Some aspects of the trophic biology of *Ilisha africana* (Teleostei; Pristigasteridae) in Qua Iboe estuary, Nigeria

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Aspects of the food and feeding biology of the pristigasterid, *Ilisha africana* (Bloch, 1795) were studied over a 12-month period (November, 1987 - October 1988 inclusive) based on 1028 specimens (5.6 - 21.1 cm TL) from the Qua Iboe estuary, Nigeria. Feeding intensity increased with fish size and was higher in males than females; it was also higher in the dry season (November - February) than during the rains (March - October). Dominant food items comprised macrocrustaceans (notably mysids and penaeid + palaemonid shrimps) while fish, molluscs, polychaetes, algae, free living nematodes, insect remnants and detritus were of incidental importance. Variations in food composition with fish size, sex, months and seasons are presented. Food richness was higher in females than males and in the wet than dry season. No size-based variation in food richness was noted. Diet breadth was higher in the dry than wet season but no marked size and sex linked variations were discerned.

Quelques aspects de la nourriture et du régime alimentaire de Ilisha africana *(Teleostei: Pristigasteridae) dans l'estuaire de Qua Iboe, Nigéria.* – L'alimentation et le régime alimentaire de *Ilisha africana* (Bloch, 1975) a été étudié durant une période de 12 mois (de novembre, 1987 à octobre 1988) sur base de 1028 spécimens (5,6 - 21,1 cm LT) péchés dans l'estuaire de Qua Iboe au Nigéria. La quantité de nourriture ingérée augmente avec la taille des poissons et est supérieure chez les mâles par rapport aux femelles, elle est également plus importante en saison sèche (novembre-février) qu'en saison des pluies (mars-octobre). Les éléments importants de la nourriture sont les macrocrustacés (en particulier les Mysidae et les crevettes Penaeidae et Palaemonidae) tandis que les poissons, les mollusques, les polychètes, les algues, les nématodes libres, les restes d'insectes et les détritus sont d'importance mineure. Des variations dans la composition du régime alimentaire en relation avec la taille des poissons, leur sexe, les mois et les saisons sont mises en évidence. La richesse du régime alimentaire est plus élevée chez les femelles que chez les mâles ainsi que durant la saison humide par rapport à la saison sèche. Aucune variation de la richesse du régime n'est liée à la taille des poissons. Le régime alimentaire est plus varié durant la saison sèche que durant la saison humide mais aucune variation liée à la taille ou au sexe n'a été mise en évidence.

Key words: *Ilisha africana,* Pristigasteridae, Qua Iboe estuary, Nigeria, biology, food consumption.

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INTRODUCTION

The Nigerian coastal marine waters support considerable stocks of the shoaling pelagic pristigasterid, *Ilisha africana* (Bloch, 1795) which constitute a significant proportion of the canoe landings of artisanal fishermen (Williams, 1968). In the inshore waters East of the Niger Delta, *I. africana* is most abundant in the Qua Iboe estuary where it forms the dominant element of the artisanal fishery (Marcus *et al.* 1984).

In spite of the fishery importance of *I. africana* to Nigeria, very little attention has been given to its biology. Available records on various aspects of its biology are restricted to Lagos lagoon (Fagade & Olaniyan, 1973) and off the Lagos coast (Marcus & Kusemiju, 1984; Marcus, 1986) in western Nigeria. No attempt has hitherto been made to study the biology of this species from other areas of the coastal waters of the country.

In view of this paucity of information, the present study on aspects of the food and feeding biology of the population of *I. africana* in the Qua Iboe estuary, was conducted. These involved the assessment of the diet and feeding intensity of the fish in relation to size, sex, months and seasons.

STUDY AREA

Qua Iboe river (7°30' - 8°20'W; 4°30' - 5°30'N) (Fig. 1) is a dominant hydrographic feature in Akwa Ibom State, Nigeria. It drains a catchment area of about 7,092 km² and the river course covers a distance of c.150 km from its source at Umudike in Imo State to where it discharges into the Atlantic ocean at the Bight of Bonny, close to Ibeno. The southernmost part of the river basin consists of fine sandy coastal beach ridges covering an area of c.560 km². The estuary consists of tidal creeks, small brackish water lagoons and fringing mangrove swamps.

