Observations on Liza falcipinnis *(Valenciennes, 1836) in Bonny River, Nigeria*

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ABSTRACT

Some aspects of the ecology of Liza falcipinnis *(Valenciennes) were studied in the Bonny River, Niger Delta, Nigeria. The fish which occurred in the river throughout the year was distributed throughout most of the river's length, penetrating the freshwater zone, up to 87 km from the coast. It preferred muddy and sandy bottoms and was the most common and abundant mugilid, constituting 34% of the canoe landings of artisanal fishermen.*

L. falcipinnis *fed primarily on fine particulate organic matter, mud, sand, Bacillariophycae, Myxophyceae, Chlorophyceae and secondarily on coarse particulate organic matter, Rhodophyceae, Dinophyceae, Microarthropoda and free living Nemathelminthes. It ingested inorganic particles of 0.035 ± 0.004 mm (mean size). There was substantial variation in diet with fish size but no significant seasonal and spatial variations.*

L. falcipinnis *fed in schools during day and night albeit more actively during the day. Active feeding behaviour involved body inclination at an obtuse angle to the river bottom, with head pointing downward and swimming forward as it grubbed through bottom deposits. Less active feeding involved stirring of bottom deposits with the paired and caudal fins and thereafter sucking up the total suspended load. It also browsed on 'aufwuchs' algae on* Rhizophora *prop roots by nibbling on the latter.*

KEY WORDS : West Africa — Estuaries — *Liza falcipinnis* — Nigeria — Food consumption.

RÉSUMÉ

OBSERVATIONS SUR *LIZA FALCIPINNIS* (VALENCIENNES, 1836) DANS LA RIVIÈRE BONNY (NIGERIA)

Liza falcipinnis *occupe pendant toute l'année l'ensemble de la rivière Bonny, dans l'estuaire du Niger, jusqu'à 87 km de la côte. Il préfère les fonds vaseux et sableux. C'est le mugilidé le plus commun dans les pêches artisanales, dont il constitue 34% des prises.*

L. falcipinnis *insère principalement des fines particules de matière organique, de vase, de sable, des algues Bacillariophyceae, Myxophyceae, Chlorophyceae et secondairement de particules plus grosses de débris organiques, des Rhodophyceae, Dinophyceae, des micro-arthropodes et des Nemathelminthes libres. La taille moyenne des particules minérales ingérées est de 0,035 + 0.004 mm. Il apparaît une évolution du régime alimentaire en fonction de la taille, mais pas de variations saisonnières ou spatiales.*

L'espèce se déplace en bancs et se nourrit plus activement le jour, essentiellement par alimentation active, tête pointée vers le sédiment. Elle peut aussi agiter le sédiment et filtrer les matières mises ainsi en suspension. L. falcipinnis *broute occasionnellement les épibiontes des racines de* Rhizophora.

MOTS-CLÉS : Afrique de l'Ouest — Estuaires — Nigeria — *Liza falcipinnis* — Nutrition — Mulgilidae.

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1. INTRODUCTION

In the Niger Delta, Nigeria, *L. falcipinnis* constitutes a significant proportion of the canoe landings of artisanal fishermen and is reared in polyculture in brackishwater ponds.

Various aspects of its ecology have been studied in the Black Johnson estuary, Sierra Leone (PAYNE, 1976; WILSON, 1977) and Lagos lagoon, Nigeria (FAGADE and OLANIYAN, 1973). Apart from the recent works of KING (1984) and OLANIYI (1984), the ecology of this species has received little consideration in the Niger Delta, despite its economic importance. In view of this paucity of information, ecological observations on *L. falcipinnis* in the Bonny River were undertaken between December, 1982 and November, 1983 inclusive. These involved, *inter alia*, its spatial distribution, relative abundance, food composition, dietary shifts with growth and spatio-temporal patterns in food preference.

