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The Biology of *Pellonula leonensis* Boulenger, 1916 (Osteichthyes: Clupeidae) in Anambra River, Nigeria.

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Abstract
The biology of the commercially important clupeid, *Pellonula leonensis,* was studied from May 1998 to March 1999 in the Anambra river. In the *atalla* fishery of this river, the clupeid was the dominant species in terms of number and weight. Total length (TL) ranged from 3.4 to 8.5 cm and weight from 0.3 to 4.6 g; males were not longer or heavier than females. The mean exponent (b = 2.66) of the length-weight relationships of 12 populations indicated negative allometric function. Mean monthly Fulton's condition (K) was not dependent on season. There was little variability in the mean monthly gonadosomatic index (GSI) and breeding occurred throughout the year. Maturity occurred earlier in males than females; 50% of both sexes matured at 4.7 cm TL. Fecundity ranged from 126 to 1580 oocytes (mean 896 ± 477 oocytes). Total length was a better predictor of fecundity than ovary weight. Index of food significance (IFS) showed that Insecta (51:67%) was the dominant food group, followed by Algae (15.66%) and plant detritus (8.02%). Food items of primary importance were Ephemeroptera nymphs, Chironomidae, unidentified insects, fish, *Microcystis*, plant detritus and sand grains. Food richness and diet breadth were dependent on season.

Key Words: Pellonula, Leonensis, Anambra River

Introduction

The fresh and brackish waters of tropical Africa harbour about 20 species of clupeids. Of these, five species are found in Nigerian freshwaters, viz. *Odaxothrissa mento* (Regan, 1917), *Laeviscutella dekimpei* (Poll, Whitehead and Hopson, 1965), *Sierrathrissa leonensis* (Thys van den Audenaerde, 1969), *Pellonula vorax* (Gunther, 1868) and *P. leonensis* (Boulenger, 1916). *P. leonensis* has a

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widespread distribution occurring in both remote sahelian and coastal basins (Reid & Sydenham, 1979; Teugels, Reid & King, 1992 and Gourene & Teugels,1991). It is the dominant species, by number and weight in the *atalla* fishery of Anambra river and fetches good income on account of its tasty characteristic.

Aspects of the biology of *P. leonensis* [= *Pellonula afzeluisi* (Johnels, 1954)] have been reported by Otobo (1976, 1977, 1978) and Otobo & Imevbore (1979) in the Kainji lake, and Reynolds (1969, 1970) in Volta lake. However, virtually no information on the biology of the species in rivers is available despite its enormous fisheries and ecological importance. The present paper seeks to fill this information gap and focuses on abundance, size structure, morphometric relationships, reproduction and the diet of *P. leonensis* in the lower reaches of the Anambra river, Nigeria.

Materials and Methods

Monthly samples of *P. leonensis* were randomly collected from artisanal *atalla* fishers in the lower reaches of Anambra river, southeastern Nigeria between May, 1998 and March, 1999 inclusive. Total length (TL) to the nearest 0.1 cm and body weight (g) to the nearest 0.1 g of each *P. leonensis* were measured and the sex determined. The length-weight relationships (LWR) were determined using the power curve: $W = aTL^b$. The parameters of the LWR were determined for the same species collected at different periods. These different estimates were considered separate 'populations'. Fulton's condition factor, K, was calculated as: $K = W/L^3 \times 100$. To determine gonad maturation, gonads were evaluated macroscopically and four maturation stages were recognized: I – immature, II – mature, III – ripe and IV – spent. Size at maturity was determined as the length at which 50% of individuals were in gonad stage II. Fecundity, defined as the number of spawnable oocytes prior to the next breeding period, was determined by direct counting of the spawnable oocytes in both ovaries. The relationship between fecundity and gonad weight, and total length, was determined by the least squares method. The gonadosomatic index (GSI) was determined as: $GSI = W_1/W_2 \times 100$, where W_1 = gonad weight (g) and W_2 = fish weight (g) (less gonad weight).

The stomach of each *P. leonensis* was dissected and slit open, and its degree of fullness estimated by an arbitrary 0 – 20 point scale: thus 0, 2.5, 5, 10, 15 and 20 points were allotted to empty, trace, quarter-full, half-full, three quarter-full and fully distended stomachs.