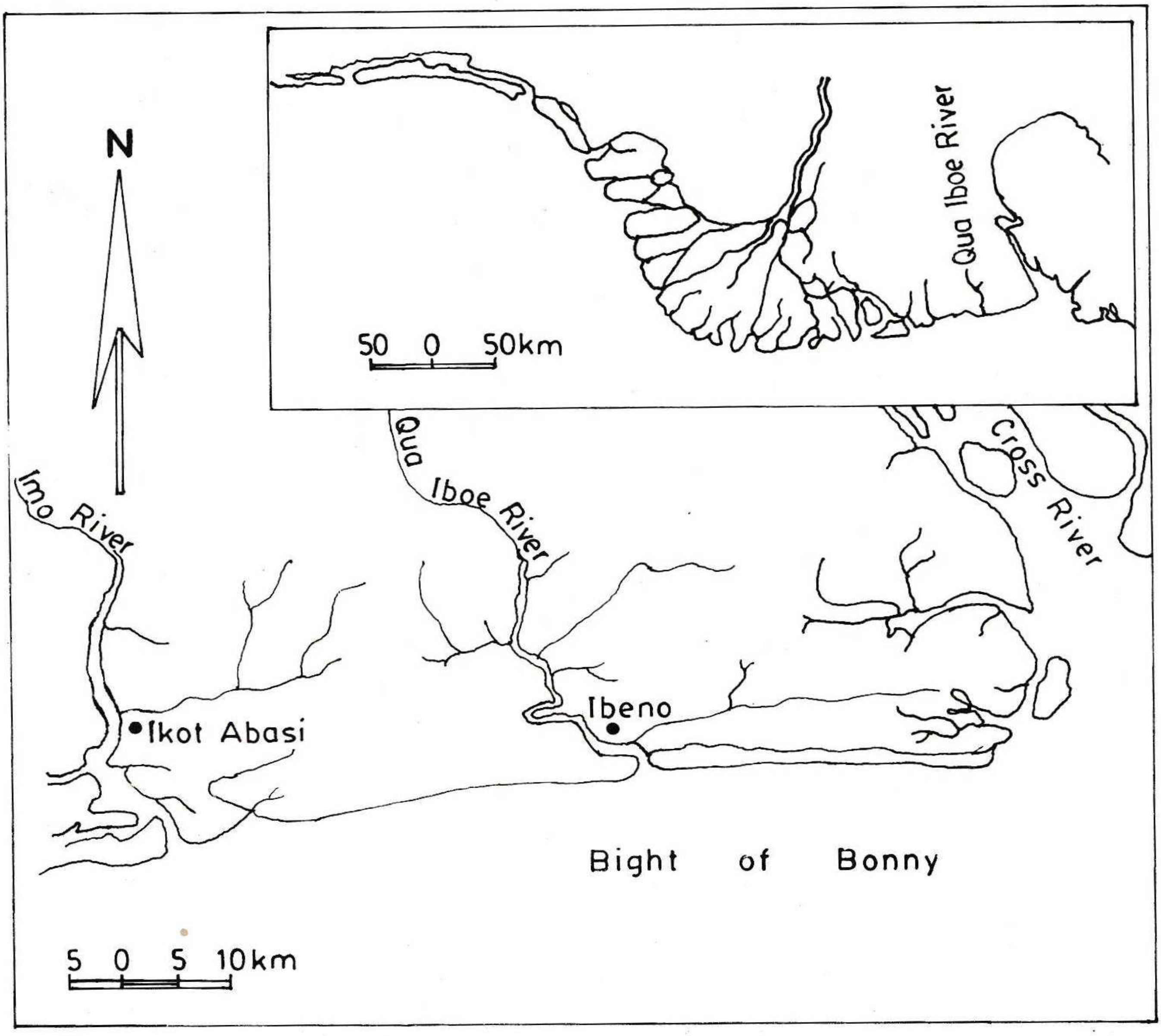

Fig. 1. – Map of the eastern coast of Nigeria showing the Qua Iboe estuary. Inset: the coast of Nigeria, showing the Qua Iboe River.

The vegetation of the mangrove swamps consists of predominantly *Rhizophora harrizonii* Leechman, *R. mangle* L., *R. racemosa* Meyer, *Avicennia africana* Beauv., and *Laguncularia racemosa* Gaertn. Few stands of *Nypa fructicans* Wurmb, *Phoenix reclinate* Jacq., and *Achrostichum aureum* L. also grow in some places.

The climate of the estuarine zone is typical of the equatorial regime with rainfall throughout the year. Two seasons (dry and wet) are however, discerned in the area. The dry season ranges between November and February with peak in January. The wet season extends from March to October with peak in August. The study area has been described in more detail elsewhere (Tahal Consultants, 1979).

MATERIALS AND METHODS

Monthly samples of *I. africana* were collected over a 12-month period (November, 1987 - October, 1988 inclusive) at about noon each day from artisanal fishermen who landed their catch at Ibeno terminal (Fig. 1). Fishing was mainly done by the use of encircling gill-nets (50 - 70 mm stretched mesh) operated from dugout canoes (7 - 12 mm LOA), some of which were powered by 15 - 40 H.P. outboard motors.

The specimens were transported to the laboratory where their total lengths (*TL*) were measured to the nearest 1 mm; they were preserved for 2 - 5 days in a deep freezer (at -10°C) pending further examination. Specimens were later dissected and the stomachs removed and slit open. The degree of fullness of each was estimated by an arbitrary 0-20 points scale; thus 0, 5, 10, 15 and 20 points were alloted to empty, 1/4 full, 1/2 full, 3/4 full and fully distended stomachs respectively. The percentage of empty stomachs (*ES*), full stomachs (*FS*), partially-filled stomachs (*PS*) (i.e. 1/4 - 3/4 full) and average stomach fullness (*AS*) (mean points per stomach) were used to evaluate patterns in feeding activity.