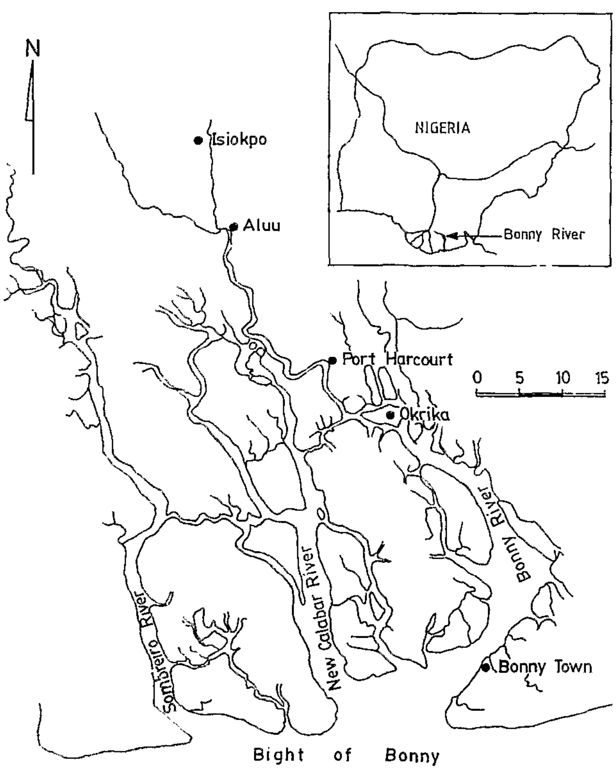

FIG. 1. — Map of eastern Niger Delta showing the location of Bonny River. Inset : map of Nigeria illustrating the aproximate position of Bonny River. *Carte de la partie est du delta du Niger. En encart, position de la R. Bonny dans le Nigeria*

2. THE STUDY AREA

The Bonny River (4°20'N, 7°13'E) (fig. 1) lies within the equatorial guinean deltaic zone of Nigeria (SYDENHAM, 1977). It drains a tidal swamp of about 60,762 ha. Ebb and flood volumes are 630 × 10^6 and 586 × 10^6 m^3 respectively (NEDECO, 1961; DANGANA, 1985). Mean tidal range increases from 1.35 m at Bonny town (4°30'N, 7°15'E; ca. 13 km from the coast (FTC)) on the estuary to 2.15 m upstream at

