made up only 0.4% of the stomach contents. The shrimps were the most important crustacean, with an occurrence of 36.4% and constituting 17.9% and 70.4% by number and volume respectively of the food of the fish. The fish and fish larvae were also very important food items of I. africana. They had an occurrence of 33.3% and 30.3% respectively, constituted 16.4% and 14.9% by number of the fish food respectively while by volume they contributed 15.2% and 6.4% respectively. Fish eggs were relatively unimportant in the diet of I. africana occurring in only 3.0% of the stomachs and constituting 0.01% and 1.5% of the fish food by volume and number respectively. Similarly, calanoids and amphipods contributed 0.13% and 0.12% respectively by volume of the fish food and respectively occurred in 9.1% and 3.0% of the stomachs. Though euphausiids contributed only 1.7% by volume of food of the species, by number, they constituted 14.9% and occurred in 30.3% of the stomachs. The mantis shrimps with an occurrence of 3.0% constituted 1.5% and 0.2% by number and volume of the food. Table 23 is a summary of the food of I. africana caught off Brass River.

(ix) Food of I. africana caught off Bonny River

The food of I. africana caught off Bonny River consisted of

Table 23. Summary of the food of *I. africana* caught off Brass River

Food items	Occurrence (%)	Number (%)	Volume (%)
CRUSTACEA			
Shrimp	36.36	17.91	20.41
Crustacean appendages	18.18	8.96	4.23
Crustacean larvae	12.12	5.97	2.84
Calanoida	9.09	4.48	0.13
Euphausiids	30.30	14.93	1.67
Amphipods	3.03	1.49	0.12
Mantis shrimp	3.03	1.49	0.20
PISCES			
Fish	33.33	16.42	15.22
Fish larvae	30.30	14.93	6.41
Fish scales	12.12	5.97	0.86
Fish eggs	3.03	1.49	0.01
MOLLUSCA			
Sepia sp	6.06	2.99	4.20
NEMATODA			
Nematodes	6.06	2.99	0.41
UNIDENTIFIED MASS	84.84	-	43.30

crustaceans, fish larvae and nematodes. The shrimps had an occurrence of 63.6% while crustacean larvae had an occurrence of 24.2% and fish larvae and nematodes each had an occurrence of 3.0%. By number, the shrimps constituted 75.9% and 48.7% by volume. The crustacean larvae constituted 22.2% by number and 16.1% by volume. Fish larvae and nematodes each contributed 0.9% by number to the food of the fish while by volume they contributed 1% and 0.01% respectively. The food of I. africana caught off Bonny River are summarised in Table 24.

Table 24. Summary of the food of *I. africana* caught off Bonny River

Food items	Occurrence (%)	Number (%)	Volume (%)
CRUSTACEA			
Shrimp	63.64	75.93	48.70
Crustacean larvae	24.24	22.22	16.10
PISCES			
Fish larvae	3.03	0.93	0.99
NEMATODA			
Nematodes	3.03	0.93	0.01
UNIDENTIFIED MASS	33.0	-	34.20

5. REPRODUCTION

(i) Gonad anatomy and maturity classification

The gonads of both sexes of *I. africana* consisted of two unequally sized lobes, together opening posteriously into a common tube. Examination of eggs from both lobes of the ovaries showed that eggs mature in both lobes at the same time.

Five macroscapic stages of development were observed in the testes and ovaries. The first four stages were similar to those described by Sturm (1978) for *S. maculatus*. The second stage of maturation which was described as Immature developing by Sturm is referred to as ripening stage in this study. The gonad maturation stages for both the testes and ovaries were classified as immature, ripening, ripe, ripe running and spent stages. Sturm did not observe the fifth stage (spent stage) in his study. The classification for the male gonad was as follows:

a) Immature stage

The gonad was very small and a microscopic view was necessary to establish the sex. Fish size was less than 12.0cm and gonad weight was usually less than 0.15g or about 0.1% of the body weight. The gonads appeared as whitish, thin transparent filaments. Histological appearance of the gonad showed that only spermatogonia were present. These spermatogonia were few and scattered. The testicular wall was 7 - 8 Um thick. Plate 2 shows a section through an immature male gonad.

b) Ripening stage

The fish was normally over 12.0cm. The gonad weight was over 0.15g. The gonad was whitish or light pink and was more easily recognisable as male reproductive organ. From histological sections, two stages could be identified during the ripening stage of the gonad. These were the developing immature and resting mature stages termed ripening 1 stage and the ripening 2 stage respectively. In the ripening 1 stage, the periphery of the testis consisted of nests of larger spermatogonia while the bulk of the testis was made up of smaller spermatogonia. The ripening 1 stage is shown in Plate 3.

Plate 2 Section through an immature gonad of male *I. africana*

t.w. thin testicular wall

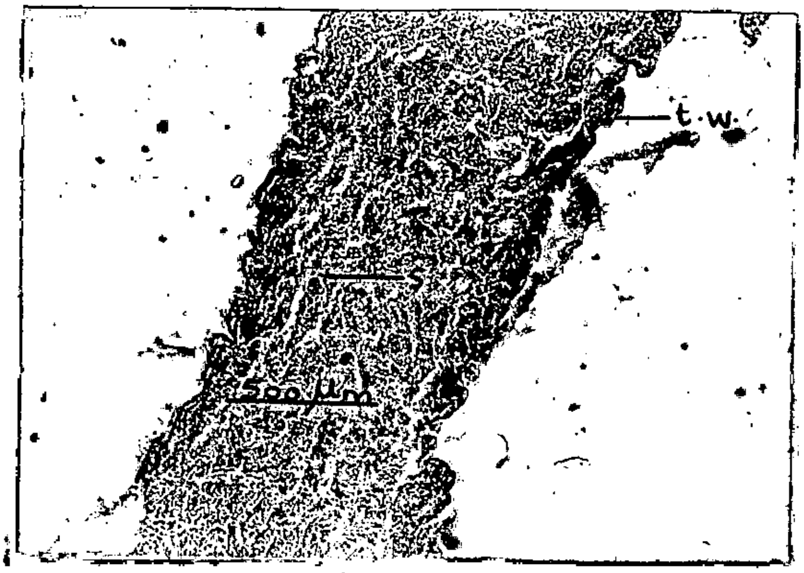
s. spermatogonium

Plate 3 Section through a testis of *I. africana* in the ripening 1 stage

s.s. smaller spermatogonia

l.s. larger spermatogonium

PLATE 2



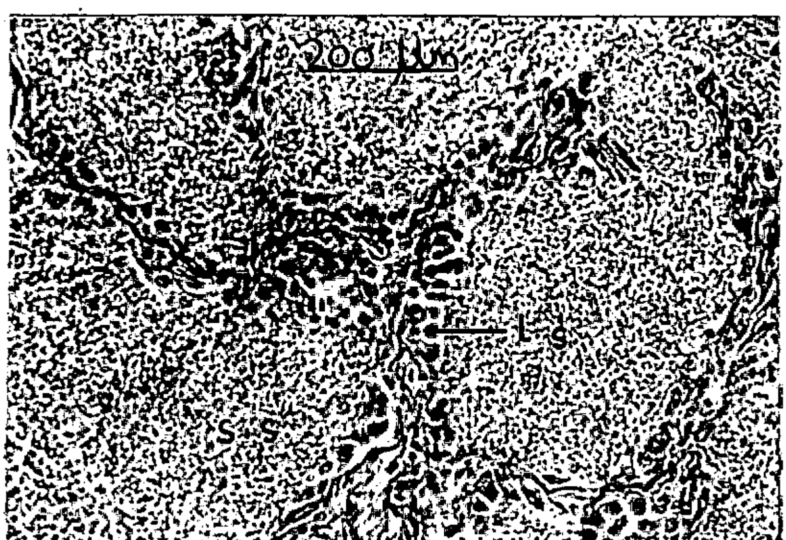
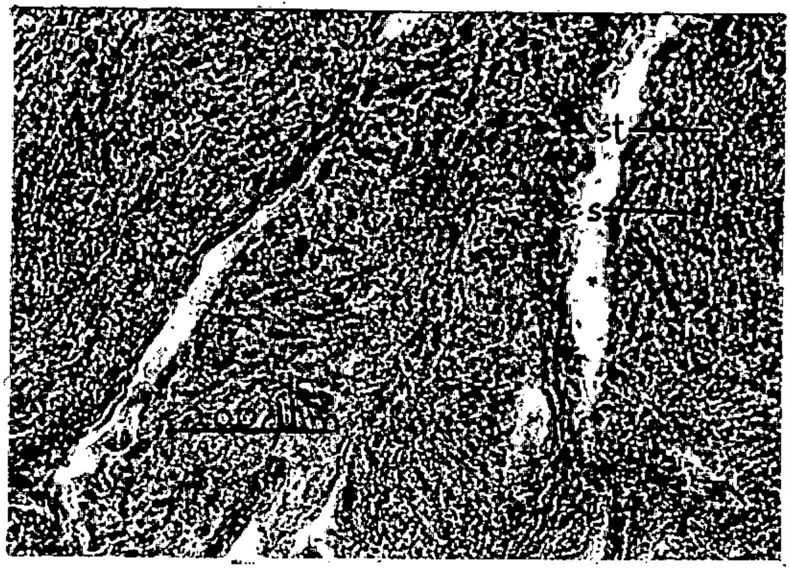


PLATE 3

PLATE 4



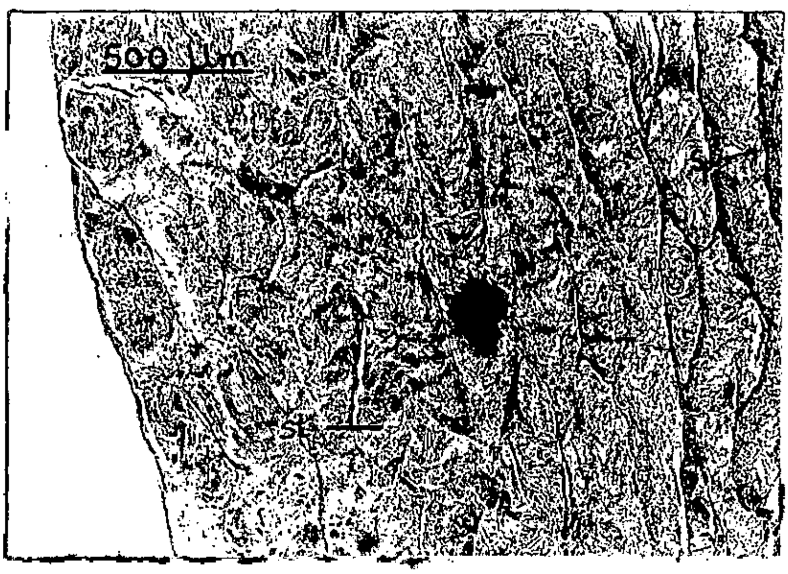


PLATE 5

Plate 1 Section through a testis of *I. africana* in the ripening 2 stage

sec. s.	secondary spermatocyte
st.	spermatid.

Plate 2 Section through a ripe testis of *I. africana*

st.	spermatid
sp.	spermatozoa

In the ripening 2 stage of the male gonad of I. africana, secondary spermatocytes (stage III cells) and spermatids (cup-shaped stage IV cells) predominated. A few spermatozoa were present but these were attached to lobular walls. Thickness of the testicular wall was 11 - 15 Um. Plate 4 is a section through a male gonad in ripening 2 stage.

c) Ripe stage

The testes were large, full, swollen and soft. The gonad was often up to 3% of the fish body weight. The colour was pink or light red. Histological sections showed that testicular lumen contained mainly unattached active spermatozoa which gave a wavy appearance. A few spermatids were also present. The testicular wall was 5 - 8 µm. Plate 5 shows a section through a ripe testis.

d) Ripe running stage

The testes were similar to those of ripe testis but with slight pressure on the flanks of the fish, milt ran out of the genital pore. Plate 6 shows a section through a ripe running testis. Some empty spaces could be seen due to loss of some milt. The content of the testis in the ripe running stage were mainly spermatozoa which gave a wavy appearance in histological sections.

e) Spent stage

The testes were flabby and pink, reddish or brown due to vascularisation. The vas deferens was usually empty but some milt may still be contained within. A histological section through the spent testis showed that the latter was unfilled. A few inactive spermatozoa were present. The periphery of the testis was lined with spermatozoa and the testicular wall thickness was 15 - 55 µm. Plate 7 is a section through a spent testis.

The maturity classification for the female gonad was as follows:

a) Immature stage

The gonad was very small and a microscopic view was usually necessary to establish the sex. When eggs could be seen with unaided eyes, they were very small. Fish was less than 12.0cm. Gonad weight was usually less than 0.2g or about 0.1% of the body weight. In the histological section through the gonad, oocytes within were found to be mainly oogonia and primary oocytes. The oocytes had no vacuoles and the maximum diameters ranged from 90 - 100 μm (mean 92.4 μm). The ovarian wall was about 10 μm thick. The oocytes were usually oblong in histological sections and they were scattered. A section through an immature female gonad of I. africana is shown in Plate 8.

b) Ripening stage

The fish were usually over 12.0cm. The eggs were visible to the naked eyes though they were minute. The gonad was yellowish. Two histologically distinct stages were observed among fish in the ripening stage. These were designated as ripening 1 and ripening 2 stages. In the ripening 1 stage, the oocytes were mostly in stage II (primary oocytes) but a few stage III oocytes (primary vitellogenic oocytes) which had vacuoles were present. Oocyte diameter was about 300 μm and the ovarian wall had a mean thickness of 18.5 μm.

In the ripening 2 stage of gonad development, the oocytes were mainly stage III oocytes but some stage IV oocytes (secondary vitellogenesis) with yolk droplets and a few stage V (with yolk globules) were present. Some oocyte diameters were up to 460 μm while the ovarian wall thickness was about 90 μm. Plate 10 shows a section through an ovary in the ripening 2 stage of development. The observed changes in ovarian wall thickness with maturity is perhaps due to hormonal changes.

Plate 6 Section through a ripe running testis of *I. africana*

sp. spermatozoa

e.s. empty space.

Plate 7 Section through a spent testis of *I. africana*

e.s. empty space

sp. spermatozoa.

PLATE 6

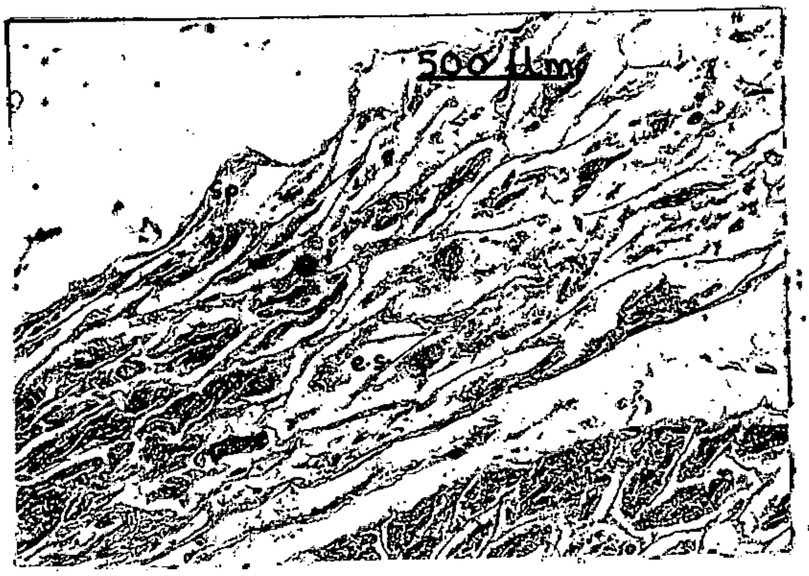


PLATE 7

PLATE 8

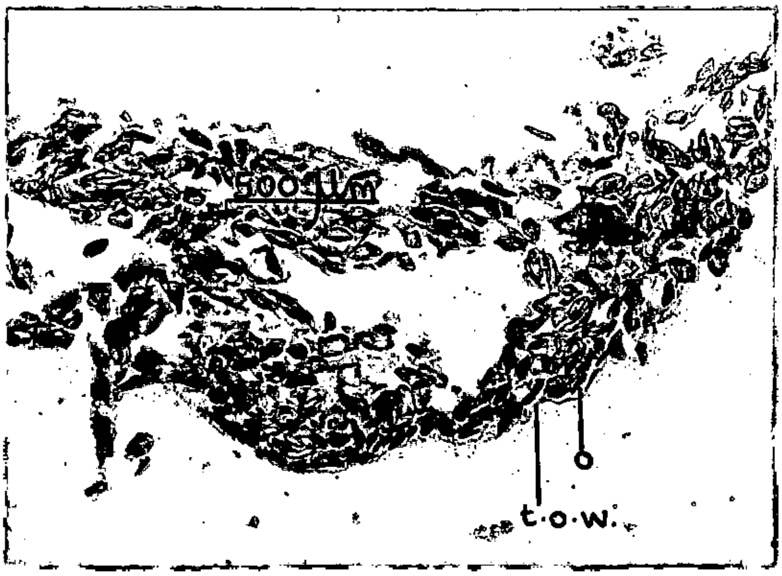


PLATE 9

Plate 8 Section through an immature ovary of *I. africana*

t.o.w. thin ovarian wall

o. oogonium

Plate 9 Section through an ovary of *I. africana* in the ripening 1 stage

o. oogonium

p.o. primary oocyte

p.v. primary vitellogenic oocyte

Plate 10 Section through an ovary of *I. africana* in the ripening 2 stage

z.r. zona radiata

p.v. primary vitellogenic oocyte

s.v. secondary vitellogenic oocyte

t.v. tertiary vitellogenic oocyte

Plate 11 Section through an ovary of *I. africana* in the ripe stage

t.v. tertiary vitellogenic oocyte

h.o. hyaline

c.a. corpora atretica

PLATE 10

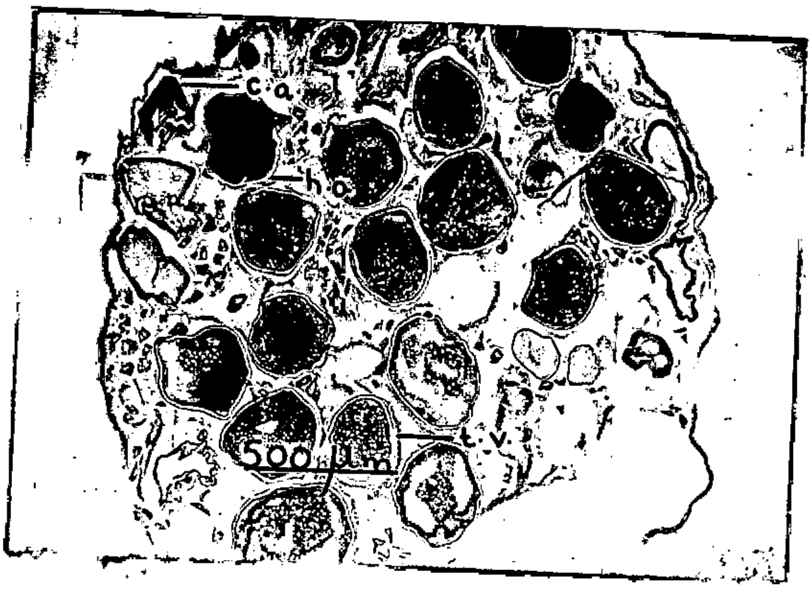


PLATE 11

PLATE 12

PLATE 13

Plate 12 Section through an ovary of *I. africana* in the ripe running stage

t.o.w.	thin ovarian wall
h.o.	hyaline oocyte
r.e.m.	ruptured egg membrane
e.s.	empty space