The stomach contents of each specimen were placed in a petri dish and aggregates dispersed with a small amount of water prior to macroscopic and microscopic examination. The contents were sorted, identified and the importance of each was assessed by the relative frequency (*RF*) and percentage points (*PP*) methods (Hyslop, 1980) modified by King (1988a, b) in trophic studies on *Liza* species. The integrated importance of each item was then expressed by an index of food dominance (*IFD*) (cf. Natarajan & Jhingran, 1961) according to the formula:

Table 1. – Monthly numbers and sizes of *I. africana* examined for food (November 1987 - October 1988)

Month	Number examined	Total length (cm)
November	81	12.3 - 19.2
December	108	12.0 - 20.2
January	98	12.0 - 19.8
February	102	13.2 - 21.1
March	54	11.3 - 20.5
April	51	12.6 - 20.3
May	16	11.2 - 17.2
June	24	5.6 - 9.8
July	107	5.6 - 18.8
August	137	11.3 - 19.5
September	116	11.3 - 21.0
October	137	12.0 - 20.3

$$IFD = \frac{RF\,.\,PP}{\sum(RF.\,PP)} \times 100$$

This index ranges from 0 to 100 %. Items with *IFD* ≥ 10 % were arbitrarily considered as dominant food items; those with *IFD* 1-9.9 % as secondary and those with *IFD* < 1 % as incidental. The use of *IFD* to establish overall food preponderance is adequate as it incorporates the *RF* and *PP* data, thus minimising the bias characteristic of cases in which results from different analytical methods are independently interpreted.

Food richness was defined as the number of major items in the diet; the *IFD* data were used to compute diet breadth based on Shannon's function, *H'* (King, 1988a, 1989). Feeding intensity and food composition data were analysed by *d*-statistic and *t*-test (Bailey, 1959). The number of specimens examined per month and their size ranges are presented in Table 1.

RESULTS

Of the 1028 specimens of *I. africana* (5.6 - 21.1 cm TL) examined for food (Table 1), 21 (2.04 %) had full stomachs, 512 (49.81 %) empty, and 495 (48.15 %), partially-filled stomachs.

Variation in feeding intensity with size

In order to assess the ontogenetic changes in food and feeding habits of *I. africana,* specimens were categorised into two size-groups (small-sized group (*SSG*: < 15 cm *TL*) and large-sized group (*LSG* ≥ 15 cm *TL*)). These two size-groups were chosen since according to King (unpubl.), *I. africana* of the *SSG* are sexually immature while those of the LSG comprise mature fishes. Fig. 2a illustrates the indices of stomach fullness of the *SSG* (size range 5.6 - 14.9 cm *TL*; $n = 535$) and *LSG* (size range 15.0 - 21.1 cm *TL*; $n = 487$) examined. There was no significant difference in FS and PS between the size groups (*d* - test: $p > 0.05$ in each case). However, *ES* was significantly higher in the *SSG* ($d = 1.988, p < 0.05$) while *AS* was higher in the *LSG* ($t = 1.775, p < 0.05$).