Stomach contents were sorted into categories and analyzed using relative frequency (RF) and points method (Hynes, 1950; Hyslop, 1980). In the RF, the frequency of a particular food item in all stomachs was expressed as a percentage of the frequencies of all food items. For the points scheme, each stomach was allotted 20 points regardless of the fish size and these were shared amongst the various contents, taking account of their relative proportion by volume. The points gained by each food item in all stomachs examined were computed and expressed as a percentage of the total points of all food items. The points scheme gave an indication of bulk contribution of each food category to the diet composition. % RF and % PP were then used to determine the index of food significance as follows:

$$IFS = \frac{\%RF \times \%PP}{\sum \%RF \times \%PP} x100$$

Food with IFS ≥ 3 % was regarded as primary, ≥ 0.1 to < 3% as secondary, whereas food with <0.1% was regarded as incidental.

The IFS data were used to compute diet breadth based of Shannon – Wiener function (H) as follows:

$$H_{(IFS)} = -\sum (ni/N) \log_e (ni/N)$$

where ni = IFS of each food item, N = total IFS of all food items.

Food richness was defined as the number of food items in the diet with IFS ≥ 0.1%. Food composition and sex ratio were analyzed by Student's t-test and X^2 test respectively (Bailey, 1994). Differences were considered significant at 5% level of probability.

RESULTS

Abundance of the species

Of the 40 species of fin fish and three shell fish caught in *atalla* fishery totalling 24354 individuals and weighing 36.81 kg, *Pellonula leonensis* was the most abundant in both number (8601,35.32%) and weight (8.52kg, 23.14%). The clupeid was significantly more numerous in the rainy season months of June to October than in the dry months of November to March (P < 0.05).

Size Range

The length of *P. leonensis* (n = 550) ranged from 3.4 – 8.5 cm TL (mean 5.88 ± 0.84 cm TL). Males range from 3.4 – 8.0 cm TL (mean 5.84 ± 0.82 cm TL) were not longer than females that range from 3.8 – 8.5 cm TL (mean 5.91 ± 0.84 cm TL). Weight ranged from 0.3 – 4.6 g (mean 1.70 ± 0.76 g). The weight of the males, ranging from 0.4 – 4.0 g (mean 1.68 ± 0.72 g), was not significantly heavier than the weight of females that range from 0.3 – 4.6 g, (mean 1.71±0.76 g).

Table 1: The overall monthly sex ratio of *Pellonula leonensis* in Anambra river

Month	Number Collected		Sex ratio
	M	F	M:F
M	14	36	1:2.6
J	23	27	1:1.2
J	30	20	1:0.7
A	23	27	1:1.2
S	28	22	1:0.8
O	23	26	1:1.1
N	22	24	1:1.1
D	19	28	1:1.5
J	22	28	1:1.3
F	23	26	1:1.1
M	16	32	1:2.0
Total	243	296	1:1.3

Population Structure

The population structure is presented in fig 1. From this it can be seen that both sexes had one mode (>53% individuals) at 6 cm TL. The 5 – 7 cm TL size classes constitute over 90% of the total sample. The females predominated in the 3 cm TL size class, whereas the males were dominant in the 8 – 9 cm TL size classes (Fig 2).

The overall monthly sex ratio was significantly different from 1:1 (X^2=5.21, df= 1, $P<0.05$) (Table 1). Within the months, females dominated in March (X^2 = 9.68, df= 1, $P < 0.05$) and May (X^2 = 5.33, df= 1, $P < 0.05$). There is seasonal variation in the number of individuals depending on the sexes. For example, during the dry season the sexes (male = 102, 42.5%; female = 138, 57.5%) showed significant difference in the number collected. (X^2 = 5.4, df= 1, P = 0.05). However, during the rainy season the difference was not significant as the number of males collected (141, 47.2%) does not differ markedly from the number of females collected (158, 52.8%) (X^2 = 0.96, df = 1 $P > 0.05$).