Plate 13 Section through a spent ovary of *I. africana*

o.	oogonium
p.o.	primary oocyte
e.s.	empty space
th.o.w.	thick ovarian wall

c) Ripe stage

The ovary was full and swollen. Most of the eggs were transparent while a few were transluscent giving a speckled appearance. The gonad weight was about 10% of fish weight. The gonad was usually red due to heavy blood supply. Histological section through the ovary showed that the oocytes were stage V and hyaline oocytes predominately. The oocyte diameter was up to 480 μm while the thickness of the ovarian wall ranged from 20 - 30 μm. The hyaline oocytes were irregularly shaped due to histological distortions. Plate 11 is a section through a ripe ovary.

d) Ripe running stage

The ovaries were similar to those of the ripe fish but eggs were easily extruded from the vent when slight pressure was applied to the flanks of the fish. Histologically, sections through the ovaries were also similar to those of the ripe ovaries, but hyaline oocytes were in the lumen of the ovaries in the ripe running stage. The ovarian wall was also thinner and empty spaces were seen in the ovarian section. Plate 12 is a section through an ovary in the ripe running stage.

e) Spent stage

The ovaries were flaccid and partly or mostly empty. The gonad appeared red or brown due to vascularisation. Histological section showed that in the partly spent ovary, conspicuous empty spaces were present in the septa. A few hyaline oocytes remained and the ovarian wall thickness was 40 - 200 μm. In the fully spent ovary, oocytes of all stages of maturity were present but those of stages I and II predominated. Empty spaces were present and atretic follicles were also visible in some sections. Ovarian wall was thicker than in the partly spent stage. It was about 300 μm. Plate 13 is a section through a fully spent ovary of I. africana.

(iii) Monthly occurrence of gonad stages

Fishes in all stages of maturity were encountered in six months of the year. Ripe and ripe running female fishes were not encountered in November and December 1978, February, March, October and November 1979 while immature females were not in the sample for July 1979. Among the males, ripe and ripe running fish were not encountered in the sample of April and August 1979. Also, the monthly percentages of ripe and ripe running fish were relatively low in comparison with the percentages of the other maturity stages. Among the females, the percentages of the ripe/ripe running stage ranged from 0 - 22.2%, while those of the immature fish ranged from 0 - 37.9%, those of the ripening stage ranged from 42.9 - 89.1% and those of the spent fish ranged from 3.5 - 27.0%. Among the males the percentage of the ripe/ripe running fish ranged from 0 - 22.2% while those of immature fish ranged from 8.5 - 47.8%, those of the ripening fish ranged from 30.4 - 71.2% and those of the spent fish ranged from 2.4 - 26.0%. Table 25 shows the monthly occurrence percentages of fishes in the immature, ripening, ripe/ripe running and spent stages of maturity. Fishes in the ripening stage were the most frequently encountered in all the months of the year.

The monthly percentages contributed by female fishes in the ripe, ripe running and spent stages of maturity were relatively higher from July to November/December while in the male fish they were higher from November to February, April to July and September to December. In the female fish, the percentages ranged between 12.8% and 49.2% between July and December in comparison with a range of 3.5% - 14.8% between December and June. Among the male fish, the percentages of the ripe, ripe running and spent fish ranged between 19.8% and 29.6% from November -

Table 25 Monthly occurrence of different maturation stages in *I. africana* (in percentages)

Month		Female fish					Male fish				
		Number of fish	Immature	Ripening	Ripe/Ripe running	Spent	Number of fish	Immature	Ripening	Ripe/Ripe running	Spent
Nov.	1978	188	27.13	48.93	0	23.94	126	35.71	44.44	15.08	4.76
Dec.	"	82	32.93	60.98	0	6.10	69	47.83	30.43	7.25	14.49
Jan.	1979	107	10.28	83.18	2.80	3.74	80	28.75	50.00	5.00	16.25
Feb.	"	76	9.21	77.63	0	13.16	81	27.16	43.21	12.35	17.28
Mar.	"	58	37.93	58.62	0	3.45	67	55.22	35.82	1.49	7.46
Apr.	"	54	11.11	74.07	5.56	9.26	96	40.63	33.33	0	26.04
May	"	58	3.45	84.48	10.34	1.72	71	43.66	42.25	2.82	11.27
June	"	55	1.82	89.09	3.64	5.45	72	12.50	52.78	22.22	12.50
July	"	53	0	73.58	7.55	18.87	108	22.22	59.26	4.63	13.89
Aug.	"	58	12.07	74.14	6.90	6.90	42	50.00	47.62	0	2.38
Sept.	"	44	6.82	63.63	9.09	20.45	47	17.02	46.81	4.26	31.91
Oct.	"	63	7.94	77.78	0	14.29	59	8.47	71.19	8.47	11.86
Nov.	"	47	29.79	57.45	0	12.77	46	39.13	39.13	4.35	17.39
Dec.	"	63	7.94	42.86	22.22	26.98	59	20.34	52.54	8.47	18.64

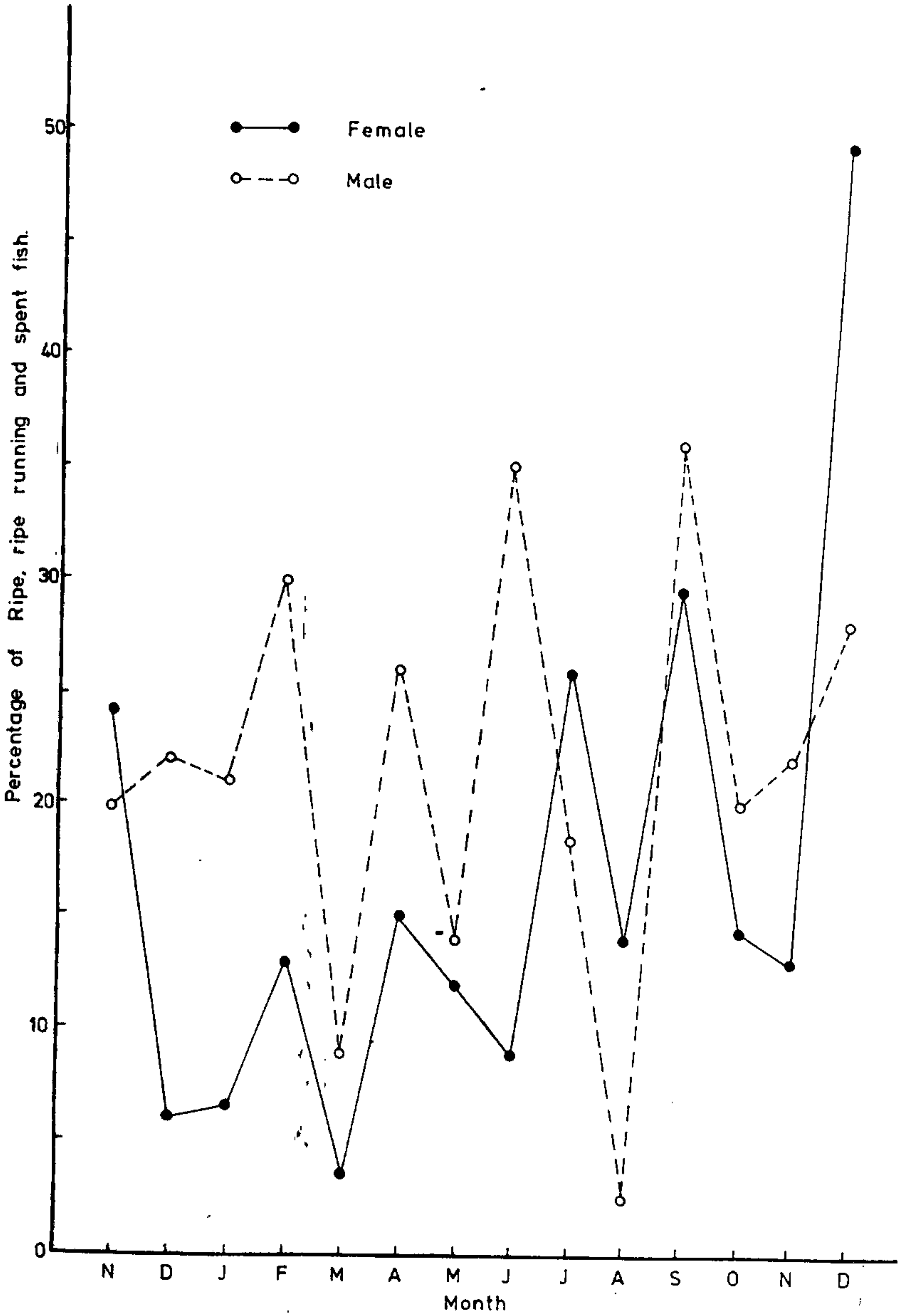


FIG. 31, Monthly variation in percentage of ripe, ripe running and spent I. africana.

February, 14.1 and 26.0 from April - July and 20.3 and 36.2% from September to December. In March, the percentage was 9.0% while in August it was 2.4%. The monthly variations in percentages of ripe, ripe running and spent fishes are illustrated in Figure 31.

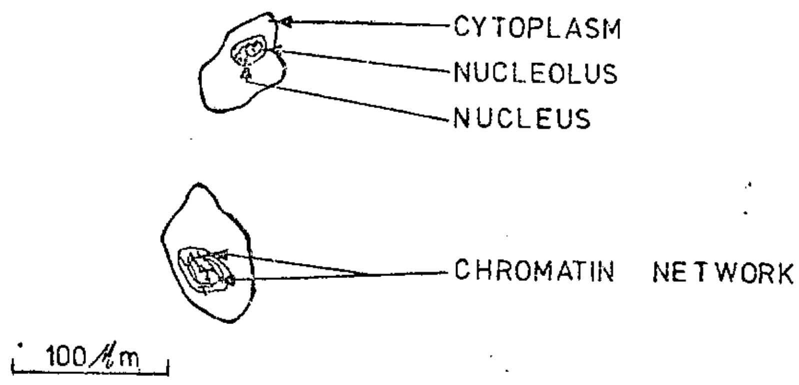
(iv) Development of the egg

Seven stages were found to be involved in oogenesis of *I. africana* namely oogonium, primary oocyte, primary vitellogenic oocyte, secondary vitellogenic oocyte, tertiary vitellogenic oocyte, hyaline oocyte and corpora atretica.

Oogonia (stage I)

These were small and spherical cells but many of them appeared oblong in histological sections. They occurred in small nests or singly. The nucleus possessed only one large nucleolus and a chromatin network.

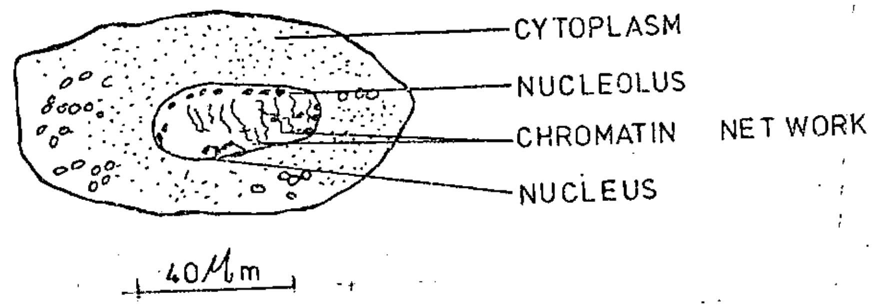
OOGONIA



Primary oocyte (stage II)

This was larger than the stage I cell. It had a large nucleus with many nucleoli around its periphery.

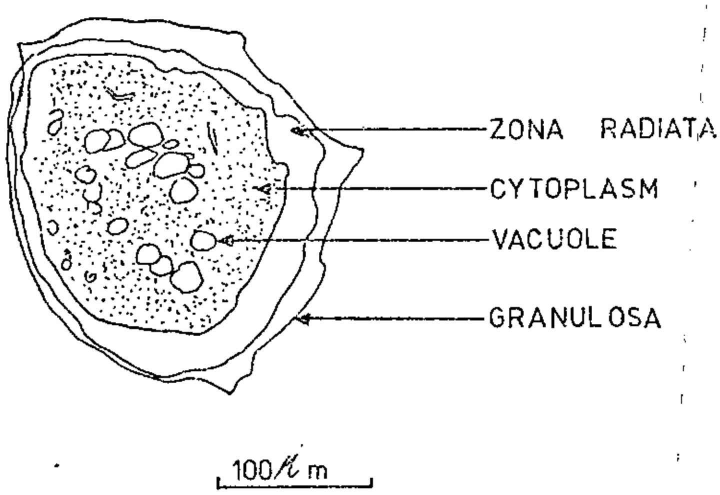
PRIMARY OOCYTE



Primary vitellogenic oocyte (stage III)

The cell contained a ring of vacuoles inside the cytoplasm just next to the cell membrane. Simultaneously, the zona radiata was formed between the cytoplasm and the granulosa. Stage III cells found in the post spawning and resting stages of development were irregularly shaped.