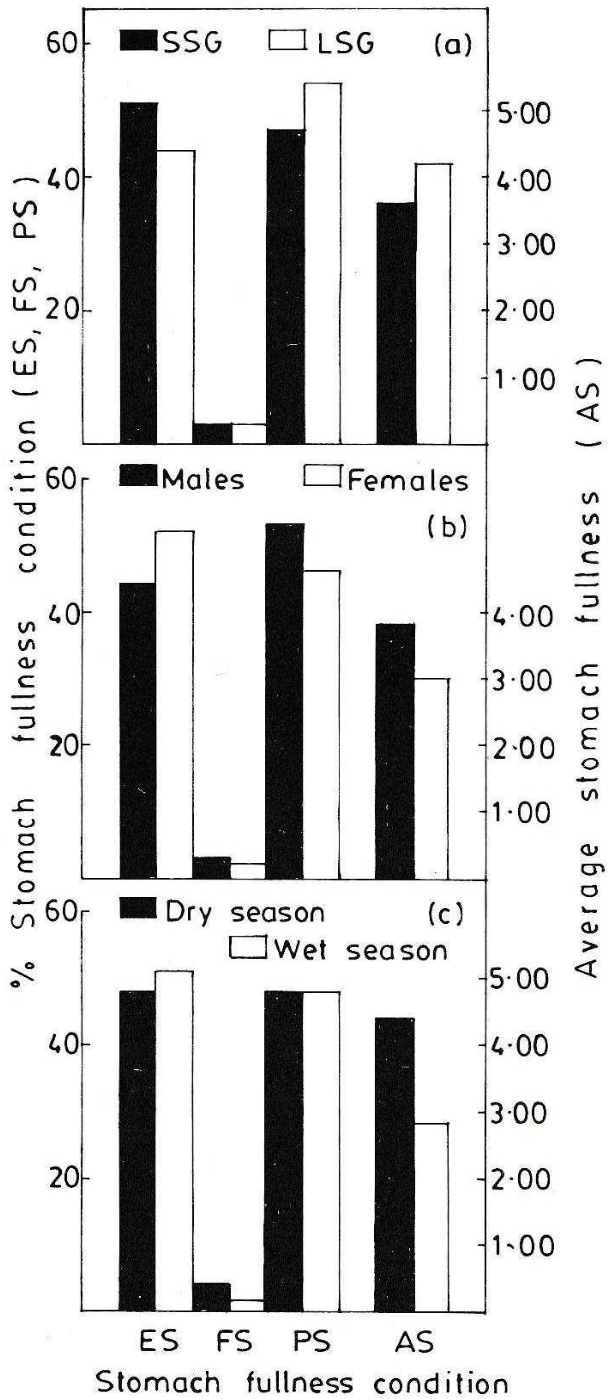

Fig. 2. – Variations in indices of feeding activity ES = % empty stomachs; FS = % full stomachs; PS = % partially filled stomachs; AS = average stomach fullness) of *I. africana* in relation to size (a) (SGG = small-sized group; LSG = Large-sized group), sex (b) and season (c).

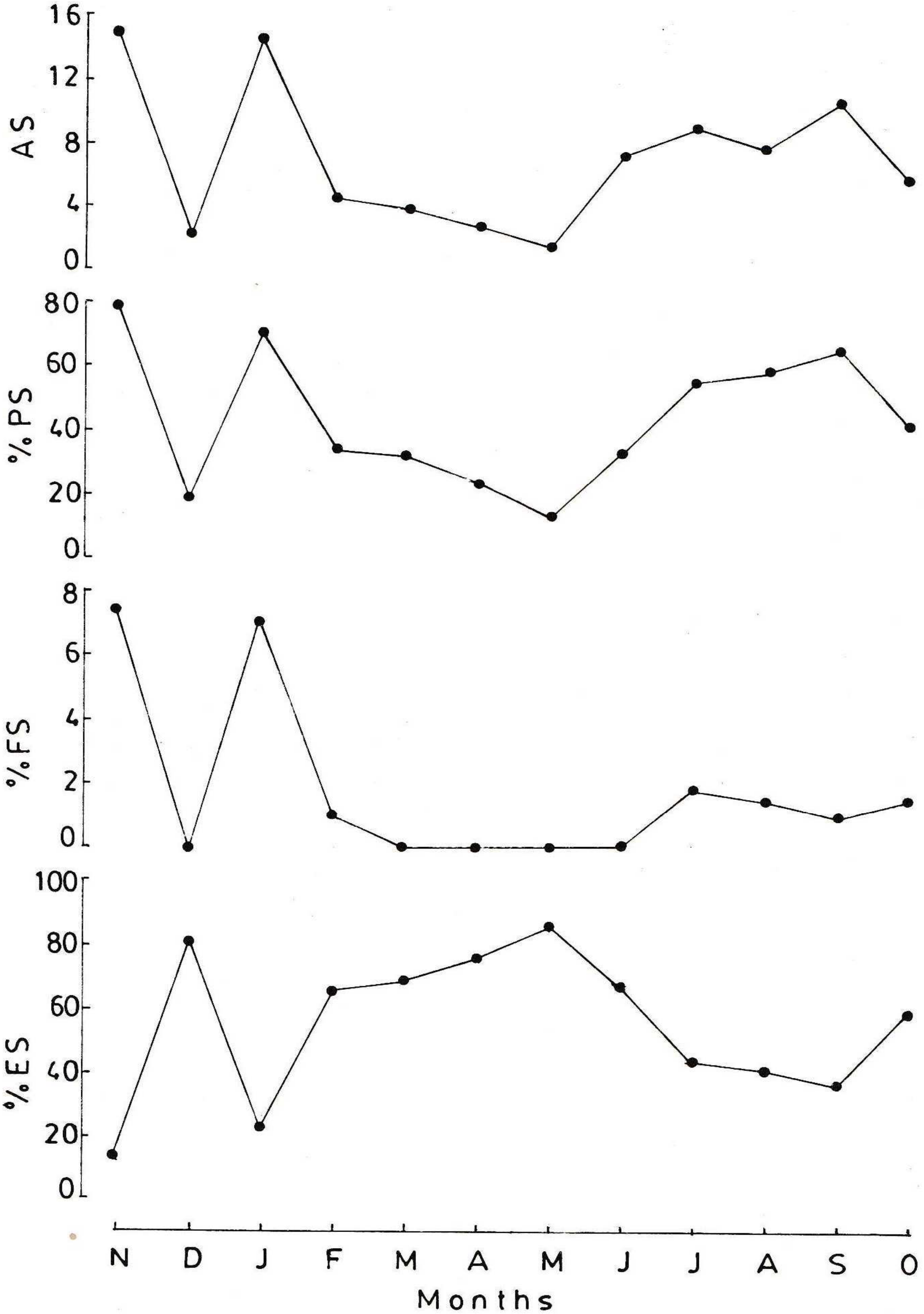

Fig. 3. – Monthly variation in indices of feeding activity (% ES = percentage empty stomachs; % FS = percentage full stomachs; % PS = percentage partially filled stomachs; AS = average stomach fullness) of *I. africana*.