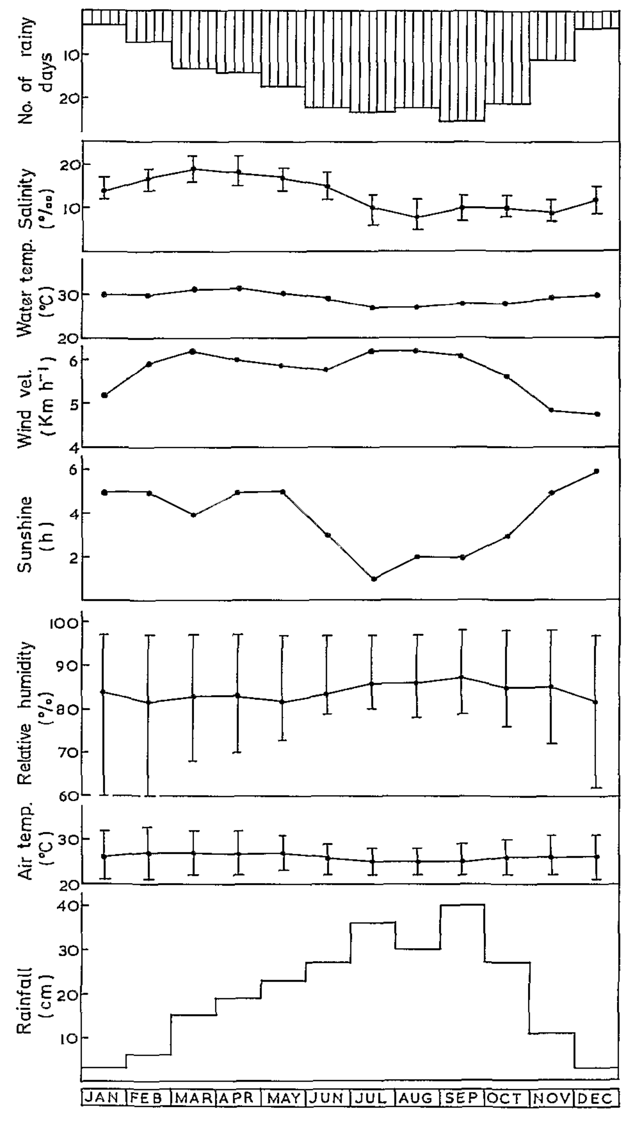

FIG. 2. — Temporal dynamics in mean hydrometeorological parameters of the Bonny basin at Port-Harcourt. Vertical lines are ranges. *Environnement climatique et physique de la R. Bonny à Port-Harcourt. Les barres verticales indiquent les extrêmes observés*

Port-Harcourt (4°25'N, 7°03'E; ca. 60 km FTC) (Wokoma and Ezenwa, 1982).

The water is mixohaline throughout the year and freshwater discharge is insignificant. The salinity is ca. 25‰ at the estuary, 11-22‰ at Okrika (4°36'N, 7°06'E; ca. 48 km FTC), 5-22‰ at Port Harcourt and less than 0.5‰ at Aluu (ca. 87 km FTC) (fig. 1). Salinity variations with tide and depth are less than 2‰ (Nedeco, 1961). Mean monthly surface temperature ranges between 27 and 30 °C. Temporal dynamics in salinity and temperature regimes are presented in figure 2. The predominant macrophytes of the fringing swamps are *Rizophora harrizonii* Leechman, *R. mangle* L., *R. racemosa* G. R. W. Meyer, *Avicennia africana* P. Beauv., *Laguncularia racemosa* Gaertn., *Nypa fruticans* Wurmb, *Phoenix reclinate* Jacq., *Acrostichum aureum* L. and *Paspalum vaginatum* Swartz.

Two seasons (dry and wet) prevail in the Bonny basin. The dry season (November - April) is characterized by the prevalence of dry north-easterly winds from the Sahara desert and low mean monthly rainfall (3-19 cm); the wet season (May-October) is characterised by the prevalence of moist south-westerly winds from the Atlantic Ocean and high mean monthly rainfall (23-40 cm) with a double maximum, in July and September. Annual mean total rainfall is 240 cm with 182 rainy days.

Further details on the Bonny basin are provided by Nedeco (1961), Scott (1966) and Dangana (1985).

3. MATERIALS AND METHODS

Samples of *L. falcipinnis* were collected monthly from the main channel and creeks of the Bonny River at Bonny town, Okrika and Port-Harcourt, although field observations were extended to Aluu (fig. 1). Fishing was done with cast-nets (10-25 mm mesh size) during day/night and high/low tides. These gears plus field observations provided information on spatial distribution, habitat preference and feeding behaviour. Relative abundance was estimated by numerical analysis of canoe landings of artisanal fishermen (King, 1984).

Samples of *L. falcipinnis* were taken for gut contents analyses; after being given a reference number, each specimen was measured to the nearest mm total length before preservation in 10% formalin. Total length can be converted to standard length using the following relationship :

SL = 0.0254 + 0.7708 TL ($r = 0.999$, $P < 0.002$) where SL = Standard length and TL = total length. Each specimen was later dissected and the stomach contents placed in a Petri dish. Aggregates were dispersed with a small amount of distilled water; subsamples taken from this stock were examined under a binocular microscope (X100). Food items were identified and their relative importance evaluated by the 'relative frequency' and 'points' methods.