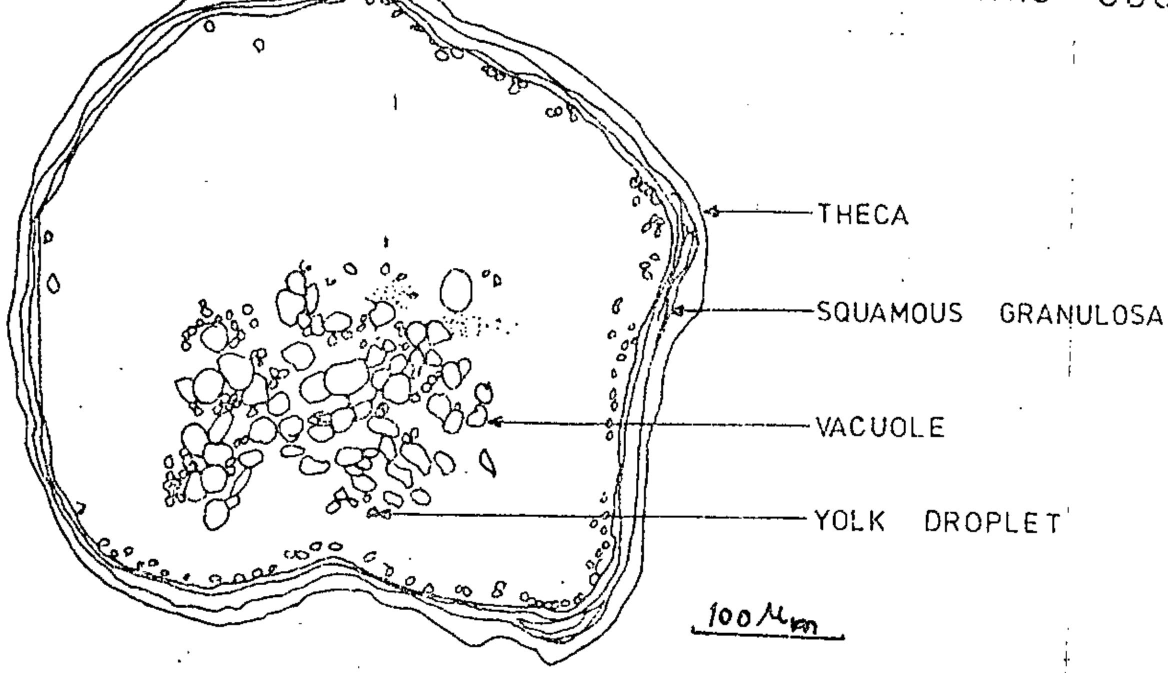
PRIMARY VITELLOGENIC OOCYTE



Secondary vitellogenic oocyte (stage IV)

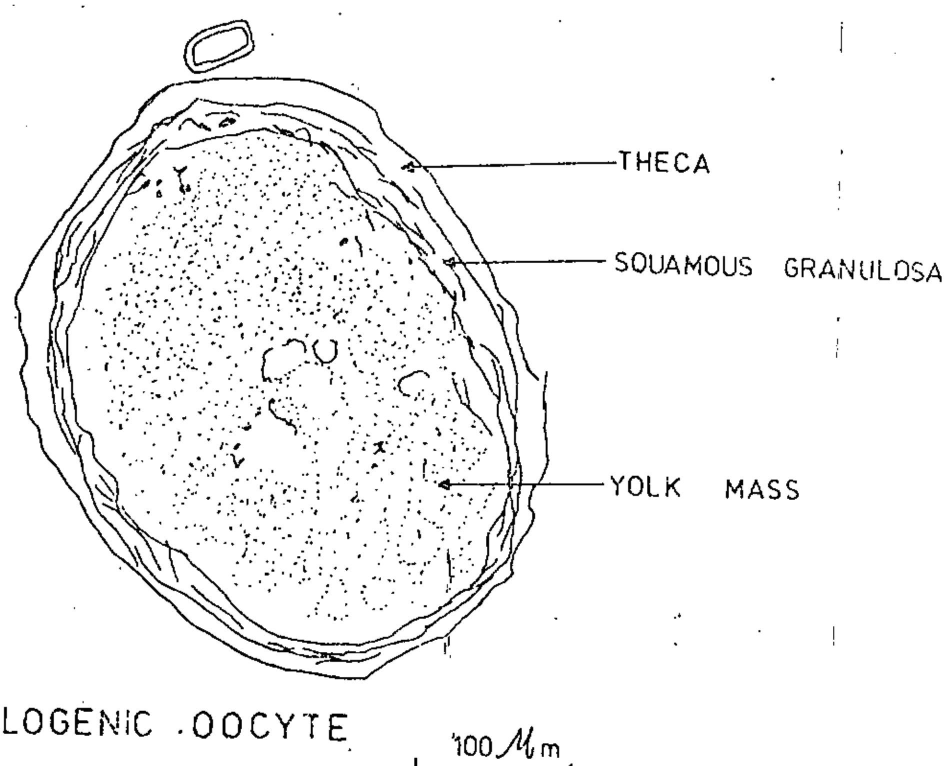
In the early stage, yolk droplets were associated with the ring of vacuoles which were formed in the stage III. These later formed yolk globules throughout the cytoplasm leaving a narrow zone at the periphery.

SECONDARY VITELLOGENIC OOCYT



Tertiary vitellogenic oocyte (stage V)

This contained yolk which were large, dark and were very prominent. The egg was enveloped by 2 layers, namely the squamous granulosa and the cellular theca.

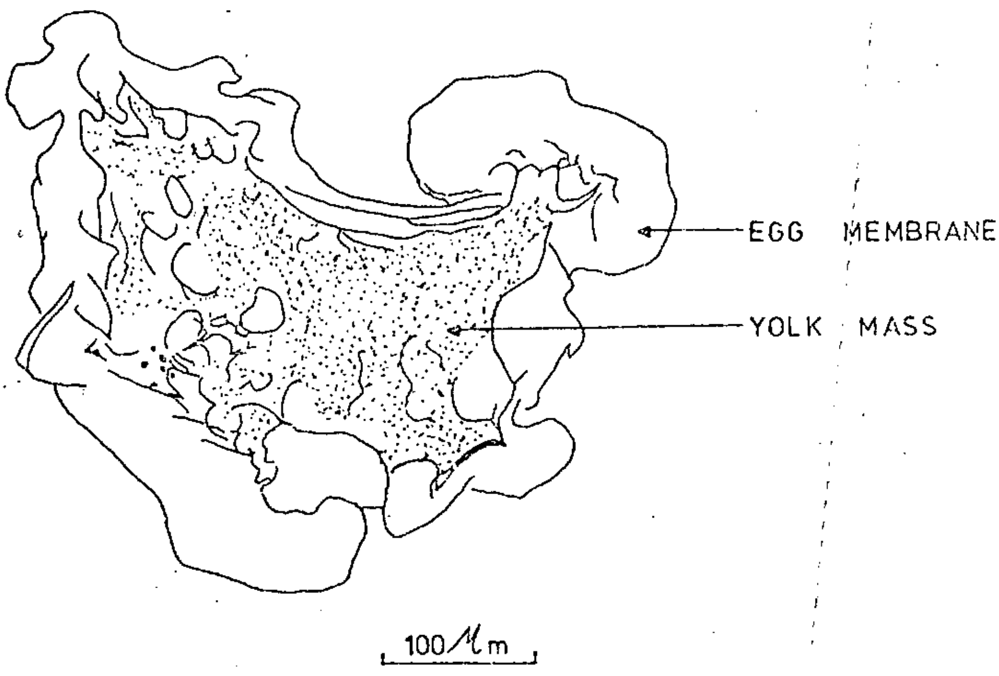


TERTIARY VITELLOGENIC OOCYTE

Hyaline oocyte (stage VI)

The egg became very enlarged. The yolk appeared as a homogenous dark mass filling the interior of the oocyte. The zona radiata became thinner due to the enlargement of the egg. The hyaline oocyte was often found to have collapsed in histological sections.

HYALINE OOCYTE



Corpora atretica (stage VII)

These developed either from vitellogenic cells or hyaline oocytes. These did not develop further but degenerated and became reabsorbed. Corpora atretica, thus were found in various stages of reabsorption.

CORPORA ATRETICA

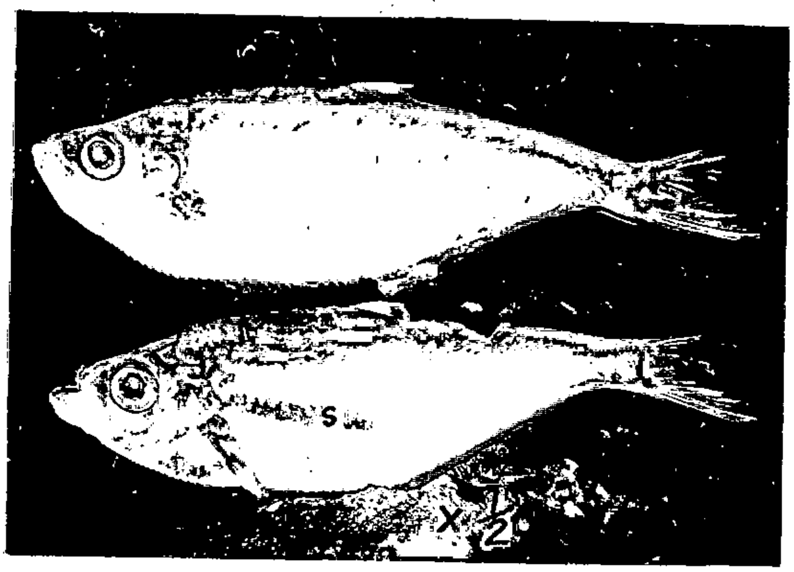
100 μm

(V) Breeding marks

In almost all the specimens of I. africana examined, dark patches occurred on the opercula of the fishes. However, in some of the fishes, these dark patches extended along either side of the trunk of the fish, towards the tail. Their intensity varied from fish to fish. It was found that rather than a taxonomic variation, these marks were related to breeding in the species. Plate 14 is a photograph of two fishes of the same size. The lower fish has a dark streak on its side while the upper one has no such streak.

The dark streaks were formed from the late ripening stage of development and became more intense as maturity progressed such that the fish in the ripe and spent stages had the most intense streaks. After the fish had become spent, the intensity of the streak gradually diminished until finally, the dark patches on the opercula were the only visible traces.

PLATE 14



S = Streak

(VI) Sex ratio:

On thousand, nine hundred and ninety (1,990) specimens of *I. africana* were examined out of which 1,011 were males while 979 were females giving an overall sex ratio of 1:097 males to females. The monthly variation in sex ratio was also examined. Table 26 shows the ratio of male to female *I. africana* from November 1978 to February 1980. In November 1978 and December 1978, the ratio of male to female *I. africana* were respectively 1:1.19 and 1:1.18 and in January 1979, the ratio was 1.1.76. In February, March, April, May June and July 1979, the respective ratios were 1.0.99, 1.0.89, 1.0.55 1:0.81, 1:0.50 while for August, September, October, November and December 1979, the ratios were 1:1.40, 1:1.19, 1:1.05 and 1:1.03 respectively. In February 1980, the ratio of male to female fish was 1:0.95.

The X2 was employed in testing whether the observed ratios of male to female significantly deviated from the expected 1:1 ratio. For the months of January, April and July 1979, the calculated X^2 were 11.60, 12.90 and 18.00 respectively. Tabulated x^2 at 5 percent level of significance and 1 degree of freedom =3.84. The data thus showed that the sex ratio observed for these months were significantly different from the expected 1:1 ratio. For the sex ratios for all the other months examined and the ratio of all the males to all females, the sex ratios were not significantly different from the expected ratio of 1:1. Table 26 shows the values of calculated X2.

(vii) Gonadosomatic index (GSI)

The gonadosomatic index is a percentage which defines a relationship between the gonad weight and the body weight. It is defined as

Table 26 Sex ratio in *I. africana* off Lagos Coast

Month/Year		Sample size	Male	Female	Ratio of male to female	X^2 on sex-ratio (calculated)
November	1978	320	146	174	1:1.19	2.45
December	"	148	68	80	1:1.18	0.97
January	1979	152	55	97	1:1.76	11.60*
February	"	158	82	76	1:0.93	0.22
March	"	126	67	59	1:0.89	0.50
April	"	150	97	53	1:0.55	12.90*
May	"	130	72	58	1:0.81	1.50
June	"	128	73	55	1:0.75	2.53
July	"	162	108	54	1:0.50	18.00*
August	"	101	42	59	1:1.40	2.86
September	"	75	37	38	1:1.03	0.01
October	"	105	48	57	1:1.19	0.77
November	"	76	37	39	1:1.05	0.05
December	"	122	60	62	1:1.03	0.03
February	1980	37	19	18	1:0.95	0.02
		1990	1011	979	1:0.97	0.51

Tabulated X^2 (5%, 1 df) = 3.84

* Significant at 5%, 1 df.

$$\frac{Gwt}{Twt - Gwt} \times 100$$

where Gwt = weight of the gonad

Twt = weight of the fish

The fish were divided into two size groups namely 3 - 15cm size group and the 16 - 28cm size group. The gonadosomatic index was calculated for each sex in the two size groups.

For the male fish, the values of the gonadosomatic index ranged from 0.29 - 1.06 for the 3 - 15cm size group and 0.67-1.31 for the 16 - 28cm size group. Details of the gonadosomatic indices for this species are presented in Table 27. The highest values of 1.06 and 1.31 were obtained for the respective size groups in November 1978 while the lowest value of 0.29 in the 3 - 15cm size group was obtained in August 1979 and the lowest value of 0.67 in the 16 - 28cm size group was obtained in September and October 1979. Except for March 1979, when the values of the gonadosomatic indices were 0.88 and 0.82 for the 3 - 15cm and 16 - 28cm size groups respectively, the gonadosomatic indices were greater in the larger size group.

For the female fish, values of the gonadosomatic indices ranged from 1.27 to 3.44 for the 3 - 15cm size group and 2.17 - 4.22 for the 16 - 28cm size group. The lowest values of gonadosomatic indices for the respective size groups were obtained in November 1979 and December 1978 respectively while the highest values were obtained in May 1979 and December 1979 respectively. The gonadosomatic indices were higher in the bigger size group of fishes than in the smaller size group for the same months except in April when a value of 2.36 was obtained for the 3 - 15 cm size group while 2.26 was obtained for the 16 - 28 cm size group

Table 27. Monthly Variation of gonadosomatic indices (GSI) of *I. africana*

Month	Males 3 - 15cm		Males 16 - 28cm		Females 3 - 15cm		Females 16 - 28cm	
	Number of fish	GSI	Number of fish	GSI	Number of fish	GSI	Number of fish	GSI
November 1978	88	1.06	48	1.31	68	1.40	67	2.60
December "	48	0.69	20	0.92	61	2.00	21	2.17
January 1979	34	0.79	45	1.22	27	2.08	77	2.80
February "	43	0.82	40	1.28	24	2.22	51	2.44
March "	52	0.88	15	0.82	38	1.42	20	2.20
April "	49	0.49	48	1.29	27	2.36	27	2.26
May "	45	0.72	26	0.89	13	4.44	44	3.73
June "	32	0.88	38	0.97	11	2.36	43	3.02
July "	54	0.76	50	0.89	18	2.65	36	3.22
August "	23	0.29	18	0.67	12	2.33	46	2.60
September "	16	0.61	31	0.67	8	1.29	35	3.69
October "	13	0.72	41	1.07	18	1.88	46	2.90
Nobember "	35	0.79	12	1.10	27	1.27	19	2.48
December "	18	0.74	41	1.14	13	2.22	50	4.22

For the same size group, the gonadasomatic indices were higher in the female fish in the male fish. In the 3 - 15cm. size group, the gonadosmatic indices ranged from 0.49 - 1.05 with a mean of 0.73 for the males while in the females, it ranged from 1.27 - 3.44 with a mean of 2.14. Similarly in the 16 - 28cm size group, the gonadosomatic indices in the males ranged from 0.67 - 1.31 with a mean of 1.02 while in the females it ranged from 2.17 - 4.22 with a mean of 2.68.

There was also variation by month within the came size category of each sex. This variation was noticeable in the larger size group and more conspicuously among the female fishes than the males. Among the males in the 16 - 28cm size group, the gonadosomatic index was 1.31 in November 1978 but 0.92 in December. In January and February 1979, the values were respectively 1.22 and 1.28. In March, it was reduced to 0.82 but rose to 1.29 in April. From May to September, the gonadosomatic indices ranged between 0.67 and 0.97 and in October, November and December 1979 the values were respectively 1.07, 1.10 and 1.14. Among the female fish, for the 16 - 28cm size group, the gonadosomatic indices were 2.60 and 2.17 in November and December 1978 respectively. In January it was 2.80 while in February, March and April, it was 2.44, 2.20 and 2.26 respectively. From May to July, it range between 3.02 and 3.73 while in August it was 2.6 and in September it was 3.69. In October and November it was 2.90 and 2.48 respectively and in December 1979, it was 4.22. Figure 32 illustrates monthly variation of the gonadosomatic indices in this species.