Variation in feeding intensity with sex

A total of 1028 specimens, comprising 314 males (size range 5.6 - 21.2 cm *TL*) and 714 females (size range 5.6 - 21.0 cm *TL*) were examined for sex-dependent variation in feeding intensity. The stomach repletion of both sexes (Fig. 2b) showed no significant difference in FS (d-test: $p < 0.05$) between them. However, *ES* was significantly higher (d = 2.412, $p < 0.02$) in females than males while males had significantly higher *PS* (d = 2.188, $p < 0.05$) and *AS* ($t = 44.000$, $p < 0.01$) than females.

Temporal regimes in feeding intensity

The monthly changes in stomach repletion (Fig. 3) showed that peak *FS, PS* and *AS* occured in November and January, these coinciding with the months with lowest ES. These results indicate high feeding intensity in November, January and July - October while low feeding intensity occurred in December and February - May.

A total of 396 specimens (12.0 - 21.1 cm *TL*) were examined in the dry season and 632 (5.6-21.0 cm *TL*) in the wet season. The seasonal variation in stomach fullness conditions is presented in Fig. 2c. There was no significant seasonality in *ES* and *PS* of the fish (d-test: $p > 0.05$ in each case). However, there was a significant dry season increase in *FS* (d = 2.778, $p < 0.001$) and *AS* ($t = 10.733$, $p < 0.001$), thus suggesting that feeding intensity was higher in the dry season than during the rains.

Table 2. – Overall trohic spectrum of *I. africana*

Food items	% index of food dominance (*IFD*)
Crustaceans	
Penaeid + palaemonid shrimps	48.07
Mysids	50.86
Amphipods	0.02
Fish	
Ilisha africana	0.04
Unid. fish	0.61
Fish larvae	+
Fish eggs	0.28
Fish scales	0.06
Molluscs	
Cephalopods	0.01
Unid. gastropods	+
Polychaetes	
Nereis	+
Algae	
Dinobryon	+
Nematodes (free living)	0.01
Insect remnants	+
Detritus	+

+ = < 0.01 % *IFD*

Diet composition

The overall stomach contents of *I. africana* (Table 2) revealed that 15 major items were ingested, of which 2 were of primary importance and 13, of incidental importance. It fed predominantly on macro-crustaceans (98.93 % *IFD*) while fish, molluscs, polychaetes, algae, nematodes, insect remnants and detritus were of minor importance, each forming < 1.00 % *IFD* of the diet.

Crustaceans consumed were dominated by mysids and closely followed by the composite of penaeid (*Parapenaeopsis atlantica* Balss) and palaemonid (*Nematopalaemon hastatus* (Aurivillus)) shrimps; amphipods accounted for only 0.02 % *IFD* of the diet. The occurrence of *I. africana* in the stomachs of some specimens is an indication of cannibalism; other fishes consumed could not be identified. Cephalopods in the diet were represented by *Sepia*, and phytoplankton, by *Dinobryon*.

Most of the stomach contents of *I. africana* from Qua Iboe estuary are indicative of predominantly mid-water foraging. However, the ingestion of small amounts of detritus (coarse particulate organic matter) is a clue that it probably also feeds close to the bottom.

Variation in diet with size

Table 3 illustrates the ontogenetic changes in the trophic spectra of the two size groups of *I. africana*. There was no size-dependent variation in food richness although slight differences were

Table 3. – The trophic spectra of the small-sized group (SSG) and large-sized group (LSG) of *I. africana*

Food items	% index of food dominance (IFD) *SSG*	*LSG*	*P**
Penaeid + palaemonid shrimps	42.25	57.49	< 0.001
Mysids	56.76	41.54	< 0.001
Amphipods	0.07	0.01	ns
Ilisha africana	0.07	0.01	ns
Unid. fish	0.36	0.47	ns
Fish larvae	0.01	+	ns
Fish eggs	0.16	0.30	ns
Fish scales	0.17	0.02	< 0.05
Cephalopods	0.01	0.09	< 0.05
Unid. gastropods	–	+	
Nereis	0.04	–	
Dinobryon	+	–	
Nematodes	0.07	0.06	ns
Insect remnants	–	+	
Detritus	+	0.01	ns
Food richness	13	13	
Diet breadth	0.75	0.74	

**P* = significance level of difference between size groups for *d*-test.
ns = no significant difference.
+ = < 0.01 % *IFD*

discerned in the qualitative food composition of the size-groups. For instance, unidentified gastropods and insect remnants were not ingested by the *SSG* while *Dinobryon* and *Nereis* were absent from the diet of the *LSG*. Similar trends occurred in the rank-order of the *IFD* of the food items (Spearman rank correlation: $r_s = 0.823$, $p < 0.002$) of the two size-groups although there were marked differences in the proportions of some of the items.