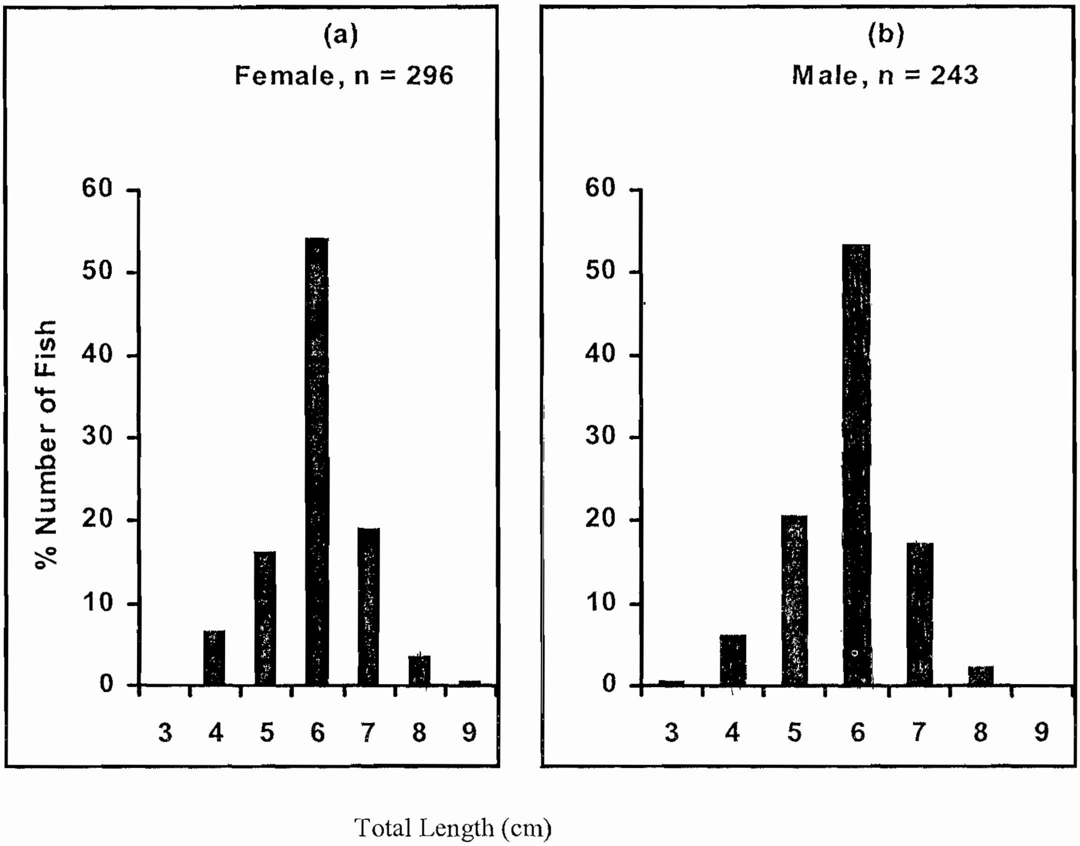

Fig. 1: Length-frequency distribution of female (a) and male (b) P. leonensis in Anambra river.

Table 2: Length-weight relationships and related statistics in *Pellonula leonensis* (May 1998 – March 1999).

Month	Total length				Length-weight relationships			N
	mean	s.d.	min	max	a	B	r	
M	6.00	0.67	5.0	8.4	0.0099	2.821	0.946	50
J	6.37	0.73	3.4	6.7	0.0227	2.192	0.735	50
J	6.56	0.56	5.9	8.5	0.0087	2.890	0.992	50
A	6.80	0.46	6.1	8.2	0.0112	2.906	0.977	50
S	5.45	0.59	4.6	7.3	0.0153	2.704	0.972	50
O	6.48	0.65	5.6	8.3	0.0307	2.348	0.949	50
N	6.04	0.43	5.3	7.3	0.0113	2.801	0.933	50
D	4.53	0.51	3.8	6.0	0.0135	2.612	0.968	50
J	5.70	0.28	5.1	6.3	0.0133	2.564	0.692	50
F	5.78	0.81	4.7	8.0	0.0116	2.859	0.967	50
M	6.20	0.50	5.4	7.9	0.0317	2.317	0.884	50
Overall	5.99	0.63	3.4	8.4	0.0086	2.939	0.941	550
Rainy season	6.3	0.57	3.4	8.4	0.0081	2.942	0.945	300
Dry season	5.6	0.62	3.8	8.3	0.0060	3.169	0.941	250

Morphometric Parameters

The LWR analyses of the 12 populations are presented in Table 2. The analyses further indicate that the calculated correlations were significant ($P < 0.05$) with coefficient of determination ranging from 48 – 98.5%.