(viii) Size and age maturity

The smallest mature female fish had a total length of 11.7cm while the smallest mature male was 11.5cm in total length. The smallest ripe female fish encountered was 12.0cm while a male fish which had a

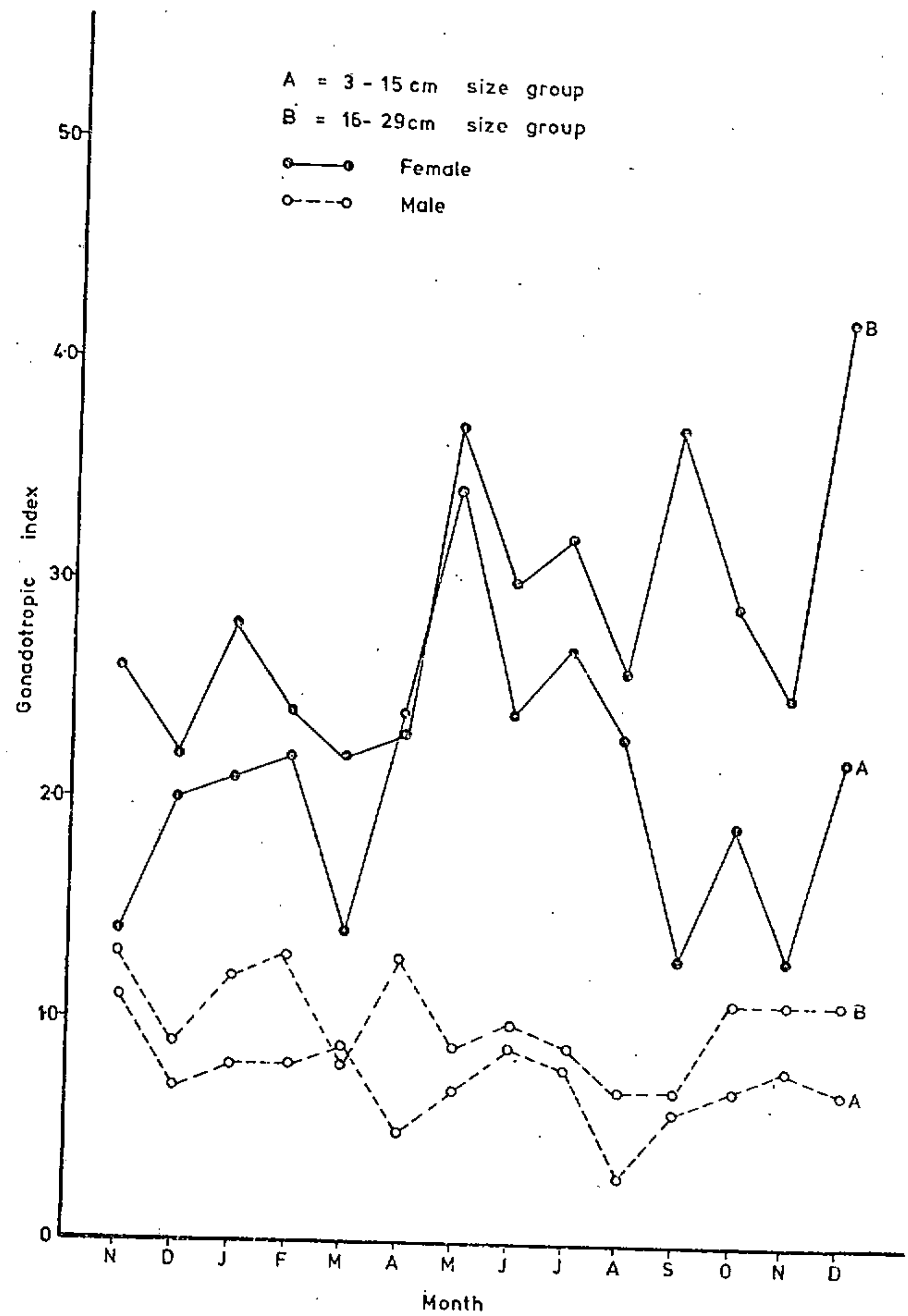


FIG. 32, Monthly variation of gonadosomatic index (GSI) in I. africana length of 13.5cm was found to be spent. Maturity was attained during the first year of life.

(ix) Fecundity

The fecundity was determined for 46 specimens from the Lagos Coastal area. For a size range of 14.0 - 25.4cm (total length) the fecundity ranged from 2,029 - 11,687 with a mean of 5,227 for an average fish size of 18.0cm.

Fecundity was examined in relation to length. There was an increase in fecundity with increasing fish length. Figure 33 is a scatter diagram showing the relationship between fecundity and fish length.

The relationship between fecundity and fish length was expressed using the equation:

$$F = aL^{b}$$

where F = fecundity (thousands)

L = fish length (cm)

a and b are constants

In logarithm form, this equation can be written as:

$$\log F = \log a + b \log L$$

The relationship between log F and log L was a straight line relationship as shown in Figure 34. The values of a and b were calculated to be ○ 0.349 and 3.291 respectively with a correlation coefficient of 0.904. Substituting for a and b in the equation above,

$$F = ○\,0.349L^{3.291}$$

The relationship between fecundity and fish weight was similarly expressed by the equation

$$F = aW^{b}$$

where F = fecundity (thousands)

W = fish weight (g)

a and b = constants

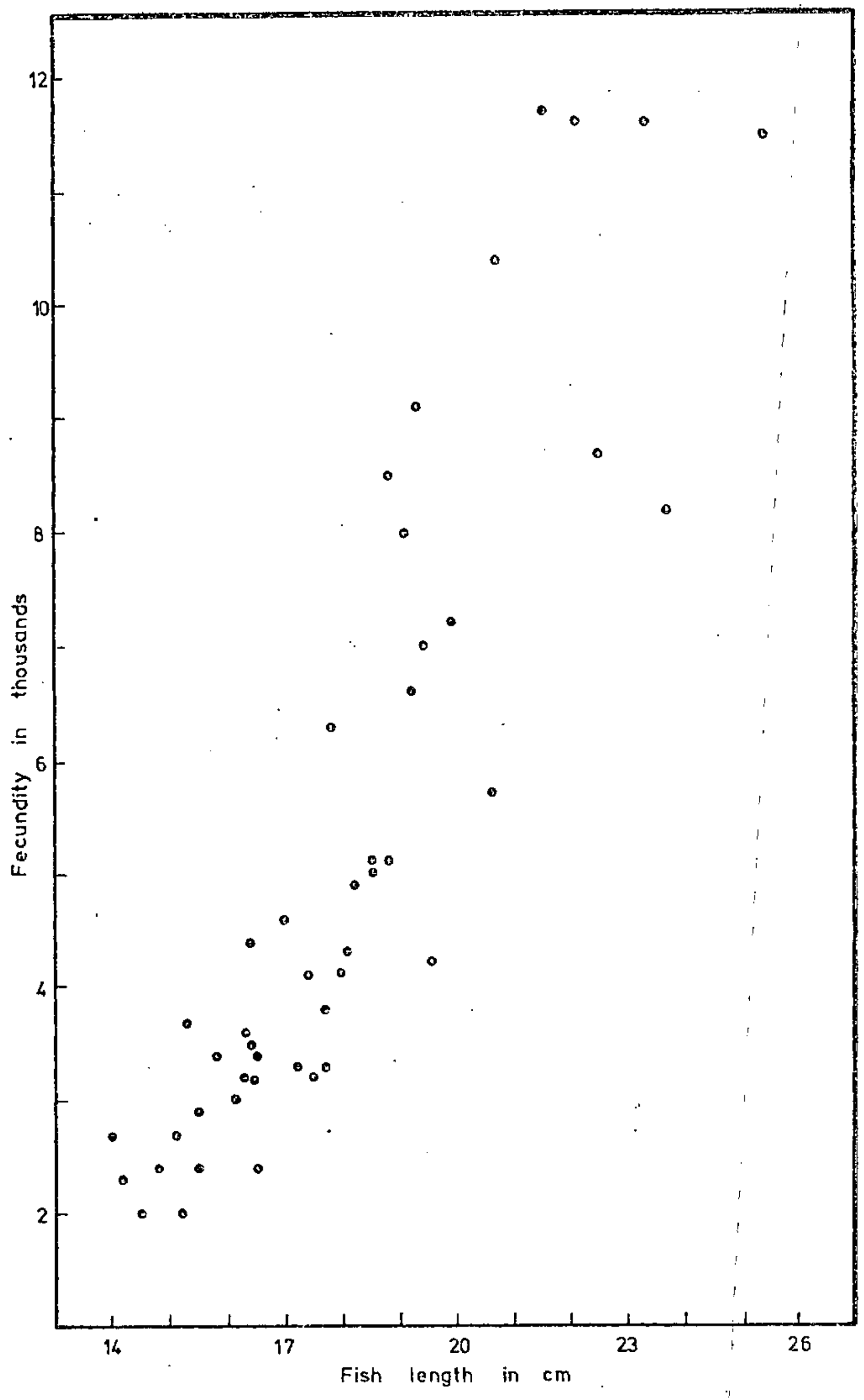


FIG. 33, Relationship between fecundity and length in *I. africana.*

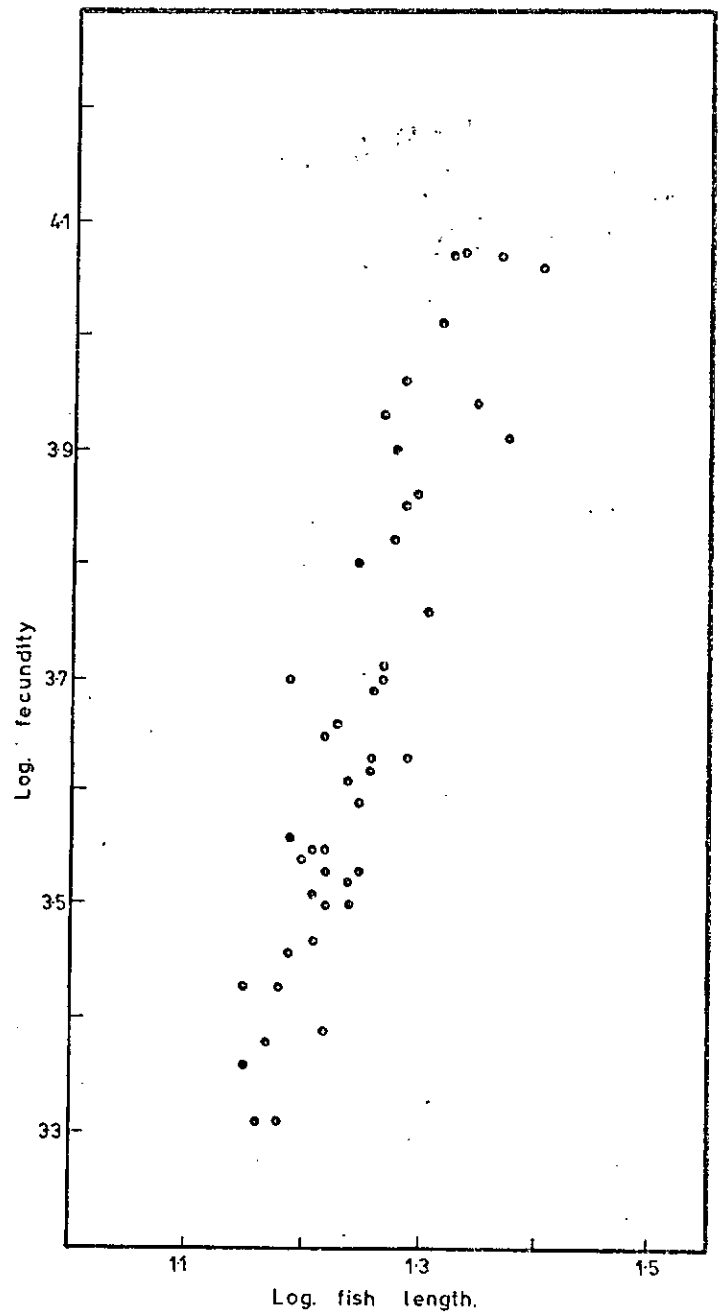


FIG. 34, Relationship between log. fecundity and log. fish length in _I. africana._

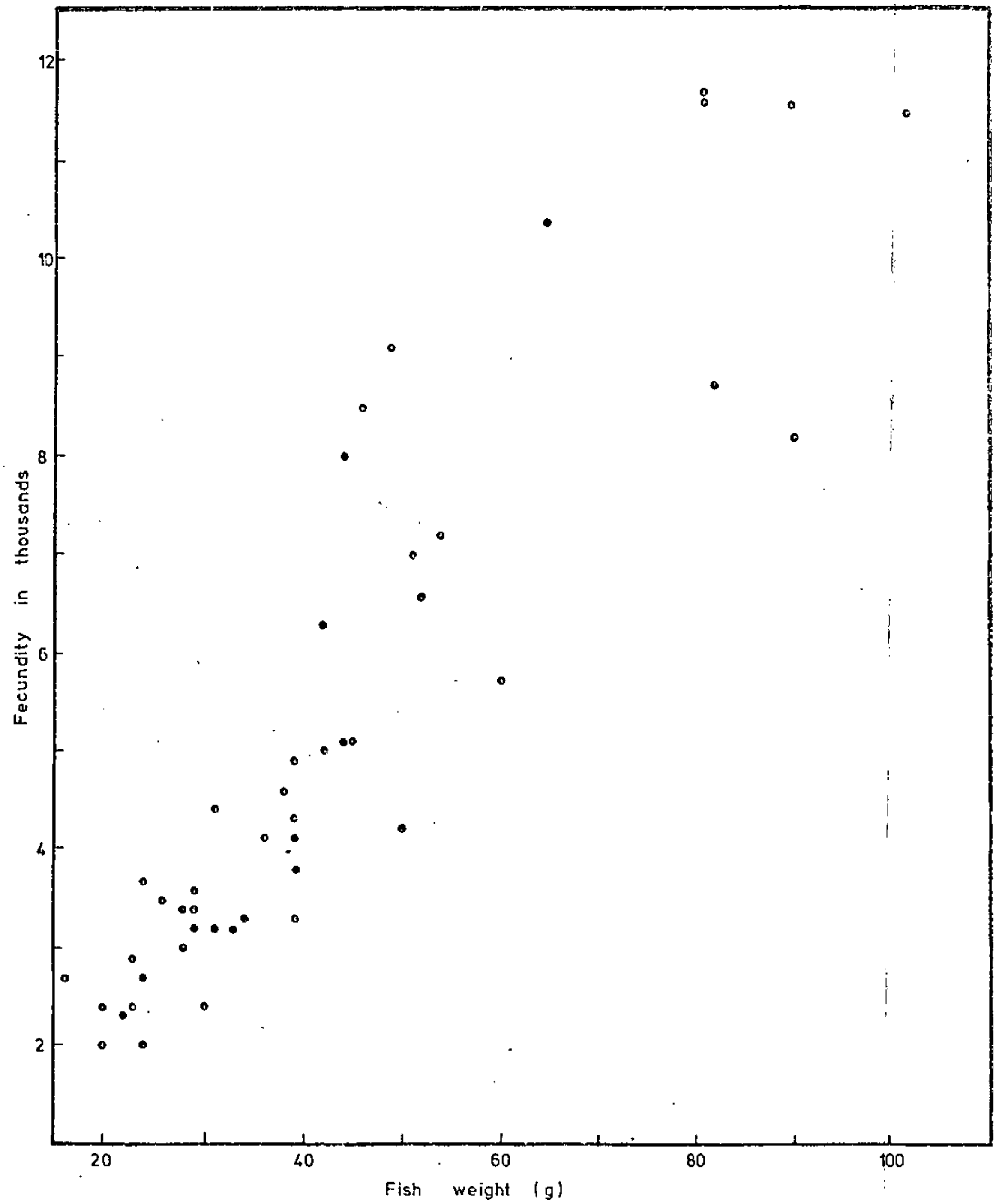


FIG. 35, Relationship between fecundity and fish weight in *I. africana*.

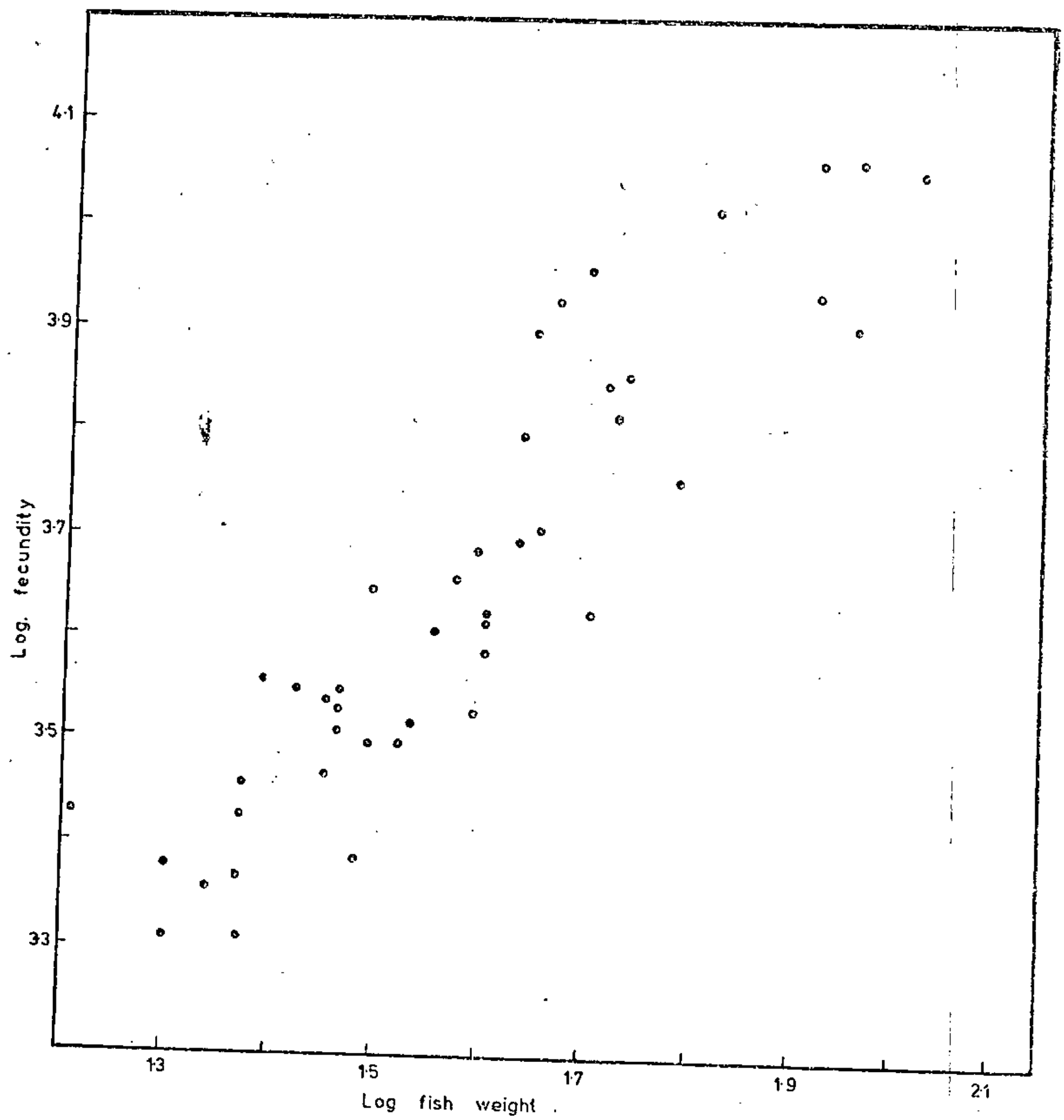


FIG. 36, Relationship between log. fecundity and log. fish weight in *I. africana*

Figure 35 is a scatter diagram showing the relationship between fecundity and fish weight. Expressing the equation in logarithm form,

$$\log F = \log a + b \log W$$

The values of a and b were calculated to be 99.08 and 1.049. A correlation coefficient of 0.915 was obtained. Figure 36 shows the relationship between log fecundity and log fish weight.