There was an increase with fish size of the *IFD* of shrimps and cephalopods and a decrease in that of mysids and fish scales. No marked size-based changes were apparent in the relative importance of amphipods, unidentified fish, fish larvae, *I. africana,* fish eggs, nematodes and detritus. Indices of diet breadth were higher in the *SSG* than in the *LSG* (Table 3), indicating an increasing food specialization with fish growth.

Variation in diet with sex

Sex-dependent changes in the food-composition of *I. africana* are summarised in Table 4. Food richness was higher in females than males by a factor of 6. Fish larvae, cephalopods, unidentified gastropods, insect remnants, *Dinobryon* and detritus were not ingested by males while the complete array of items shown in Table 4 was consumed by the females. Although both sexes exhibited similar patterns in the rank-order of the *IFD* of the food items ($r_s = 0.822$, $P < 0.002$), the proportions of some of them were different.

Table 4. – Sex-dependent variation in the food composition of *I. africana*

Food items	% index of food dominance (IFD) Males	Females	P*
Penaeid + palaemonid shrimps	42.32	51.15	< 0.001
Mysids	56.81	47.68	< 0.001
Amphipods	0.01	0.03	ns
Ilisha africana	0.06	0.02	ns
Unid. fish	0.49	0.68	ns
Fish larvae	–	+	
Fish eggs	0.16	0.35	ns
Fish scales	0.08	0.05	ns
Cephalopods	–	0.02	
Unid. gastropods	–	+	
Nereis	0.02	+	ns
Dinobryon	–	+	
Nematodes	0.05	0.01	< 0.001
Insect remnants	–	+	
Detritus	–	+	
Food richness	9	15	
Diet breadth	0.74	0.76	

*P = significance level of difference between size groups for *d*-test.
ns = no significant difference.
+ = < 0.01 % *IFD*