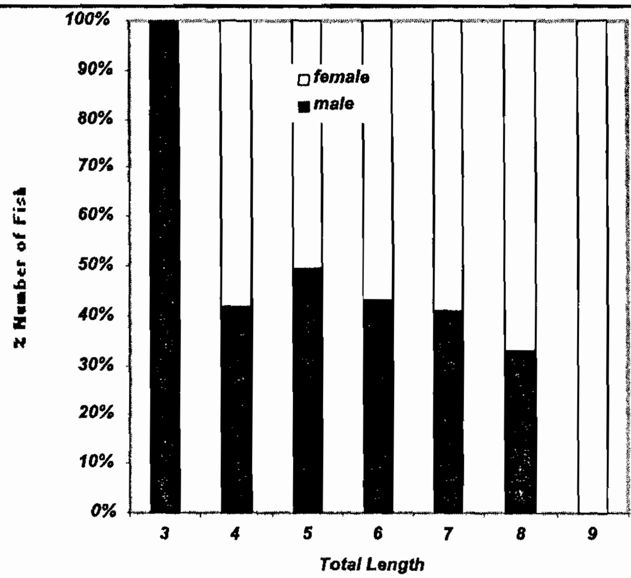

Fig. 2: Variation in sex ratio with size of P. leonensis in Anambra river.

These values were used to plot a graph (Fig 3) which showed that the intercept, a, exhibited moderate variations among the populations (CV = 52.23%) and ranged from a_{min} = 8.6 x 10^{-3} (overall) to a_{max} = 31.7 x 10^{-3} (March). Conversely, the exponent, b, showed low variations among the populations (CV = 9.64%) and varied from b_{min} = 2.192 (June) to b_{max} = 2.939 (overall).

The mean exponent (b = 2.66; s.d. = 0.257) was significantly less than 3 (t-test, df = 11, P < 0.05) indicating negative allometric function for the populations. Plotting the logs a versus b for the I2 LWR revealed no outliers (Fig. 3). Table 2 also showed that LWR exhibited in both the rainy and dry seasons were isometric.

Table 3: Mean monthly condition factor, K, of *Pellonulla leonensis* from the Anambra river.

Month	Mean K±s.d.
M	0.72±0.07
J	0.61±0.16
J	0.69±0.06
A	0.77±0.08
S	0.90±0.11
O	0.91±0.09
N	0.79±0.06
D	0.76±0.06
J	0.63±0.07
F	0.91±0.09
M	0.92±0.10
Overall mean	0.78±0.11

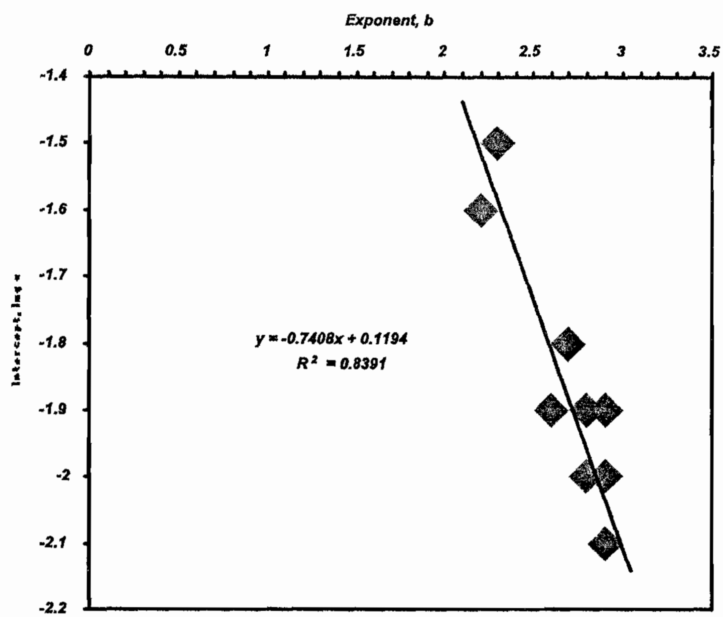

Fig. 3: The relationship between the intercept, log a, and the exponent, b in Pellonula leonensis from Anambra river.

Table 4: The monthly variation in the percentage female (n=296) and male (n=243) *Pellonula leonensis* at each maturation stage.