Fecundity for the sample of fish caught off Benin River ranged between 2,424 and 5,146 for fish whose sizes ranged between 15.3cm and 18.8cm (total length). The mean fecundity was 3,689 for a mean fish size of 16.8cm (total length).

Fecundity for the fish off Brass River ranged from 4,250 - 7,626 for fish whose sizes ranged from 16.2 - 20.2 cm. The mean fecundity was 5,207 for an average fish size of 17.9 cm (total length).

Fecundity for the fish caught off Bonny River ranged from 4,428 to 8,500 for a fish size range of 16.4 - 18.8cm. The mean fecundity was 6,864 for a mean size of 17.2 cm (total length).

Sizes of eggs from the sample from Lagos Coast varied from 0.57 - 1.35mm with a mean of 0.85mm. Mean Egg diameter, however, did not have a high correlation to fish length. Using the relationship

$$\log E = \log a + b \log L$$

where, E = mean egg diameter (mm x 10^3)

L = fish length (cm)

a and b = constants

a was calculated to be 377.6 while b was 0.330. The correlation coefficient was 0.410. Fig. 37 illustrates the variation of mean egg diameter with fish length.

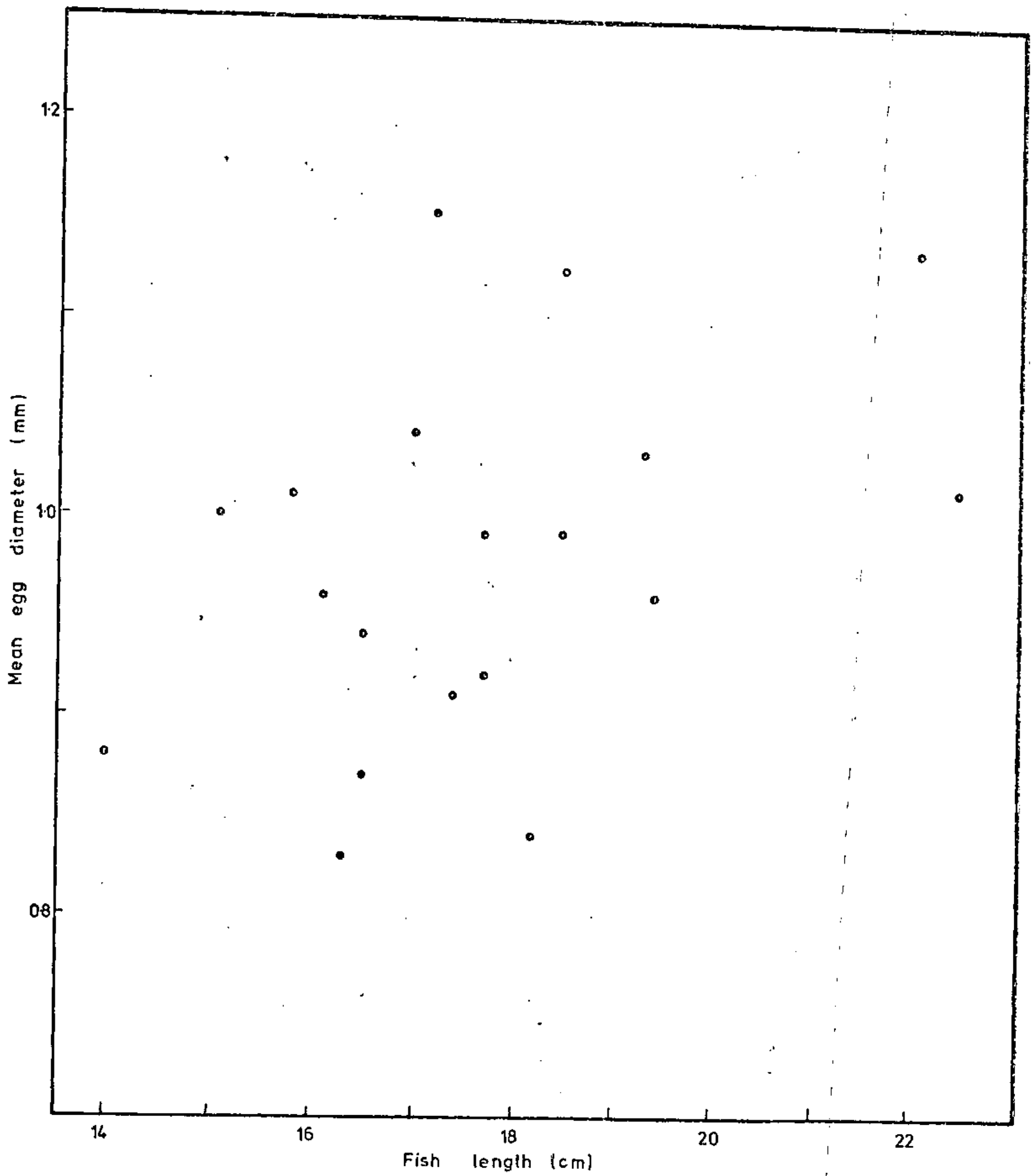


FIG. 37. Relationship between egg diameter and fish length in I. africana.

6. RACIAL STUDIES

Details of the meristic counts and morphometric characters for *I. africana* from the Lagos Coast, off Benin River, Brass River and Bonny River are presented in Appendices IV - VII.

Meristic counts

One way analysis of variance was carried out on six meristic counts, namely the dorsal fin rays, anal fin rays, abdominal scutes, pectoral fin rays and the left and right gill rakers. The ventral fin rays and the vertebral counts had constant values of 6 and 42 respectively for the populations from Lagos, Benin, Brass and Bonny. Thus, this did not require further statistical analysis.

Dorsal fin rays

The dorsal fin ray counts for *I. africana* from Lagos Coast ranged from 14 to 18 with a mean of 15.4, while for off Benin River, they ranged from 14 to 18 with a mean of 15.5 for the sample off Brass River, the range was 15 to 17 with a mean of 15.6 while for the sample off Bonny River, the range was 14 to 17 and the mean was 15.4. Table 28 shows the analysis of variance on the dorsal fin ray counts. Tabulated F - value at 5 percent level of significance = 2.68. However calculated F value = 0.73. Hence data showed strong evidence that there was no significant difference in number of dorsal fin ray counts of *I. africana* from Lagos, Benin, Brass and Bonny Coasts.

Anal fin rays

The anal fin ray counts for Lagos Coast ranged from 41 to 49 with a mean of 44.8 while for the sample off Benin River, the range was 42 to 50 with a mean of 46.2. For the sample off Brass River, the range was from 42 to 49 with a mean of 46.3 and off Bonny River,

Table 28. One way analysis of variance on dorsal fin ray counts of I. *africana* caught off Lagos Coast, Benin River, Brass River and Bonny River (Data from Appendices IV - VII).

Source of variation	Degree of freedom	Sum of squares	Mean square	F ratio
Between stations	3	1.24	0.41	0.73
Within stations	128	71.64	0.56	
Total	131	72.88		

Calculated $F_{3,128}^{(0.05)}$ = 0.73 (Not significant)

Tabulated $F_{3,128}^{(0.05)}$ = 2.68

Table 29. One way analysis of variance on anal fin ray counts of *I. africana* caught off Lagos Coast, Benin River, Brass River and Bonny River. (Data from Appendices IV - VII).

Source of variation	Degree of freedom	Sum of squares	Mean square	F ratio
Between stations	3	53.23	17.74	4.96
Within stations	128	458.85	3.58	
Total	131	512.08		

Calculated $F_{3,128}$ $^{(0.05)}$ = 4.96 (Significant)

Tabulated $F_{3,128}$ $^{(0.05)}$ = 2.68

the range was from 42 to 49 with a mean of 46.3. Table 29 shows the analysis of variance on the anal fin ray counts. Tabulated F - value at 5 percent level of significance = 2.68. However, calculated F - value = 4.96. Hence, data shows that there was significant difference in the anal fin ray counts of *I. africana* from Lagos, Benin, Brass and Bonny Coasts.

A t - test was further carried out on the mean values of the anal fin ray counts to establish which of the stations was responsible for the significant difference. The mean anal fin ray counts for Lagos, Benin, Brass and Bonny (44.82, 46.24, 46.33 and 46.27 respectively) were designated $\bar{X}_1$, $\bar{X}_2$, $\bar{X}_3$ and $\bar{X}_4$ respectively. t was calculated using the formula:

$$t = \frac{d}{S.E.}$$

where d = difference between means

S.E. = Standard error

$$S.E. = \text{mean square within station} \times \frac{1}{\text{number in sample 1}} \times \frac{1}{\text{number in sample 2}}$$

$$= 3.58 \times \frac{2}{33}$$

$$= 0.46$$

t - test on $\bar{X}_1$ vs $\bar{X}_2$

$$t = \frac{46.24 - 44.82}{0.46}$$

$$= 3.09$$

t - test on $\bar{X}_1$ vs $\bar{X}_3$

$$t = \frac{46.33 - 44.82}{0.46}$$

$$= 3.28$$

t - test on $\overline{X}_1$ vs $\overline{X}_4$

$$t = \frac{46.27 - 44.82}{0.46}$$

$$= 3.15$$

t - test on $\overline{X}_2$ vs $\overline{X}_3$

$$t = \frac{46.33 - 46.24}{0.46}$$

$$= 0.20$$

t - test on $\overline{X}_2$ vs $\overline{X}_4$

$$t = \frac{46.27 - 46.24}{0.46}$$

$$= 0.07$$

t - test on $\overline{X}_3$ vs $\overline{X}_4$

$$t = \frac{46.33 - 46.27}{0.46}$$

$$= 0.13$$

Tabulated value of t at 5 percent and 1 percent levels of significance were respectively 1.96 and 2.60. The calculated t - values were higher than the tabulated values at both the 5 percent and 1 percent levels of significance for $\overline{X}_1$ vs $\overline{X}_2$, $\overline{X}_1$ vs $\overline{X}_3$ and $\overline{X}_1$ vs $\overline{X}_4$ while for $\overline{X}_2$ vs $\overline{X}_3$, $\overline{X}_2$ vs $\overline{X}_4$ and $\overline{X}_3$ vs $\overline{X}_4$, the tabulated values were higher. These results indicated that the anal fin ray counts from fish caught off Lagos Coast, were responsible for the significant difference obtained in the analysis of variance on the anal fin ray counts.

Ginsburg's measure of overlap

Ginsburg (1938), cited by Ikusemiju (1973) suggested that a summation of the smaller percentages from each of two groups divided by 2 provided an estimate of the overlap. Ginsburg further suggested that 30 - 40% was a good ground for assuming a race, 15 - 25%, subspecies and 10% or less species. Ginsburg's measure of overlap for the anal fin ray counts between the sample from Lagos and those from Benin, Brass and Bonny were 27.27%, 36.36% and 33.33% respectively. The values for Lagos - Brass and Lagos - Bonny fall within the 30 - 40% range while the value for Lagos - Benin (27.27) approximately fall within this range. Application of the Ginsburg's measure of overlap thus indicated that the samples of I. africana off Lagos, Benin, Brass and Bonny were still of the same racial stock.

Pectoral fin rays

The pectoral fin ray counts from the Lagos sample ranged from 13 to 15 with a mean of 14.7 while those for the Benin sample ranged from 14 to 16 with a mean of 14.7. The counts for the sample from off Brass River ranged from 14 to 16 with a mean of 14.7 while those for the sample off Bonny ranged from 14 to 16 with a mean of 14.8. Table 30 shows the analysis of variance on the pectoral fin ray counts. Tabulated F at 5 percent level of significance = 2.68. However, calculated F value = 0.44. Hence data showed strong evidence that there was no significant difference in the number of pectoral fin ray counts of I. africana from Lagos, Benin, Brass and Bonny Coasts.

The right gill raker counts from the Lagos sample ranged from 32 to 36 with a mean of 33.4 while the counts for the sample off Benin ranged from 31 to 36 with a mean of 33.4 and those of the sample from off Brass River ranged from 31 to 35 with a mean of 33.2. The counts from the sample off Bonny River ranged from 32 to 35 with a mean of 33.2. Table 31 shows the analysis of variance on the right gill raker counts. Tabulated F at 5 percent level of significance = 2.68. However, calculated F value = 0.70. Hence data shows strong evidence that there was no significant

Table 30. One way analysis of variance on pectoral fin ray counts of I. africana caught off Lagos Coast, Benin River, Brass River and Bonny River. (Data from Appendices IV - VII).

Source of variation	Degree of freedom	Sum of squares	Mean square	F ratio
Between stations	3	0.44	0.15	0.44
Within stations	128	43.04	0.34	
Total	131	43.48		

Calculated $F_{3,128}^{(0.05)}$ = 0.44 (Not significant)

Tabulated $F_{3,128}^{(0.05)}$ = 2.68

difference in the number of right gill rakers of I. africana from Lagos, Benin, Brass and Bonny Coasts.

Left gill rakers

The left gill raker counts for the sample off Lagos Coast ranged from 33 to 36 with a mean of 33.4 while for the sample off Benin River, the counts ranged from 33 to 37 with a mean of 33.4. For the sample off Brass River, the range was 31 to 35 with a mean of 33.4 and for the sample off Bonny River, the range of counts was 32 to 35 with a mean of 33.2. Table 32 shows the analysis of variance on the left gill rakers. Tabulated F at 5 per cent level of significance = 2.68 while the calculated F = 0.28. The data has thus shown strong evidence that there was no significant difference in the number of left gill rakers of I. africana from Lagos, Benin, Brass and Bonny Coasts.

Abdominal scutes

The abdominal scute counts for I. africana from Lagos Coast ranged from 30 to 35 with a mean of 32.2 while for the sample off Benin River, the range was 30 to 34 with a mean of 32.1 and for the sample off Brass River, the range was 29 - 35 with a mean of 32.7. The counts from the sample off Bonny River ranged from 31 to 35 with a mean of 32.4. Table 33 shows the analysis of variance on the abdominal scutes. Tabulated F at 5 percent level of significance = 2.68 but the calculated F value = 0.49. The data has thus shown strong evidence that there was no significant difference in the number of abdominal scutes of I. africana from Lagos, Benin, Brass and Bonny Coasts.

Table 31. One way analysis of variance on right gill raker counts of *I. africana* caught off Lagos Coast, Benin River, Brass River and Bonny River. (Data from Appendices IV - VII)

Source of variation	Degree of freedom	Sum of squares	Mean square	F ratio
Between stations	3	1.3	0.43	0.70
Within stations	128	78.18	0.61	
Total	131	79.48		

Calculated $F_{3,128}$ (0.05) = 0.70 (Not significant)

Tabulated $F_{3,128}$ (0.05) = 2.68

Table 32. One way analysis of variance on left gill raker counts of I. africana caught off Lagos Coast, Benin River, Brass River and Bonny River. (Data from Appendices IV - VII)

Source of variation	Degree of freedom	Sum of squares	Mean square	F ratio
Between stations	3	0.57	0.19	0.28
Within stations	128	85.4	0.67	
Total	131	85.97		

Calculated $F_{3,128}$ (0.05) = 0.28 (Not significant)

Tabulated $F_{3,128}$ (0.05) = 2.68

Table 33. One way analysis of variance on the abdominal scutes of I. africana caught off Lagos Coast, Benin River, Brass River and Bonny River
(Data from Appendices IV - VII)

Source of variation	Degree of freedom	Sum of square	Mean square	F ratio
Between stations	3	2.57	0.86	0.49
Within stations	128	225.70	1.76	
Total	131	228.27		

Calculated $F_{3,128}$ (0.05) = 0.49 (Not significant)

Tabulated $F_{3,128}$ (0.05) = 2.68

Morphometric measurements.