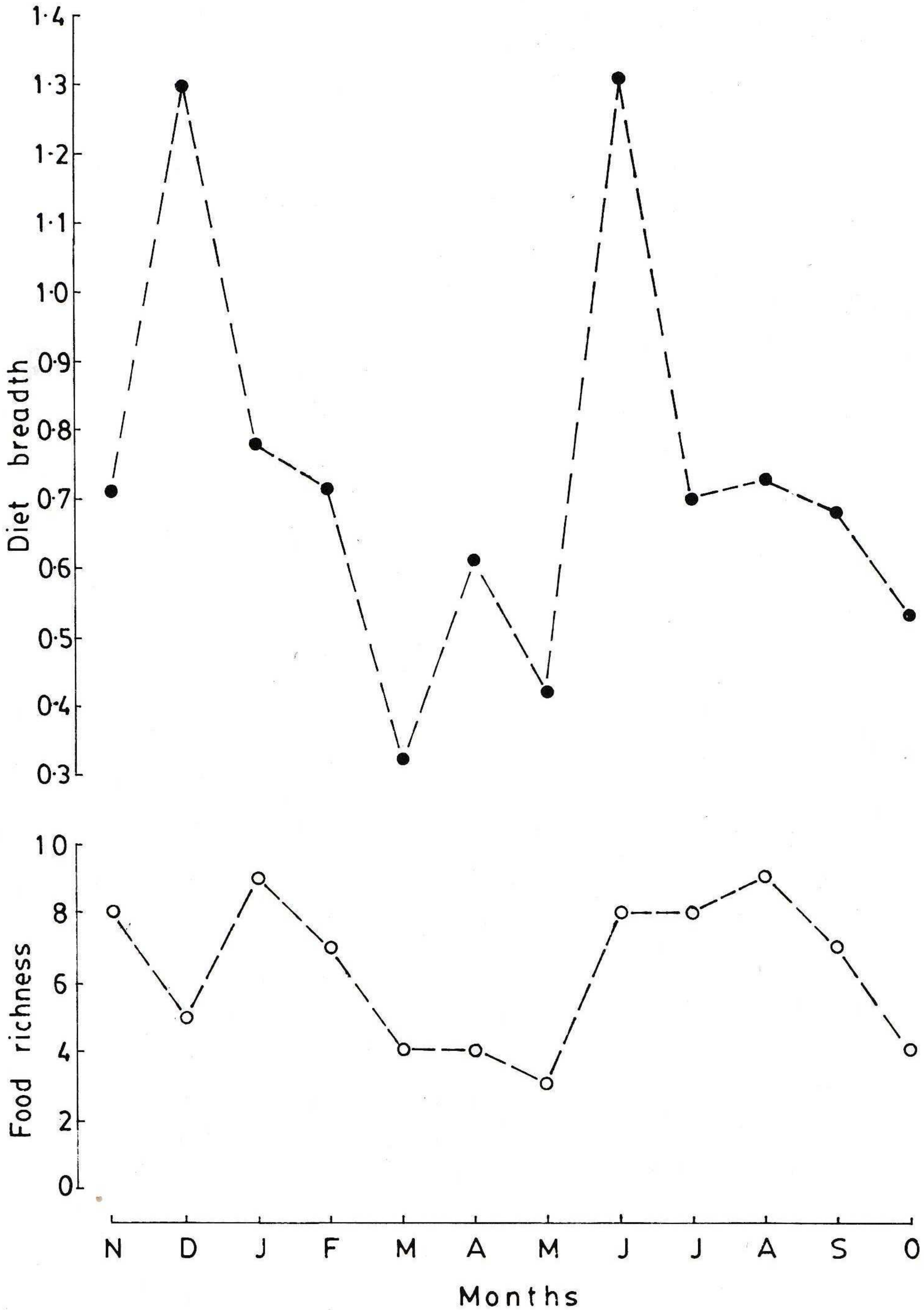

Fig. 4. – Monthly variation in food richness and diet breadth of *I. africana*.

Males had significantly higher *IFD* of mysids and nematodes than females, while females had higher *IFD* of shrimps than males. There was no variation with sex of the *IFD* of amphipods, *I. africana*, unidentified fish, fish scales, fish eggs and *Nereis*. Diet breadth was not markedly different in both sexes (Table 4).

Temporal regimes in diet

Monthly dynamics in food richness (Fig. 4) ranged from 3 in May to 9 in January and August. High values (7 - 9) were recorded in November, January, February and June - September while low values (3 - 5) were obtained for all other months.

Crustaceans predominated in all months, with peaks in November, January, March-April and August-October. Fish was of primary importance only in December and June; it was of secondary importance in January-May and July while in November and August-October, it was of incidental importance. The insect and algal components of the diet were consumed as incidental items in January and August respectively. Nematodes occurred as incidental food items in November, January and August - September and detritus in July and October; detritus was of secondary importance in June.

The monthly rhythms in diet breadth (Fig. 4) showed high variability with values ranging from 0.32 in March to 1.31 in June; it was less than 1 in all months except December and June when values exceeded 1.

The composite diet data for the two main seasons (Table 6) showed that the wet season food richness was slightly higher than the dry season value. The qualitative food compositions portrayed high similarity in both seasons apart from the exclusion of unidentified gastropods and insect remnants during the rains and fish larvae, polychaetes and detritus during the dry season. Similar seasonal trends occurred in the rank-order of the *IFD* of the food items (r_s = 0.808, P < 0.002) although there were differences in some of their relative proportions.

There was a marked wet season increase in the *IFD* of mysids and *I.*

Table 5. – Monthly variations in the % index of food dominance (*IFD*) of *I. africana*

Food items	Months N	D	J	F	M	A	M	J	J	A	S	O
Crustaceans	93.84	73.00	98.45	90.43	97.90	98.86	94.40	71.87	95.88	99.43	99.72	99.95
Fish	0.11	27.00	1.52	9.57	2.10	1.14	5.60	13.29	3.89	0.46	0.22	+
Molluscs	0.02	–	0.01	–	–	–	–	5.19	–	0.05	–	–
Polychaetes	–	–	–	–	–	–	–	6.67	0.12	–	–	–
Aglae	–	–	–	–	–	–	–	–	–	+	–	–
Nematodes	0.03	–	0.01	–	–	–	–	–	–	0.07	0.06	–
Insect remnants	–	–	+	–	–	–	–	–	–	–	–	–
Detritus	–	–	–	–	–	–	–	2.98	0.02	–	–	0.05

+ = < 0.01 % *IFD*

africana and a dry season increase in that of shrimps, unidentified fish and fish eggs. No significant seasonality occurred in the *IFD* of amphipods, fish scales, cephalopods and nematodes. Diet breadth was slightly higher in the dry season than during the rains.

DISCUSSION

The proportion of empty stomachs of *Ilisha africana* observed here is high in comparison to the value recorded by Marcus (1986) in the population off the Lagos coast. The large proportion of empty stomachs in specimens from Qua Iboe estuary could be due to the regurgitation of food when the fishes were caught in gill-nets although this is unlikely for all specimens. Another possibility is that feeding is restricted to certain periods of the day and the specimens examined were probably caught during low feeding activity. It is also attributable to a generally low feeding activity of the population which may be induced by low availability and abundance of specific food resources in the estuary. The latter assertion, however, requires further investigation.