The relative frequency (RF) of each item (based on all non-empty stomachs examined) was computed according to the formula :

$$RF = \frac{f_i}{\sum_{i=1}^{n} F_i} \times 100$$

where f_i = frequency of item i; F_i = frequency of the n^{th} item (= sum of all f_i). This is a modification of the 'occurence' method (Hyslop, 1980) commonly used in fish dietary studies. In the points method, each non-empty stomach was assigned 20 points regardless of fish size and these were shared amongst the variety of contents, taking account of their relative proportions by volume. Ten microscope fields of view were examined per stomach and mean points gained by each item determined; total mean points was calculated and expressed as percentage of grand total points gained by all stomach contents. This is similar to the points method reviewed by Hyslop (1980). Items with RF and/or percentage points (PP) of 10 and over were arbitrarily considered as primary dietaries and those less than 10 as secondary. The rectal contents of fish specimens were also examined microscopically to qualitatively assess the state of the dietaries after passing through the stomach and intestine.

Diet breadth was calculated on RF and PP data based on Simpson's (1949) diversity index (D) derived from the formula :

$$D = 1 - \sum_{i=1}^{j} ({}^{ni}/N)^2$$

where ni = relative frequency or percentage points of item i; N = total RF or PP of the jth item. The sizes of inorganic particles from stomachs of 30 specimens (90-220 mm TL) were measured in mm with a binocular microscope fitted with an eyepiece graticule calibrated against a stage micrometer slide and the mean ± standard error calculated. Spearman rank correlation coefficient (r_s) (Neave, 1978) was used to test for the relationship between fish size and the RF and PP of food items.

Seasonal and spatial variations in food composition were evaluated by Wilcoxon signed-rank statistic (W) (Neave, 1978) with the null hypotheses that there were no significant seasonal and spatial differences in food preference.

4. RESULTS AND DISCUSSION

Spatial distribution and habitat preference

The monthly incidence of occurrence of *L. falcipinnis* in canoe landings of artisanal fishermen showed that it occurred in the river on a year-round basis. It was distributed throughout most of the river's length and readily penetrated the freshwater zone up to Aluu (fig. 1).

L. falcipinnis may be regarded as a euryhaline mugilid, a trait which could enhance its suitability for culture in freshwater ponds. *L. falcipinnis* had a predilection for both muddy and sandy bottoms. This contrats with the preference of muddy bottom by *Liza grandisquamis* (Valenciennes) (King, 1984, 1986), an allied cœxisting species. Payne (1976) adduced evidence from which he asserted that *L. falcipinnis* is probably the most abundant mugilid in West African estuaries. The present observations in the Bonny River corroborate this assertion.

Food composition

The trophic spectrum of *L. falcipinnis* (table I) shows that eleven major items constituted its diet. The RF and PP methods gave similar quantitative results. This was indexed by the significant positive relationship ($r_s = 0.955$, $P < 0.002$) between ranked variates from the two analytical methods.

Primary dietaries were fine particulate organic matter (FPOM) (= fine detritus), mud, sand, Bacillariophyceae (diatoms), Myxophyceae (bluegreen algae) and Chlorophyceae (green algae); coarse particulate organic matter (CPOM) (= coarse detritus), Rhodophyceae (macro-red algae), Dinophyceae (dinoflagellates), Microarthropoda (ostracods, calanoid and harpacticoid copepods, nauplii, halacarid mites) and Nemathelminthes (free living nematodes) were of secondary importance.

FPOM and CPOM were of allochthonous origin, being derived largely from decaying shed leaves of mangrove macrophytes, particularly *Rhizophora*. Of the five categories of algae (table I), diatoms were most important (RF and PP = ca. 18% respectively); they were dominate by pennate forms *(Navicula, Nitzschia, Gyrosigma, Surirella, Rhizosolenia, Pinnularia, Pleurosigma, Amphora, Fragilaria)* while centric forms *(Coscinodiscus, Stephanodiscus, Cyclotella, Melosira, Chaetoceros, Biddulphia)* constituted a minor proportion. Bluegreen algae consisted mainly of *Oscillatoria, Anabaena, Spirulina, Microcystis* and *Merismopedia* and the green algae, *Closterium, Cosmarium, Penium, Netrium* and euglenids. Epiphytic macro-red algae *(Bostrychia, Calaglossa)* were grazed from *Rhizophora* prop roots on which they are most commonly attached (Lawson, 1985). Dinoflagellates in the diet comprised *Ceratium* and *Peridinium*.