One way analysis of variance was also carried out on four morphometric measurements namely the head length, head depth, body depth and eye diameter.

Head length

The range of head lengths of I. africana in the sample off Lagos Coast was 32 - 45mm while the mean was 36.8mm. For the sample off Benin River, the range was 30 - 45mm while the mean was 37.5mm. For the sample off Brass River, the range was 31 - 45mm with a mean of 38.4mm while for the sample off Bonny River, the range was 33mm to 46mm with a mean of 38.4mm. Table 34 shows the analysis of variance on the head length measurements. Tabulated F at 5 percent level of significance = 2.68 while the calculated F value = 1.35. The data has thus shown that there is no significant difference in the head length measurements of I. africana from Lagos, Benin, Brass and Bonny Coasts.

Head depth

The head depth measurements of I. africana from Lagos Coast ranged from 36 - 47mm with a mean of 39.4mm while for Benin Coast, they ranged from 33 - 47mm with a mean of 4[illegible].[illegible]mm. The range of measurements for the fish from off Brass River was 29 - 45mm with a mean of 39.8mm while for the sample off Bonny River, the range was 33 - 48mm and the mean was 39.9mm. Table 35 shows the analysis of variance on the head depth measurements. Tabulated F at 5 percent level of significance = 0.26. The data thus showed strong evidence that the head depth measurements of I. africana from Lagos, Benin, Brass and Bonny Coasts were not significantly different.

Table 34. One way analysis of variance on the head lengths of *I. africana* caught off Lagos Coast, Benin River, Brass River and Bonny River. (Data from Appendices IV – VII)

Source of variation	Degree of freedom	Sum of squares	Mean square	F ratio
Between stations	3	58.19	19.40	1.35
Within stations	128	1836.99	14.35	
Total	131	1895.18		

Calculated $F_{3,128}^{(0.05)}$ = 1.35 (Not significant)

Tabulated $F_{3,128}^{(0.05)}$ = 2.68

Table 35. One way analysis of variance on head depths of *I. africana* caught off Lagos Coast, Benin River, Brass River and Bonny River.
(Data from Appendices IV - VII)

Source of variation	Degree of freedom	Sum of squares	Mean square	F ratio
Between stations	3	11.45	3.82	0.26
Within stations	128	1854.19	14.49	
Total	131	1865.64		

Calculated $F_{3,128}$ (.05) = 0.26 (Not significant)

Tabulated $F_{3,128}$ (.05) = 2.68

Body depth

The body depth of *I. africana* from the Lagos Coast ranged from 41mm to 54mm while the mean was 43.9mm. For the sample from off Benin River, the range of body depth measurements was 41 - 58mm with a mean of 44.1mm while for the sample off Brass River, the range was 39 - 57mm and the mean was 44.2mm. For the sample off Bonny River, the range of measurements was 42 - 58mm and the mean was 46.3mm. Table 36 shows the analysis of variance on the body depth measurements. Tabulated F at 5 percent level of significance = 2.68 while calculated F value = 1.71. The data has thus indicated that there was no significant difference in the body depths of *I. africana* from Lagos, Benin, Brass and Bonny Coasts.

Eye diameter

For the sample of *I. africana* from Lagos Coast, the range of values for the eye diameter was 10.0 - 14.0mm with a mean of 11.3mm while for the sample off Benin River, the range of measurements was 9.0 - 13.0mm but the mean was 11.3mm. For the sample off Brass River, the range of measurements was 10.0 - 14.0mm with a mean of 11.7mm while for the sample off Bonny River, the range was 11.5mm. Table 37 shows the analysis of variance on the eye diameters. Tabulated F at 5 percent level of significance = 2.68. However, calculated F value = 0.71. The data has thus shown strong evidence that the eye diameters of *I. africana* from Lagos, Benin, Brass and Bonny were not significantly different.

Table 36. One way analysis of variance on body depths of *I. africana* caught off Lagos Coast, Benin River, Brass River and Bonny River.
(Data from Appendices IV - VII)

Source of variation	Degree of freedom	Sum of squares	Mean square	F ratio
Between stations	3	101.90	33.97	1.71
Within stations	128	2547.09	19.90	
Total	131	2648.99		

Calculated $F_{3,128}^{(.05)}$ = 1.71 (Not significant)

Tabulated $F_{3,128}^{(.05)}$ = 2.68

Table 27. One way analysis of variance on Eye diameters of I. *africana* caught off Lagos Coast, Benin River Brass River and Bonny River. (Data from Appendices IV - VII)

Source of variation	Degree of freedom	Sum of squares	Mean square	F ratio
Between stations	3	4.63	1.54	0.71
Within stations	128	277.89	2.17	
Total	131	282.52		

Calculated $F_{3,128}$ (.05) = 0.71 (Not significant)

Tabulated $F_{3,128}$ (.05) = 2.68

7. THE *ILISHA* FISHERY

Between 1971 and 1979, the annual production of clupeids in Nigeria ranged between 5,000 and 8,000 metric tons (Fishery Statistics of Nigeria, 1980). The species of clupeids comprised *E. fimbriata*, *I. africana* and *Sardinella* spp. The Guinean Trawling Survey Report (1968) noted that catch rates of *I. africana* greater than 100 kg/hr were obtained at 15 - 30m off the Nigerian Coast. The species was also found to constitute 28 - 30% of catches at the 15 - 20m depth.

Artisanal fishery is known to have contributed more than 60% of the Nigerian fish production. It is also the major means of clupeid fishing in the country. The fishing method for clupeids in the inshore waters has been mostly by the use of set gill nets using canoes driven by outboard engines or manually driven. Catches of clupeids by hooks and lines are very minimal. *I. africana* is the only major clupeid which is caught by trawlers fishing in the Nigerian Coast.

I. africana, though marketable, is not valued much as food by Nigerians particularly when other clupeid species are available. This is due to its small size and its being laterally flattened and with inter muscular bones. It is perhaps for this relative unimportance that very little attention has been shown for the species by scientists. It has however been predicted as a considerable potential fishery especially in the Nigerian Coast (GTS, 1968). The fish has for long been marketed in the traditionally smoked form, but recently, the Nigerian Institute for Oceanography and Marine Research (NIOMR) developed a more effective and faster means of fish smoking using smoking kilns. It has been reported that the method preserves the nutritive values of the fish. The NIOMR has in addition designed projects to enhance the effective utilisation of under utilised fish species including I. africana. The methods used included the separation of flesh and bones of the fish and use of the flesh in preparing such products as fish cakes and fish pies while the heads, fins and bones were crushed and made into animal feeds or fish meals.

DISCUSSION

The results obtained on the taxonomy of I. africana in this study were similar to those of Fowler (1936), Poll (1953) and Tobor (1966). While Fowler worked on specimens from Congo, Poll worked on specimens from the South Atlantic Coast and Tobor examined meristic counts for the species off the Lagos Coast. Both Poll (1953) and Tobor (1966) referred to the species they examined as Ilisha dolloi. Blache et al (1970) however pointed out that only one species of Ilisha occurred in the tropical atlantic waters and he identified this species as Ilisha africana. In fact Fowler (1936) had earlier referred to the Ilisha species off Congo as Ilisha africana.

The results of this study showed that the dorsal fin rays, anal fin rays, abdominal scutes and lateral median scales had similar counts to those made by Fowler (1936) on I. africana off the Congo. However, the gill raker counts in this study were 9 - 11 + 22 - 25 while those off the Congo River were 12 + 28. Ramaiyan and Whitehead (1975) obtained variations in their examination of meristic counts of I. melastoma from different localities in India. Tester (1938) described the variation in the mean vertebral counts of successive year classes of the herring (Clupea pallasii) with water temperature while Seymour (1959) studied the effect of temperature on the form of vertebrae and fin rays in the chinook salmon. Tester ascertained that variation in vertebral counts and counts of other meristic characters in some fishes were affected to some extent by environmental factors, notably water temperature. The variation in the number of gill rakers of I. africana off the Lagos Coast and the Congo River may be a result of variation in environmental conditions in these two areas.

The total length of fish examined for the taxonomy of this species ranged between 142 - 229mm. The head length varied from 32 - 54mm while the head depth varied from 36 - 51mm and body depth varied from 41 - 66mm. The number of gill rakers on the lower portion of the anterior gill arch varied between 66 and 72 while the number of abdominal scutes varied from 30 to 35. Though the morphometric characters measurements varied directly with increase in fish size, the gill raker and abdominal scute counts did not vary with increased fish size. Fagade and Olaniyan (1972) noted that in the clupeid, E. fimbriata, there were not only structural differences in the gill rakers of fishes in different size groups, but the counts also increased with increased fish size.

Among the clupeids, the world wide distribution of Ilisha species was noted by Ramaiyan and Whitehead (1975). They also noted that the areas of occurrence of these fishes ranged from warm seas to fresh waters. The Guinean Trawling Survey Report (1968) also pointed out that in the Gulf of Guinea, the Nigerian Coast was the area of greatest abundance for the species I. africana. The occurrence of this species from Lagos to Bonny areas indicated the wide distribution of this species along the Nigerian Coast. The occurrence of the species in the Lagos lagoon has also been noted by Fagade and Olaniyan (1973).

The greatest abundance of 39% was recorded at the bottom depth of 20 - 30m while the least abundance was 10% at a depth of 40 - 50m. These results confirm those of the GTS (1968). Though the depth range of 10 - 50m was established as the depth of occurrence of this species during daylight hours of the day, the species was not encountered in hauls made at these depths during the night periods. Diurnal vertical migration has been described in a number of clupeids such as P. afzeliusi

(Reynolds (1969), Ikusemiju (1973). Though this phenomenon has not been established for I. africana in this study, there is a possibility that it does occur. There is however a further need to establish the depths of occurrence during the night-time.

The graphs of the length frequency distributions of I. africana were normal distribution curves. There were only three distinct modes to indicating the 1^+, 2^+ and 3^+ age groups. This is an indication that the Petersens method is only suitable as a supplementary method for age determination in the species. Data obtained from this method were however very useful in the calculation of the Von Bertalanffy parameters. The value of K obtained using the data of the otolith check technique was considered too low for the growth rate of I. africana. The net used in catching fish from which otoliths were removed had a 75mm cod end mesh size. This net was primarily designed for harvesting croakers $L_{max} > 80$cm. This implies that the size first capture for I. africana (L_{max}28.7cm) must be high. In effect the actual mean of the 1 year age group would be less than the calculated mean which resulted in the low K - value obtained. This low K - value gave rise to the value of t_o being low (-4.21 years). It is considered that though the length frequency distribution failed to give distinct modes for the older age groups, values of the von Bertalanffy parameters calculated from the data were more accurate than those obtained using the data from the otolith check technique.

While fishes as small as 4.0cm were found only in 10-20m depth, fishes of 9.0cm and less were restricted to depths not more than 30m. The larger sized fishes were found at all depths but the largest sizes of 24cm and above were encountered in depths not less than 20m. These results show that very small, immature fishes were restricted to the shallow depths while the largest fishes were encountered more in the deeper waters. Fishes of intermediate sizes were common in all depths.

The b exponent for the samples from Lagos, Benin, Brass and Bonny, were respectively 3.122, 3.186, 3.068 and 3.017 in the male fish, 3.155, 3.366, 3.110 and 3.016 respectively in the female fish while they were 3.141, 3.259, 3.076 and 3.076 respectively for the combined sexes. All these values are approximately 3 which is an indication that the growth exhibited in this species was isometric. The values of the b exponent for all the stations were similar indicating that the growth pattern of the species was about the same in all the four sampled stations.

The correlation coefficients for the length - weight relationships for the male fish ranged from 0.980 - 0.999 while those of the female fish ranged from 0.971 - 0.990 and those for the combined sexes ranged from 0.982 to 0.999, so that both length and weight were highly correlated in this species.

Among the males, fish less than one year constituted 26.3% while fish in the 1^+, 2^+, and 3^+ age groups constituted 27.5%, 29.4% and 14.4% respectively. Among the females, fish less than one year constituted 11.3% while fish in the 1^+, 2^+ and 3^+ age groups constituted 34.0%, 34.0% and 17.9%. Fish in the 4^+ and 5^+ age groups constituted 2.5% and 0% respectively among the males while among the females, they constituted 1.9% and 0.9% respectively. The low percentages of the 4^+ years and 5^+ years age groups among I. africana was significant in that it indicated that these age groups contributed very little to the population size of the species. Their low percentages were probably due to both natural mortality as well as fishing effort. The sizes of these ages of fish were 22.0cm and above and they represented the sizeable fishes among this species.

Both the lengths of the otoliths and scales as well as the width of the otoliths were found to increase directly with fish length. Using the equations relating the otolith length/ width to the fish length and that relating the scale length to the fish length, the fish length could be back calculated when otolith size and scale length were known.

The condition factor K, of I. africana off the Nigerian Coast ranged from 0.38 - 0.97. For the male fish, the condition factor ranged from 0.38 - 0.81 while in the females the condition factor ranged from 0.44 - 0.97. K factor for the fish caught off Lagos Coast ranged from 0.38 - 0.85 while for the fish off Benin River, the range was 0.39 - 0.97. For the fish caught off Brass River, the range was 0.60 - 0.81 while for those fish caught off Bonny River, the K - values ranged from 0.61 - 0.79. The condition factors could therefore be said to be within the same range irrespective of area of collection of the fish sample along the Nigerian Coast. In both male and female fish, where the sample sizes were large enough, the mean K – values were higher with increasing size group. For the Lagos Coast, the condition factors for the 6 - 10, 11-15, 16-20 and 20-25cm size groups were respectively 0.60, 0.64, 0.66 in the male fish and 0.59, 0.63, 0.66 and 0.66 for females in the respective size groups. For the females in the 26-30cm size group, the mean K - value was o.72. A similar relationship was obtained between all the size groups of male and female I. africana caught off Benin River as well as for the size groups of 11-15cm and 16-20cm for the fishes off Brass River. However, the sample size in the 21-25cm size group off Brass River and 11-15cm size group off Bonny River were too few for adequate deduction to be made on the K - values. Fagade and Olaniyan (1972) recorded a range of 1.50-2.81 for the clupeid, Ethmalosa fimbriata. They however used standard lengths of fish in their calculations. Salzen (1958), quoted from Fagade and Olaniyan (1972) who used total length measurements in his calculations, obtained condition factors of 1.0 for Awefu (L_{max} = 150mm) and 1.05 for Bonga (L_{max} = 280mm). Both studies however indicated that there was increase in the condition factor of Ethmalosa fimbriata with increased fish size.

Result of the monthly mean K - values showed that for fishes caught off Lagos Coast, the condition factors were higher in the female fish than in the male. The condition factors decreased for both sexes from about November to May and thence, there was an increase in the K - values between June and December. This period of relatively high K - values (June - December) coincided with the peak spawning period (June-December) in the species when greater percentages of ripe, ripe running and spent fish were encountered in the monthly samples.

I. africana was found to be a plankton feeder in addition to its feeding on other types of food such as shrimps and fish. It showed a preference for zooplankton as compared to phytoplankton. The planktophagous nature of feeding has been established as a common mode of feeding among clupeids such as Sardinella maderensis (Lowe), E. fimbriata, I. africana and P. afzeliusi in the Lagos lagoon (Fagade and Olaniyan, 1972) Ilisha spp in the Indian waters (Ramaiyan and Whitehead, 1975), S. albella and S. gibbosa in East Africa (Okera, 1973) and P. afzeliusi in Ghana (Reynolds 1969).

The crustaceans, fish larvae and nematodes were common components in the diets of I. africana caught off Lagos Coast, Benin, Brass and Bonny. The greatest variety of food was however obtained for the specimens from Lagos Coast while the least variety of food was obtained for the specimens from Bonny. Though the crustaceans were the most important group of food in all the sampling stations, there was the greatest variety of crustaceans in the diet of fish from Lagos Coast where eighteen types of crustaceans were encountered. In Benin, six types were encountered while in Brass seven types of crustaceans were encountered in the food. The least variety was however obtained for Bonny where the shrimps and crustacean larvae were the only crustacean components of the fish diet. Similarly, molluscs which formed part of the diet of the fish from Lagos, Benin and Brass, were not found as part of the diet of fish from Bonny. The shrimps were however, the most important crustacean in all the stations.

Fagade and Olaniyan (1972) who had earlier examined the food of I. africana from Lagos lagoon, noted that this consisted of mysids, juvenile prawns (cariids and penaeids) and fish larvae. This diet had some similarity to that reported for I. africana from the marine habitat encountered in this work. It was interesting to note that the wide variety of zooplankton observed for fish from Lagos Coast was not reported by Fagade and Olaniyan.

The importance of crustaceans in the diets of clupeids have been noted by earlier authors (Okera 1973, Ramaiyan and Whitehead 1975). The types of crustaceans which were of importance in S. gibbosa and S. albella were similar to those encountered in this study for I. africana. These included mysids, euphausiids, lucifer, amphipods, crustacean larvae, stomatopod larvae and calanoids. However, though the fish and fish larvae were found to be the second most important group of food in the diet of *I. africana*, they were insignificant in the diet of *S. albella* and *S. gibbosa* from East Africa which were studied by Okera (1973) and the diet of *S. maderensis* examined during this study.