This study revealed that the feeding intensity of *I. africana* increased with fish size. This is not consistent with the idea of a negative correlation between feeding intensity and fish size relative to metabolic rates (Lagler *et al.*, 1977;

Table 6. – Seasonal variation in the food composition of *I. africana*

Food items	% index of food dominance (*IFD*)		
	Dry season	Wet season	*P**
Penaeid + palaemonid shrimps	53.69	44.85	< 0.001
Mysids	44.14	54.48	< 0.001
Amphipods	0.03	0.02	ns
Ilisha africana	+	0.08	< 0.05
Unid. fish	0.99	0.42	< 0.001
Fish larvae	–	+	
Fish eggs	1.02	0.04	< 0.001
Fish scales	0.09	0.04	ns
Cephalopods	+	0.01	ns
Unid. gastropods	+	–	
Nereis	–	0.01	
Dinobryon	–	+	
Nematodes	0.02	0.02	ns
Insect remnants	0.01	–	
Detritus	–	0.01	
Food richness	11	13	
Diet breadth	0.80	0.73	

**P* = significance level of difference between size groups for *d*-test.
ns = no significant difference.
+ = < 0.01 % *IFD*

Sarker *et al.*, 1980; Blay & Eyeson, 1982). The increase in feeding intensity with fish size in *I. africana* is probably due to the fact that larger fishes, because of their greater body size, mouth gape and swimming speed, have a greater foraging efficency than smaller ones.

The feeding intensity of male *I. africana* was significantly higher than that of the female; the precise reason for this difference is uncertain but could be linked to sex-related differential energy requirements. The seasonality in stomach fullness conditions of *I. africana* indicated a higher feeding intensity in the dry season than the rains, a pattern analogous to that of the cyprinid, *Labeo fimbriatus* (Bloch) in India (Bhatnagar & Karamchandani, 1970) and the mormyrid, *Brienomyrus brachyistius* (Gill) in Nigeria (King, 1989). According to Marioghae (1985), the peak abundance of shrimps in Nigerian coastal waters is during the dry season (November-February). Therefore, the dry season increase in feeding intensity of *I. africana* in Qua Iboe estuary could be linked to the increased abundance of one of its principal food items - the shrimps.

I. africana from Qua Iboe estuary fed principally on crustaceans while fish, molluscs, polychaetes, algae, nematodes, insect remnants, and detritus were of subsidiary importance. In Lagos lagoon, this species fed mainly on penaeid shrimps and fish fry as well as unidentified items (Fagade & Olaniyan, 1973). Marcus (1986) noted the diet of this species from off the Lagos coast as comprising mainly crustaceans, fish and molluscs; insects, annelids, chaetognaths, coelenterates, nematodes, urochordates and phytoplankton were of minor importance. The above reports are broadly similar to the present findings, except that the range of items ingested by *I. africana* in Qua Iboe estuary is appreciably less than that reported by Marcus (1986) off Lagos coast. Although the stomach contents of *I. africana* from Qua Iboe estuary protrayed predominantly mid-water foraging, planktonic items were virtually absent from the diet. This is not in accordance with the planktophagy exhibited by several related species (Reynolds, 1969; Fagade & Olaniyan, 1973; Okera, 1973; Ramaiyan and Whitehead, 1975; Otobo and Imevbore, 1979; Blay and Eyeson, 1982). The limited importance of phyto- and zoo-plankton in the diet of Qua Iboe estuary population of *I. africana* is probably due to the absence of a rich planktonic community in the estuary. The cannibalism observed among *I. africana* in this estuary has not been previously reported elsewhere. It was probably accentuated by the general paucity of food in the area and/or high water turbidity which made prey segregation difficult during foraging.

This study revealed that the relative importance of large-sized items such as penaeid/palaemonid shrimps and cephalopods increased with fish size while that of small-sized items such as mysids and fish scales decreased. Similar observations were made by Marcus (1986). The inherent increase in mouth gape with body growth of the fish probably permits this prey-size related feeding pattern by *I. africana*. Ontogenetic variation in relative importance of fish diet (as observed in *I. africana*) may result from changes in food predilection and/or foraging ability for the preferred food items. The ecological significance of the diversification in fish diet with growth is that it minimizes intraspecific competition and offers a wider spectrum of food resources for exploitation by the species (Whyte, 1975; King, 1989). The food richness and diet breadth of *I. africana* from Qua Iboe estuary did not change with growth. These contradict Nikolsky's (1963) assertion that in most fishes food spectrum widens and food richness increases with growth.

The observed sex-related divergence in food habit of *I. africana* probably reduces intersexual competition for food resources and is important for the estuary's ability to sustain large populations of the fish.

The monthly and seasonal dynamics in the relative importance of the items eaten by *I. africana* from the Qua Iboe estuary are probably due to the temporal patterns in the availability and abundance of the food items in the estuary. Thus the dry season increase in the relative importance of shrimps could closely be linked to the peak abundance of shrimps in the estuary during this period (Marioghae, 1985).

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