TABLE I

Gross trophic spectrum and seasonal variations in the relative frequency (RF) and percentage points (PP) of dietaries of *L. falcipinnis* in the Bonny River. FPOM = fine particulate organic matter; CPOM = coarse particulate organic matter

Variations saisonnières de la fréquence relative (RF) et des points (PP) des composantes de l'alimentation de L. falcipinnis *dans la rivière Bonny. FPOM = fines particules organiques; CPOM = particules grossières de matière organique*

Food items	Gross composition		Dry season		Wet season	
	RF	PP	RF	PP	RF	PP
FPOM	17·6	43·3	18·4	47·5	16·6	38·7
CPOM	7·1	1·9	8·4	2·5	5·2	1·4
Mud	16·4	7·6	17·6	6·7	14·6	8·5
Sand	10·2	7·6	8·4	5·3	12·8	9·9
Bacillariophyceae	18·0	18·1	18·8	21·8	16·8	14·5
Myxophyceae	13·6	14·9	12·0	10·7	15·8	19·2
Rhodophyceae	3·4	0·4	3·2	0·3	0·2	0·5
Chlorophyceae	10·6	5·8	9·7	4·8	12·0	6·8
Dinophyceae	1·6	0·1	1·7	0·1	1·4	0·2
Microarthropoda	0·2	0·1	0·4	0·1	-	-
Nemathelminthes	1·3	0·2	1·4	0·2	1·2	0·3
Totals	100·0	100·0	100·0	100·0	100·0	100·0
Diet breadth (D)			0·86	0·70	0·86	0·58
No. of fish exam.	436		189		247	
TL (mm) range	90 - 220		90 - 220		110 - 210	

Diatoms, bluegreen, green and red algae plus dinoflagellates were digested to some extent as evidenced by the occurrence of diatom empty frustules, algal fragments, distorted/empty cells and filaments in the recta. However, the recta of some specimens contained an admixture of the latter with intact diatom frustules/ algal cells and filaments, thus suggesting that a proportion of algae passes through the gut undigested. The presence of microarthropod fragments in rectal contents denoted that they were digested.

The Bonny River *L. falcipinnis* may be described as a 'detritivore-algivore-deposit feeder' in view of the predominance of detritus (FPOM + CPOM) (RF = 24.7%, PP = 45.2%), algae (RF = 47.2%, PP = 39.3%) and sediments (mud + sand) (RF = 26.6%, PP = 15.2%) in its diet. Minute invertebrates (microarthropods + nematodes) formed less than 2% (by RF and PP) of the diet. The trophic flexibility of *L. falcipinnis* probably ensures a constant energy source which is important for the sustenance of its large population.

Particle size selection

L. falcipinnis selectively ingested inorganic particles (mostly silica granules) of 0.035 $\pm$ 0.004 mm (mean size). Other mugilids in the Bonny River select mean particles sizes different from that of *L. falcipinnis* (KING, 1984). Differential particle size selection by allied sympatric mugilid species is an aspect of resource partitioning that could minimise interspecific competitive interactions (BLABER, 1976, 1977; MARIAS, 1980; KING, 1984).