Shrimps were found in the diet of the fish relative to their abundance in the waters. Ikusemiju (1975) noted that March was the month of least catch for the shrimps off the Lagos Coast while high catches were made in July and December to January. The results of this study showed that employing the volumetric and occurrence methods of analysis, March was the month of least importance for the shrimps as a component of the diet of *I. africana*. Though the shrimps were quite important in the diet of the fish in July and the occurrence and volume contributed by this food item in December and July were fairly high, the percentage contribution by number in December was the lowest for the whole year. This result may however be due to the large quantity of calanoids (58.5%) and amphipods (30.1%) in the diet of the fish for that month. The plankton components of the fish diet were also found in relative abundance to their occurrence in the waters as indicated by a comparison of the analysis of Plankton hauls with the plankton composition of the diet of *I. africana*.

Essentially, the differences in the diets of small sized and larger sized *I. africana* were quantitative though insignificant food items such as tunicates, flagellates, sinophores harpacticoida and lamellibranchs were found only in the small fishes while penaeid larvae and *Sagitta* larvae were found only in the larger fishes. The larger food items such as fish, fish larvae, shrimps, mantis shrimps and *Sepia* sp were of greater importance in the diet of the larger specimens while calanoids, amphipods cyclopoids, crustacean larvae and molluscs (small food items) were conspicuously more important in the diet of the smaller fishes. Fagade and Olaniyan (1972) found qualitative differences in the diet of E. fimbriata relative to size. They attributed the ability of the larger fishes to feed more to the increased number and size of gill rakers which enabled the filteration of more water. They also noted that structural changes that have occurred in the gill rakers of the larger fishes were responsible for their increased ability to feed on phytoplankton. Okera (1973) found no qualitative variation in the food of Sardinella species relative to size while Ikusemiju et al (1979) noted only quantitative variations in the diets of small and large B. auritus. Okera suggested that rather than by filteration, the larger food items of clupeids were eaten by acts of direct seizure with the jaws followed by gulping while the smaller plankton were obtained by filter feeding. This type of feeding may be practicable in I. africana which has no specialization of gill rakers in the larger specimens.

There were qualitative and quantitative differences in the diets of fish caught in the shallow waters (10 - 20m) and those caught in the deeper waters (40 - 50m). There were twenty types of food items in the fish from shallow waters, twelve of these being crustaceans while twelve types of food items were encountered in the stomachs of fish from the deeper waters seven of them being crustaceans. The urochordates, annelids, nematodes, insecta, caridean and anomuran larvae, diatoms, isopods, lucifer, fish eggs and cephalopods were only encountered in the shallow waters while a small incidence of Trichodesmium sp, cladocera and flagellates were encountered in the deeper waters alone. The shrimps and fish were very important in the diets of the fish caught in the shallow and deeper waters. The shrimps and molluscs (mostly larvae) were however more important in the diets of fishes from the shallow waters.

Similarly fish, fish larvae and calanoids were more important in the diet of fishes caught in the shallow depth. Ikusemiju et al (1979) similarly found qualitative and quantitative differences in the diets of B. auritus from shallow and deeper waters. While during this study, the crustaceans were found to be more important both quantitatively and qualitatively in the diets of I. africana from the shallow waters, Ikusemiju et al noted that the crustaceans were more important in the diet of B. auritus from the deeper waters. This relationship in the diets of I. africana and B. auritus may be interpreted as a means of avoiding interspecific competition since both species are planktonic feeders and are caught together in hauls. The occurrence of more I. africana in the shallow depth is possibly a reaction of the species to the greater variety and quantity of food at these depths.

Though the diets of I. africana and S. maderensis both of the family clupeidae were similar, there were distinct differences. The crustaceans notably the calanoids and amphipods as well as molluscs were important to both species while the shrimps which were of great importance in the food of I. africana were relatively unimportant in the diet of S. maderensis. The fishes were similarly of less importance to S. maderensis. The relative insignificance of fishes and nematodes in the diet of S. maderensis is similar to the finding of Okera (1973) for S. albella and S. gibbosa from the East African waters. The food of I. africana in relation to members of other families which were commonly caught together with it in fishing hauls was such that would prevent serious competition for food among the fish species. Though the crustaceans were common food to all the fish species, certain crustaceans were peculiar to the diet of particular fish species or where they occurred in more than one fish species, they had varying importance in their diets. The calanoids and amphipods were the only crustaceans encountered V. setapinnis while shrimps and crustacean larvae occurred in G. decadactylus. Amphipods, isopods, cyclopoida, harpacticoids, mysids and lucifer which were some crustacean food of I. africana were not encountered in the diet of B. auritus. In addition to the variation in the crustacean components of the diets of the fish species, mantis shrimps and diatoms were food of B. auritus while. Foraminifera and lobster were food of G. decadactylus alone. Nematodes occurred in the stomachs of V. setapinnis and I. africana while molluscs occurred in S. maderensis and I. africana. It was believed that these variations in the diets of these fishes were ways of avoiding interspecific competition among the fish species.

The occurrence of ripe/ripe running/spent fish in all the months of the year indicated that spawning took place throughout the year in I. africana. This had been commonly observed among clupeids (Reynolds, 1969; Vandepuye 1971 (cited by Otobo, 1978); Ellis 1971; Otobo, 1978). The result of this study further confirms Houde and Fore's (1973) ascertain that clupeids breed for most part of the year. The relatively low monthly percentages of ripe/ripe running fish may be due to the fact that trawling and handling of fish on board caused running fish to shed their eggs or milt. This view had been earlier expressed by Htun-Han (1978). He reported that extremely ripe fish shed their eggs when lifted out of water, no matter how gently this was done. The higher percentages of ripe/ripe running/spent fish in some months of the year indicated that peak spawning in the species took place from about June to December with a slight drop in August and around October. All the fish in the 16 - 28 cm size group were mature, hence their monthly gonadosomatic indices gave a clearer indication of gonad maturity than was found in the 3 - 15 cm size group. Similarly, there was a more distinct variation in the gonadosomatic indices for the females than those of the male fish. The values for the females in the 16 - 28 cm size group were higher from about May to December when they ranged from 2.5 - 4.3 as compared with January to April when they ranged between 2.2 - 2.8. In the male fish belonging to the 16 - 28 cm size group, higher values were obtained in January - February, April and October - December. Halliday (1969) successfully used the monthly variation of the gonadosomatic indices, variation in occurence of late ripening and ripe fish and the occurrence of eggs in plankton samples to delimit the spawning period in <u>Argentina sphyraena</u>. In this study, eggs of <u>I. africana</u> were not obtained in plankton samples. However, the occurence of ripe/ripe running/spent fish in fish samples showed that some spawning occurred in the species through out the year but peak spawning occurred between June and December while the variation of the gonadosomatic indices indicated that peak spawning occurred in the species from about May to December.

The gonad weights and hence the gonadosomatic indices were relatively small compared with the fish weight. This, However, is typical of clupeids which are noted for breeding the year round. Htun-Han (1978) noted that the testes increased in weight earlier than the ovaries and this was maintained for a longer period to facilitate and ensure successful fertilization. This same purpose was achieved in <u>I. africana</u> with the high values of gonadotropic indices earlier in the year in the males than in the females, and these being more extensive into the year. The gonadosomatic indices were higher in the females than males of comparable sizes. Htun-Han who found a similar occurrence in <u>Limanda limanda</u> (L) explained that this was due to uptake of fluid by fully ripe oocytes.

Monthly sex ratios of <u>I.</u> africana showed that female fish were encountered more than males between August and January while male fish were more between February and July.

Most of the months with higher occurrence of female fish fell within the peak spawning period in the species. This result may thus be an indication that females were more encountered than males during the peak spawning season. Ikusemiju (1976) and Sturm (1978) however noted the higher percentage of males to females during the spawning seasons of Chrysichthys walkeri and Scombemorus maculatus respectively. The higher percentage of females during the spawning season in I. africana might be due to the fact that the females were more liable to capture during this period as suggested by Healey (1971).

Variation in colouration of fishes may be taxonomic or associated with the breeding cycle. Talbot and Williams (1956) noted sexual colour differences in Caranx ignobilis. They found that mature male fish had a different colour from the mature female. Results of this study have shown that irrespective of sex of the fish, black streaks developed on either side of the fish as maturity progressed towards spawning. In I. africana, colour variation was therefore related to breeding.

Fecundity in the species increased with fish length and fish weight and the increment of fecundity relative to the length and weight of the fish were isometric. There were high degrees of correlation between fecundity and fish length and between fecundity and fish weight, the correlation coeffients respectively being 0.9044 and 0.9153. Similarly, there was an increase in mean egg size with fish length. Though the correlation between mean egg diameter and fish length was positive, it was relatively low (0.4100).

According to Ikusemiju (1975) the main objective of racial studies is to determine the amount of variation among widely distributed species. Results of the racial study of I. africana has shown that of all the meristic and morphometric characters used in this study, only the anal fin ray counts had significant differences among the samples from Lagos, Benin, Brass and Bonny. Results of the t-test indicated that with respect to this meristic character, it was the counts from the sample off Lagos Coast that were significantly different from those of the other sampling stations. However, application of the Ginsburg's measure of overlap indicated that despite this variation, the fish from the four stations of sampling namely: Lagos, Benin, Brass and Bonny, all along the Nigerian Coast, still belonged to the same racial stock.

Heuts (1949) similarly found variations in fin ray counts of salt and fresh water races of the stickle-backs (Gasterosteus aculeatus) while Ikusemiju (1975) found variations in the number of gill rakers of C. nigrodigitatus from the Lagos and Lekki lagoons, Nigeria. McHugh (1951) found increase in anal fin ray counts of anchovy from British Columbia to United States of America/Mexico border and he observed a converse decrease in gill raker counts. The present study has further confirmed the view of McHugh (1951) that anal fin ray counts could provide additional useful information on the population structure of species.

SUMMARY

1. Aspects of the biology of *I. africana* (Bloch) caught off the Nigerian Coast were studied. These included the taxonomy, distribution, age and growth, food and feeding habits, reproduction and racial studies. The use of meristic and morphometric characters were employed in the taxonomy and racial studies. The fishery of the species was reviewed.

2. The meristic counts were as follows:

Dorsal fin rays D = 14 - 18 ($\bar{D}$ = 15.39); Anal fin rays A = 41 - 49 ($\bar{A}$ = 46.22); Pectoral fin rays P = 13 - 15 ($\bar{P}$ = 14.67); Vertebrae 42; Ventral fin rays V = 6; Abdominal scutes = 25 - 29 + 5 - 7; Gill rakers on the left side of the lower portion of the anterior gill arch = 33 - 36; gill rakers on the right side of the lower portion of the anterior gill arch 32 - 36.

The morphometric ratios obtained for this species were: Standard length/Head length ranged between 3.33 and 3.88; Standard length/Body depth was 2.71 - 3.02; Head length/Head depth was 0.90 - 1.06; Head length/Snout length was 3.5 - 3.9; Head length/Eye diameter was 3.0 - 3.86; Head length/Caudal peduncle length was 2.86 - 3.53; Head depth/Eye diameter was 3.14 - 3.70.

3. *I. africana* was widely distributed along the Nigerian Coast. Catches were made from Lagos to Bonny areas. The greatest abundance occurred at depths between 20m and 30m while the lowest abundance was between the depths of 40m and 50m. The phenomenon of diurnal vertical migration is possibly exhibited in the species.

4. The sizes of fish encountered ranged from 4.2cm to 28.7cm. Very small fishes were restricted to shallow depths while the larger fishes occurred more in the deeper waters. Maturity was attained at a size of about 12.0cm in both sexes. This was during the first year of the fish. The maximum age attainable in the species was 5 years.

Growth was isometric in the species, the values of the b exponent ranging between 3.017 and 3.186 in the male fish and between 3.016 and 3.366 for the female fish from Lagos, Benin, Brass and Bonny.

Otolith length, scale length and otolith width were positively correlated to fish length.

The condition factor ranged from 0.38 - 0.97 and it increased with increased fish size. It was greater in the females than the males of the same size group. Higher condition factors were encountered from about June to December.

5. *I. africana* was found to be planktophagous but in addition, it fed on fish and shrimps. The food of the fish was mostly crustacea. Other important components of the diet were fish, fish larvae and molluscs. There were quantitative variations in the diets of small and larger sized fishes. Larger food items were encountered more in the diets of the bigger fishes while the smaller food items were of greater importance in the diets of the smaller fishes. There was a greater variety of food organisms in the diets of fish from the shallow waters. The amount of planktons in the diet of the fish was found to be relative to the abundance in the waters. Though *I. africana* fed on some common food items with other fish species, there was an active response to interspecific competition as the importance of these food items varied in the diets of various fish species. Crustaceans, fish larvae, molluscs and nematodes were found to be common food items in the diets of *I. africana* from Lagos Coast, off Benin River, off Brass River and off Bonny River.

6. Maturity stages encountered in the species were immature, ripening, ripe, ripe running and spent stages. Spawning occurred in the species through out the year but the peak spawning season was June to December. Black streaks were formed on either side of *I. africana* during the breeding period and these disappeared soon after spawning had taken place in the fish.

Female fish outnumbered the male fish during the peak spawning season. Gonadosomatic index was greater in the 16 - 28cm size group than the 3 - 15cm size group. The gonadosomatic indices for the females were higher than those of the males in the same size group. Particularly in the female fish and in the larger size group, there were monthly variations in the values of gonadosomatic indices. The values were relatively higher from May to December.

Fecundity for the sample of fish from Lagos Coast ranged from 2,029 to 11,687 for a fish size range of 14.0 - 25.4cm. The mean fecundity was 5,227 for an average fish size of 18.0cm. For the sample off Benin River, fecundity varied between 2,424 and 5,146 for a size range of 15.3 - 18.8cm (total length) while for the sample off Brass it ranged between 4250 and 7626 for a size range of 16.2 - 20.2cm and for the sample off Bonny River the fecundity ranged between 4428 and 8500 for a size range of 16.4 - 18.8cm. Egg sizes varied between 0.57mm and 1.35mm.

7. Though the fin ray counts from the samples of fish off Lagos Coast were significantly different from those of the fish off Benin, Brass and Bonny Rivers, the fish from the four sampling stations off the Nigerian Coast were still of the same racial stock.

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Appendix 1 Meristic counts of <u>Ilisha africana</u> caught off Lagos Coast, Nigeria.

No.	D	A	P	Vert	AS	V	GRrt	GRLt
1	14	44	15	42	27+6	6	10+24	10+24
2	15	45	14	42	26+6	6	10+24	10+24
3	15	46	15	42	27+6	6	10+24	10+24
4	15	46	15	42	25+5	6	10+23	10+23
5	15	45	15	42	26+5	6	10+24	10+24
6	15	45	15	42	27+6	6	10+24	10+24
7	15	46	14	42	25+6	6	10+24	10+24
8	16	47	15	42	27+6	6	10+23	10+23
9	15	45	15	42	29+6	6	9+23	10+23
10	16	41	15	42	25+6	6	10+23	10+23
11	15	45	15	42	28+6	6	10+23	10+23
12	15	44	15	42	25+6	6	10+23	10+23
13	15	47	15	42	25+5	6	10+23	10+23
14	18	45	14	42	26+7	6	10+23	10+23
15	15	48	15	42	25+6	6	10+25	10+25
16	17	49	15	42	28+5	6	11+25	10+25
17	15	41	14	42	26+5	6	11+25	11+25
18	16	44	15	42	26+6	6	10+23	10+23
19	16	43	15	42	25+5	6	10+23	10+23
20	15	47	15	42	25+6	6	10+23	10+23
21	15	46	15	42	26+5	6	10+23	10+23
22	16	43	15	42	27+7	6	10+23	10+23
23	16	42	15	42	27+6	6	10+23	10+23
24	15	46	14	42	27+6	6	10+23	10+23
25	15	45	14	42	26+6	6	11+23	11+23

(Contd.)

No.	D	A	P	Vert	AS	V	GRrt	GRLt
26	16	46	15	42	28+7	6	10+23	10+23
27	15	42	15	42	27+6	6	10+23	10+23
28	16	43	14	42	27+6	6	10+23	10+23
29	16	41	15	42	27+6	6	10+23	10+23
30	15	42	13	42	25+6	6	10+23	10+23
31	15	48	15	42	26+6	6	10+23	10+23
32	15	45	14	42	27+6	6	10+23	10+23
33	15	47	14	42	26+6	6	10+23	10+23

…hometric data for I. africana caught off Lagos Coast, Nigeria

…	HL (mm)	SL/HL	HD (mm)	HL/HD	Snl (mm)	HL/Snl	ED (mm)	HL/ED	C.P	HL/CP	HD/ED
[illegible]	…3	3.50	37	1.03	10.8	3.52	11	3.45	12	3.17	3.36
[illegible]	…7	3.62	40	0.93	10.6	3.50	11	3.36	12	3.08	3.33
[illegible]	…3	3.56	40	0.95	10.6	3.60	12	3.17	12	3.16	3.33
[illegible]	…5	3.51	37	0.95	9.4	3.71	10	3.50	11	3.18	3.70
[illegible]	…5	3.66	37	0.95	9.2	3.80	10	3.50	11	3.18	3.70
[illegible]	…5	3.66	36	0.97	8.8	4.00	10	3.50	11	3.18	3.60
[illegible]	…3	3.88	36	0.92	8.8	3.75	10	3.30	11	3.0	3.60
[illegible]	…5	3.86	39	0.90	9.4	3.74	11	3.18	11	3.18	3.55
[illegible]	…7	3.68	40	0.93	10.2	3.62	12	3.08	12	3.08	3.33
[illegible]	…2	3.60	34	0.94	9.0	3.54	10	3.20	10	3.20	3.40
[illegible]	…3	3.45	51	1.03	14.7	3.61	14	3.79	15	3.53	3.64
[illegible]	…7	3.68	40	0.93	9.9	3.72	12	3.08	11	3.36	3.33
[illegible]	…6	3.75	35	1.00	9.8	3.58	10	3.50	10	3.50	3.50
[illegible]	…5	3.72	36	0.97	9.9	3.52	11	3.18	12	2.92	3.27
[illegible]	…4	3.45	51	1.06	14.8	3.65	14	3.86	17	3.18	3.64
[illegible]	…8	3.65	51	0.94	12.9	3.72	14	3.43	15	3.20	3.64
[illegible]	…6	3.69	38	0.95	9.6	3.74	11	3.27	12	3.00	3.45

(Contd.)

	SL (mm)	TL (mm)	BD (mm)	SL/BD	HL (mm)	SL/HL	HD (mm)	HL/HD	Snl (mm)	HL/Snl	ED (mm)	HL/ED	C.P	HL/CP	HD/ED
18	116	147	45	2.58	33	3.52	36	0.92	8.6	3.84	10	3.30	11	3.00	3.60
19	135	165	45	3.00	38	3.56	40	0.95	9.7	3.90	11	3.45	12	3.17	3.64
20	120	150	43	2.79	35	3.42	37	0.95	9.3	3.76	10	3.50	11	3.18	3.70
21	160	196	54	2.96	45	3.56	47	0.96	12.7	3.54	13	3.46	13	3.46	3.62
22	121	151	43	2.82	34	3.56	36	0.94	9.3	3.64	10	3.40	11	3.09	3.60
23	150	183	53	2.83	45	3.33	43	1.05	12.1	3.72	12	3.75	15	3.00	3.58
24	155	190	54	2.87	45	3.45	44	1.02	12.0	3.74	14	3.21	15	3.00	3.14
25	116	145	42	2.76	32	3.62	34	0.94	8.5	3.76	10	3.20	11	2.91	3.40
26	175	210	61	2.87	48	3.65	51	0.94	13.5	3.56	15	3.20	16	3.00	3.40
27	131	160	47	2.79	37	3.55	38	0.97	10.1	3.66	11	3.36	12	3.08	3.45
28	145	179	53	2.73	40	3.62	44	0.91	10.9	3.68	12	3.33	14	2.86	3.67
29	132	158	46	2.87	36	3.66	40	0.90	9.7	3.72	12	3.00	12	3.00	3.33
30	122	154	45	2.71	35	3.48	35	1.00	9.3	3.75	10	3.50	12	2.92	3.50
31	147	178	53	2.77	41	3.58	43	0.95	10.8	3.80	12	3.58	14	2.93	3.58
32	173	208	61	2.83	52	3.33	50	1.04	13.5	3.84	15	3.37	15	3.47	3.33
33	131	159	45	2.91	35	3.75	38	0.92	9.2	3.80	11	3.45	12	2.92	3.45

Appendix III Fecundity data for *I. africana*

Total Length (cm)	Weight (g)	Fecundity
15.1	23.5	2695
15.5	23.4	2880
17.0	37.5	4579
18.5	42.3	5013
16.1	28.1	2976
17.7	39.3	3349
17.5	33.4	3173
17.7	39.4	3843
18.2	38.5	4856
22.5	81.7	8692
16.5	29.0	3402
14.0	16.2	2703
16.3	29.1	3240
15.5	23.2	2366
20.6	60.4	5728
18.5	44.2	5136
23.3	89.9	11610
19.5	49.9	4219
19.2	52.3	6625
19.4	50.9	7047
14.8	20.0	2395
18.1	39.4	4251
18.0	39.3	4147
17.4	35.7	4080
19.9	54.1	7238
23.7	89.7	8192
22.1	81.4	11614
19.1	43.7	7968
19.3	49.2	9065
17.2	33.6	3276
16.3	29.1	3565
25.4	102.7	11480
17.4	36.1	4039
14.2	22.0	2263
14.5	20.1	2029
21.5	80.7	11687
20.7	64.7	10420
15.2	23.5	2034
15.3	24.4	3650
15.8	28.0	3440
16.4	30.9	3191
17.8	42.2	6280
18.8	44.7	5146
16.4	30.8	4423
18.8	45.8	8500
16.5	33.5	6411

Appendix IV Racial data of *I. africana* from Lagos Coast (23rd April 1979)

	TL (mm)	SL (mm)	HL (mm)	HD (mm)	BD (mm)	ED (mm)	D	A	P	GR (lt)	GR (rt)	V	AS	Vert.	Sex
1	165	133	38	37	47	11	14	44	15	34	34	6	33	42	F
2	165	134	37	40	47	11	15	45	14	34	34	6	32	42	M
3	167	135	38	40	46	12	15	46	15	34	34	6	33	42	M
4	153	123	35	37	44	10	15	46	15	33	33	6	30	42	F
5	156	128	35	37	43	11	15	45	15	34	34	6	31	42	M
6	156	128	35	36	47	10	15	45	15	34	34	6	33	42	F
7	158	128	33	36	45	10	15	46	14	34	34	6	31	42	M
8	165	135	35	39	46	11	16	47	15	33	33	6	33	42	F
9	168	137	37	40	47	12	15	45	15	33	32	6	35	42	M
10	142	115	32	36	52	10	16	41	15	33	33	6	31	42	F
11	164	135	40	40	42	14	15	45	15	33	33	6	34	42	F
12	168	136	37	40	47	12	15	44	15	33	33	6	31	42	M
13	150	120	32	38	41	10	15	47	15	33	33	6	30	42	M
14	159	130	35	38	44	11	18	45	14	33	33	6	33	42	F
15	175	142	35	41	51	13	15	48	15	35	35	6	31	42	M
16	176	142	37	41	52	12	17	49	15	35	36	6	33	42	F
17	164	133	36	38	44	11	15	41	14	36	36	6	31	42	F
18	147	116	33	36	45	10	16	44	15	33	33	6	32	42	M
19	165	135	38	40	45	11	16	43	15	33	33	6	30	42	M
20	150	120	35	37	43	10	15	47	15	33	33	6	31	42	M
21	196	160	45	47	54	13	15	46	15	33	33	6	31	42	M

(Contd.)

	TL (mm)	SL (mm)	HL (mm)	HD (mm)	BD (mm)	ED	D	A	P	GR (lt)	GR (rt)	V	AS	Vert.	Sex
22	151	121	34	36	43	10	16	43	15	33	33	6	34	42	M
23	183	150	45	43	53	12	16	42	15	33	33	6	33	42	M
24	190	155	45	44	54	14	15	46	14	33	33	6	33	42	M
25	145	116	32	37	42	10	15	45	14	34	34	6	32	42	M
26	175	142	35	41	51	12	16	46	15	33	33	6	35	42	F
27	160	131	37	38	47	11	15	42	15	33	33	6	32	42	F
28	179	145	40	44	53	12	16	43	14	33	33	6	33	42	M
29	158	132	36	40	46	12	16	41	15	33	33	6	33	42	F
30	154	122	35	40	45	10	15	42	13	33	33	6	31	42	M
31	178	147	41	43	53	12	15	48	15	33	33	6	32	42	F
32	164	135	42	40	47	11	15	45	14	33	33	6	33	42	F
33	159	131	35	40	45	11	15	47	14	33	33	6	32	42	M

Appendix V Racial data of I. africana off Benin River (24th April, 1979)

	TL (mm)	SL (mm)	HL (mm)	HD (mm)	BD (mm)	ED (mm)	D	A	P	Ge (lt)	Ge (rt)	V	AS	Vert.	Sex
1	150	121	32	37	45	10	16	47	15	33	33	6	31	42	M
2	147	120	35	35	42	10	15	43	14	34	34	6	33	42	M
3	155	126	36	38	45	11	18	46	14	34	34	6	30	42	M
4	172	141	40	45	54	12	17	46	15	37	36	6	33	42	M
5	175	145	41	44	48	13	16	42	15	33	33	6	30	42	F
6	146	120	31	35	42	10	16	50	15	33	33	6	34	42	M
7	176	145	40	44	52	13	16	50	15	34	34	6	31	42	M
8	180	148	40	45	52	13	15	46	14	33	33	6	33	42	M
9	147	120	32	35	43	10	16	48	15	33	33	6	32	42	M
10	170	138	38	41	50	12	15	47	16	33	33	6	32	42	M
11	171	140	40	43	50	12	15	47	16	35	34	6	32	42	M
12	187	156	42	44	52	12	15	47	15	33	33	6	33	42	F
13	164	135	36	41	46	10	16	44	15	33	33	6	30	42	F
14	156	125	35	40	45	10	15	46	14	33	33	6	33	42	M
15	158	127	35	40	45	11	15	46	16	33	33	6	32	42	M
16	142	115	32	31	41	9	16	48	15	34	34	6	34	42	M
17	161	128	36	41	46	11	15	48	15	33	33	6	33	42	F
18	148	121	33	36	43	10	15	46	15	33	33	6	33	43	F
19	157	130	35	39	44	11	17	47	15	33	33	6	30	42	M
20	146	118	31	38	41	10	16	44	14	33	33	6	32	42	M
21	150	120	37	38	42	10	16	44	15	33	33	6	31	42	M
22	148	119	34	36	43	10	15	48	15	33	33	6	33	42	F

(Contd.)

	TL (mm)	SL (mm)	HL (mm)	HD (mm)	BD (mm)	ED (mm)	D	A	P	Ge (lt)	Ge (rt)	V	AS	Vert.	Sex
23	186	150	45	45	52	13	16	46	14	34	34	6	34	42	F
24	175	143	41	42	48	12	14	47	14	33	33	6	30	42	M
25	180	145	43	43	51	13	14	45	14	34	34	6	32	42	M
26	165	135	37	41	47	11	15	48	15	34	33	6	33	42	F
27	190	155	44	44	58	13	15	46	15	33	33	6	31	42	F
28	176	142	38	40	51	12	15	46	15	33	33	6	31	42	M
29	188	152	43	45	52	13	16	44	14	33	33	6	32	42	F
30	175	142	39	41	50	12	16	46	14	33	33	6	32	42	M
31	189	153	46	47	57	13	15	48	14	34	34	6	33	42	F
32	169	137	40	40	47	11	15	46	15	31	31	6	31	42	M
33	142	115	30	33	41	9	15	44	14	33	33	6	32	42	M

Appendix VI Racial data of I. africana off Brass River (23rd April 1979)

	TL (mm)	SL (mm)	HL (mm)	HD (mm)	BD (mm)	ED (mm)	D	A	P	GR (lt)	GR (rt)	V	AS	Vert.	Sex
1	143	120	31	29	40	10	16	44	15	34	34	6	32	42	M
2	187	153	45	43	55	13	17	45	16	34	34	6	32	42	F
3	170	139	39	38	47	12	16	48	15	34	34	6	33	42	M
4	181	146	41	42	50	12	16	46	15	31	31	6	34	42	F
5	157	126	35	35	43	11	16	46	15	33	33	6	32	42	M
6	161	135	37	38	45	12	17	47	14	33	33	6	35	42	M
7	146	117	32	30	39	10	17	44	14	33	33	6	31	42	M
8	175	143	40	40	44	12	15	49	16	33	33	6	33	42	F
9	176	142	40	42	48	12	17	46	14	34	34	6	34	42	M
10	156	126	35	36	44	10	15	47	14	33	33	6	31	42	M
11	148	122	34	35	43	10	16	47	14	33	33	6	32	42	M
12	183	150	41	44	50	12	15	45	14	35	35	6	31	42	M
13	188	155	41	43	57	13	15	48	15	33	33	6	33	42	M
14	190	156	41	45	51	14	16	45	14	33	33	6	34	42	F
15	181	147	40	44	52	12	17	47	15	34	34	6	33	42	F
16	150	122	35	36	44	11	15	45	14	33	33	6	33	42	M
17	175	142	40	44	51	12	15	49	15	34	34	6	32	42	F
18	164	133	40	40	48	12	15	42	14	34	34	6	31	42	M
19	175	142	40	43	51	12	16	45	14	33	33	6	32	42	F
20	191	155	45	45	52	14	15	48	15	34	34	6	31	42	M
21	171	140	40	43	50	12	16	49	15	34	34	6	31	42	F

(Contd.)

	TL (mm)	SL (mm)	HL (mm)	HD (mm)	BD (mm)	ED (mm)	D	A	P	GR (1t)	GR (1t)	V	AS	Vert	Sex
22	188	150	43	45	53	13	15	45	15	33	33	6	33	42	F
23	150	122	35	37	44	11	15	49	15	33	33	6	28	42	M
24	180	148	40	43	49	12	15	46	14	33	33	6	34	42	F
25	187	153	45	43	57	13	15	46	15	33	33	6	34	42	F
26	161	135	37	37	45	11	15	49	15	34	34	6	31	42	M
27	175	142	40	42	48	12	15	47	15	34	34	6	31	42	M
28	164	133	39	40	48	12	16	45	15	33	33	6	31	42	F
29	141	113	35	35	40	10	15	42	14	34	34	6	29	42	M
30	149	122	35	35	42	10	15	47	14	33	33	6	33	42	F
31	177	145	42	43	50	13	15	46	15	33	33	6	35	42	F
32	156	127	37	38	44	11	15	47	14	33	33	6	32	42	M
33	160	130	37	39	46	11	16	48	15	33	32	6	31	42	F

Appendix VII   Racial data of I. *africana* off Bonny River (5th May, 1979)

	TL (mm)	SL (mm)	HL (mm)	HD (mm)	BD (mm)	ED (mm)	D	A	P	GR (lt)	GR (rt)	V	AS	Vert.	Sex
1	179	147	40	39	48	12	15	49	15	34	35	6	32	42	F
2	158	129	35	35	45	12	15	44	15	34	34	6	31	42	M
3	187	154	43	43	52	13	15	47	15	33	33	6	33	42	M
4	157	129	35	37	45	11	16	47	14	32	32	6	32	42	F
5	169	138	40	40	49	12	15	47	15	34	33	6	33	42	F
6	161	130	37	37	48	12	15	46	14	33	33	6	33	42	M
7	197	164	44	45	58	14	15	44	14	35	33	6	34	42	F
8	147	120	37	35	42	10	15	47	16	34	34	6	33	42	M
9	167	135	35	37	48	11	15	45	15	32	32	6	32	42	M
10	162	135	35	35	47	10	14	44	14	32	32	6	32	42	F
11	164	133	36	37	47	11	16	47	16	33	33	6	34	42	F
12	180	150	42	45	55	12	15	49	14	34	34	6	32	42	F
13	178	145	40	42	52	11	15	45	14	35	34	6	33	42	F
14	185	153	40	45	55	12	15	46	15	33	33	6	32	42	F
15	163	135	35	35	48	10	16	46	15	32	32	6	31	42	M
16	200	166	45	48	60	14	16	46	15	33	33	6	30	42	F
17	152	127	34	35	44	10	16	42	14	34	34	6	31	42	F

(Contd.)

	TL (mm)	SL (mm)	HL (mm)	HD (mm)	BD (mm)	ED (mm)	D	A	P	GR (1t)	GR (rt)	V	AS	Vert.	Sex
18	188	154	41	40	52	11	17	46	15	33	33	6	34	42	F
19	193	155	40	45	55	13	15	48	15	33	34	6	31	42	F
20	199	163	46	45	57	14	15	47	15	34	34	6	33	42	F
21	184	150	40	40	51	12	15	48	15	33	33	6	32	42	F
22	153	125	35	36	43	13	16	49	15	34	34	6	35	42	F
23	162	132	37	38	47	11	16	48	15	33	33	6	31	42	M
24	169	135	37	41	49	11	16	44	15	33	33	6	33	42	M
25	146	118	35	36	43	10	15	48	15	33	33	6	33	42	F
26	161	130	37	40	45	11	17	48	15	33	33	6	31	42	M
27	172	140	39	45	50	11	15	45	15	33	33	6	33	42	M
28	168	138	37	44	50	11	15	47	14	32	32	6	32	42	F
29	159	129	35	33	47	11	15	44	14	33	33	6	31	42	F
30	172	142	40	42	50	11	15	45	15	32	32	6	32	42	M
31	178	145	41	43	51	12	15	45	15	35	34	6	33	42	F
32	178	145	41	44	51	11	15	48	15	33	33	6	34	42	F
33	143	115	33	35	43	9	16	46	15	33	33	6	33	42	M