Variation in diet with fish size

Figure 3 illustrates the RF and PP of the dietaries of different sizes of *L. falcipinnis* examined. Fish size was positively correlated with the relative frequency of FPOM (r_s = 0.537, $P<0.1$), CPOM (r_s = 0.653, $P<0.02$), diatoms, (r_s = 0.533, $P<0.1$), red algae (r_s = 0.560, P = 0.05) and dinoflagellates (r_s = 0.680, $P<0.01$) and negatively correlated with the RF of bluegreen algae (r_s = − 0.709, $P<0.01$) and green algae (r_s = − 0.445, $P<0.02$). There was no significant correlation between fish size and the RF of mud (r_s = 0.158, $P>0.2$), sand (r_s = − 0.143, $P>0.2$), microarthropods (r_s = 0.342, $P>0.2$) and nematodes (r_s = − 0.106, $P>0.2$).

A significant positive relationship occurred between fish size and the percentage points of FPOM (r_s = 0.720, $P<0.01$), CPOM (r_s = 0.966, $P<0.002$), red algae (r_s = 0.632, $P<0.05$) and dinoflagellates (r_s = 0.463, $P<0.2$) while an inverse relationship existed between fish size and the PP of diatoms (r_s = − 0.581, $P<0.05$). Fish size was not significantly correlated with the PP of mud (r_s = 0.368, $P>0.2$), sand (r_s = 0.306, $P>0.2$), bluegreen algae (r_s = − 0.221, $P>0.2$), green algae (r_s = − 0.026, $P>0.2$), microarthropods (r_s = 0.375, $P>0.2$) and nematodes (r_s = − 0.110, $P>0.2$).

The diversification in diet with growth of *L. falcipinnis* (fig. 3) not only minimises possible intraspecific competitive interactions between different cohorts but also offers a wider spectrum of food resources for exploitation by the species. These could be important in the maintenance of large populations of different cohorts of the fish.

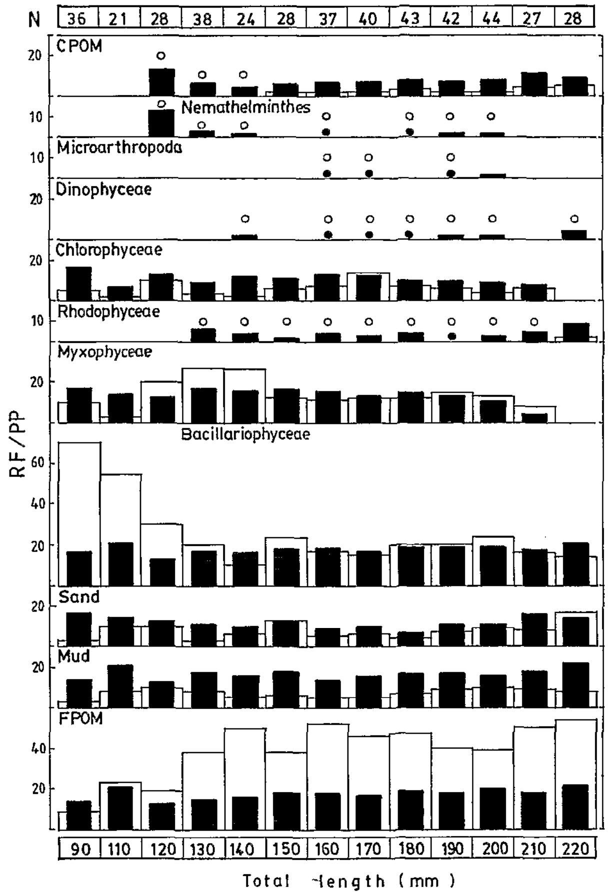

FIG. 3. — Variations with fish size of the relative frequency (RF) (black bars) and percentage points (PP) (open bars) of the dietaries of *L. falcipinnis*. ● = RF < 2 %; ○ = PP < 2 %; FPOM = fine particulate organic matter; CPOM = coarse particulate organic matter; N = number of specimens examined. *Variations, en fonction de la taille, de la fréquence relative (RF, en noir) et des points (PP, en clair) de l'alimentation de* L. falcipinnis. *Les petits cercles indiquent les valeurs inférieures à 2 % (noir pour RF, clair pour PP); FOPM = fines particules de matière organique; COPM = particules grossières de m.o.; N = nombre d'individus examiné*

Spatio-temporal patterns in diet

The diets of *L. falcipinnis* from the estuary (Bonny town) and Port-Harcourt (fig. 1) were analysed separately to test for possible spatial variation in feeding regime. The results (table III) showed no significant differences in the RF (W = 33, $P>0.05$) and PP (W = 23, P = 0.05) of the dietaries at the two stations. Diet breadth index $D_{(RF)}$ was not significantly different at the two stations but $D_{(PP)}$ was slightly higher at the estuary than at Port-Harcourt.

The composite diet data for the two major seasons (table I) showed that apart from the exclusion of microarthropods from the diet during the wet season, there was no qualitative seasonality in food composition. Only small variations appear when bimonthly data are plotted (fig. 4) Quantitatively, Wilcoxon signed-rank statistic showed no significant

TABLE II

Spatial variations in the relative frequency (RF) and percentage points (PP) of the dietaries of *L. falcipinnis* in the Bonny River. FPOM = fine particulate organic matter; CPOM = coarse particulate organic matter

Variations spatiales de la fréquence relative (RF) et des points (PP) des différentes composantes de l'alimentation de L. falcipinnis *dans la rivière Bonny. FPOM = fines particules organiques ; CPOM = particules grossières de matière organique*

Food items	Estuary		Port Harcourt	
	RF	PP	RF	PP
FPOM	16·4	37·1	18·4	49·1
CPOM	5·2	2·2	8·4	1 7
Mud	14·6	10·4	17·6	4·7
Sand	12 8	10·9	8·4	4 4
Bacillariophyceae	16·8	22·7	18 8	13 6
Myxophyceae	15·8	15·1	12·0	14·8
Rhodophyceae	3 6	0·3	3·2	0 4
Chlorophyceae	12·0	0 5	11·4	11·1
Dinophyceae	1·4	0·3	-	-
Microarthropoda	0·2	0·1	0·4	0·1
Nemathelminthes	1·2	0·4	1·4	0·1
Totals	100·0	100·0	100·0	100·0
Diet breadth (D)	0·86	0·76	0·85	0·70
No of fish exam.	204		232	
TL (mm) range	110 - 220		90 - 121	

seasonality in the RF (W = 27, P>0.05) and (W = 29, P>0.5) of the dietaries. The reliance of *L. falcipinnis* on FPOM as a primary dietary component in all months and seasons is probably facilitated by the vast mangrove swamp (NEDECO, 1961, SCOTT, 1966; DANGANA, 1985) which ensures a constant allochthonous input of this item through decaying shed leaves of *Rhizophora*.

There was no substantial seasonality in diet breadth (RF) of *L. falcipinnis* but diet breadth (PP) was higher during the dry season (table I). The optimal foraging theory (SCHOENER, 1971; PYKE *et al.*, 1977; ANGERMEIER, 1982) postulates an inverse relationship between diet breadth and resource abundances; thus diet breadth expands during periods of depressed resource abundances and contracts during periods of high abundances. Evidence from fish dietary reports in the tropics (ZARET and RAND, 1971; WELCOMME, 1969, 1975, 1979; LOWE-MCCONNEL, 1975; ANGERMEIER and KARR, 1983) suggests higher wet season abundances of food resources and lower levels of abundances during the dry season. Therefore fish diet breadth should expand in the dry season and contract during the rains in conformity with the optimal foraging theory. Assuming that the food resources of *L. falcipinnis* are more abundant during the rains, the observed seasonal variations of diet breadth (table I) conform to the optimal foraging theory.

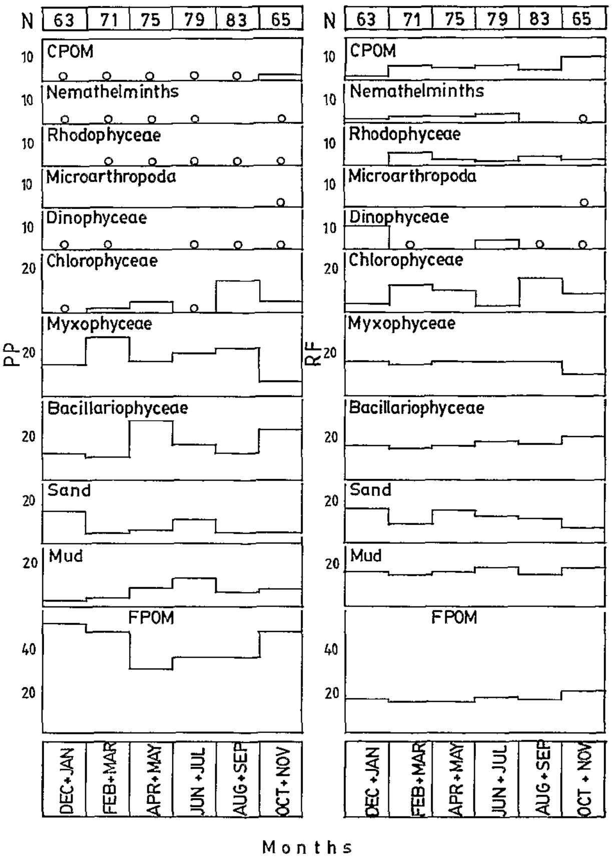

FIG. 4. — Temporal variations in the relative frequency (RF) and percentage points (PP) of the dietaries of *L. falcipinnis*. o = RF or PP < 2 %; FPOM = fine particulate organic matter; CPOM = coarse particulate organic matter; N = number of specimens examined. *Variations de RF et PP en fonction du temps. Mêmes symboles que pour la figure 3. Les cercles indiquent des valeurs inférieures à 2 %*

Feeding behaviour

L. falcipinnis fed in schools. Although feeding occurred during day and night, it was more intensive during the day as indexed by the fully distended stomachs of fish caught during the day. Contrarily, most fish caught during the night had empty or partially filled stomachs (KING, 1984).

During active feeding, *L. falcipinnis* inclined itself at an obtuse angle to the bottom, with head pointing downward and moved forward as it grubbed through bottom deposits. This feeding technique closely parallels that of *L. grandisquamis* (KING, 1986) and is effective for ingesting bottom deposits with associated meiofauna, epipelic and episammic micro-algae. During less active feeding, *L. falcipinnis* remained horizontal close to the bottom, stirred up bottom deposits by movements of the paired and caudal fins and thereafter sucked up the entire mass of suspended matter. This is similar to the observation of FAGADE and OLANIYAN (1973) that mugilids (*L. falcipinnis* inclusive) in Lagos lagoon fed on bottom deposits by stirring up the bottom and then filtering the suspended materials with the aid of gill rakers. The Bonny River *L. falcipinnis* also occasionally browsed on 'aufwuchs' algae on *Rhizophora* prop roots by nibbling on the latter.

The diverse feeding behaviour of *L. falcipinnis* partly accounts for the wide variety of items that comprise its diet.

CONCLUSION

The present study reveals that *L. falcipinnis*, the dominant mugilid in the Bonny River, has a wide spatial distribution as evidenced by its ability to penetrate the low salinity zone of the river and its penchant for both sandy and muddy bottoms. Its diet which comprises a wide range of items changes in composition with growth and months. The wide distribution and trophic flexibility of *L. falcipinnis* account, in part, for its success and preponderance in the Bonny River.

ACKNOWLEDGEMENTS

I wish to thank Dr. S. A. WHYTE, formerly of the Department of Zoology, University of Port-Harcourt, for encouragement and advice throughout this study and Dr. G. EBUKANSON of University of Cross River State, for reading and criticizing the manuscript of this paper.

Manuscrit accepté par le Comité de Rédaction le 5 décembre 1987

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