Month	No. of females examined	Maturation Stages: Female I	Female II	Female III	Female IV	Male I	Male II	Male III	Male IV	No. of males examined
M	36	61.1	36.1	2.8	-	28.6	71.4	-	-	14
J	27	37.0	51.9	11.1	-	21.7	56.5	21.7	-	23
J	20	25.0	25.0	45.0	5.0	16.7	46.7	33.3	3.3	30
A	27	14.8	25.9	51.9	7.4	34.8	43.5	13.0	8.7	23
S	22	22.7	31.8	27.3	18.2	46.4	28.6	21.4	3.6	28
O	26	46.2	34.6	7.7	11.5	30.4	39.1	30.4	-	23
N	24	41.7	16.7	33.3	8.3	54.5	27.3	18.2	-	22
D	28	50.0	25.0	21.4	3.6	36.8	36.8	26.3	-	19
J	28	42.9	42.9	7.1	7.1	27.3	40.9	31.8	-	22
F	26	26.9	19.2	15.4	38.5	17.4	26.1	47.8	8.7	23
M	32	3.1	9.4	59.4	28.1	12.5	6.3	81.3	-	16
Total	296									243

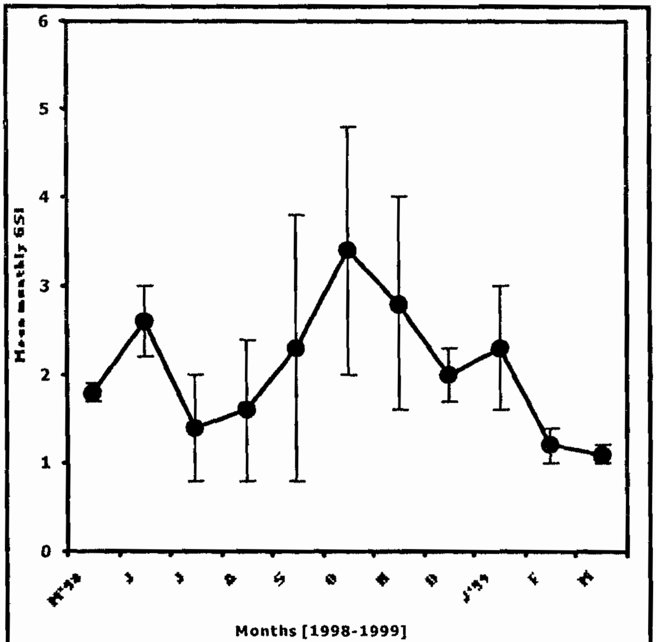

Fig. 4: The mean monthly GSI of 94 mature female *P. leonensis* in Anambra river.

Table 5: The dynamics of female and male *P.leonensis* in maturation stages

Maturation stage	Female	Male	Sex ratio M:F
Immature	102	73	1:0.7
Mature	86	93	1:1.1
Ripe	74	71	1:1
Spent	34	6	1:0.2
Total	296	243	1:0.8

Fulton's conditions factor, K.

The mean monthly K was 0.78 ± 0.11 and varied from 0.61 ± 0.16 in June to 0.92 ± 0.10 in March (Table 3). The clupeids were in very good condition in September, October, February and March, whereas the poorest conditions occurred in January, June and July.

Reproductive biology

The mean monthly gonadosomatic index (GSI) of 94 female *P. leonensis* varied from 1.1 – 3.3% (mean 2.05 ± 0.72%). There were only slight variations in the mean monthly GSI indicating an all year round reproductive pulse, although three peaks in June, September and January were evident (Fig. 4). The monthly dynamics in the percentage male and female at each maturation stage (Table 4) showed that immature, mature, ripe and spent gonads were present throughout the year indicating an all year round gonad recrudescence, breeding period and recruitment. There were significantly more females than males in immature stage ($X^2 = 4.4$, df = 1, $P < 0.05$) and spent stage ($X^2 = 19.6$, df = 1, P = < 0.05) Males and females did not depart from a 1:1 sex ratio in mature and ripe *P. leonensis* (Table 5). The size at maturity varied in females and males. The smallest female matured at 4.3 cm TL, whereas in the males it was at 3.4 cm TL. Over 50% of both sexes matured at 4.7 cm TL.

Oocyte count of 15 females ranged from 126 to 1580 (mean 896 ± 477 oocytes). The regression equations for the relationships between fecundity and total length, and ovary weight ($F = aX^b$, where X stands for either total length or ovary weight) were:

$$F = 21.93TL^{1.82}, r = 0.37$$
$$F = 847.65\ OW^{0.04}, r = 0.02$$

The correlations were positive but low; total length had a better predictive value of 0.37 than ovary weight (0.02).

Table 6: Trophic spectrum of the diet of all sizes of *Pellunula leonensis* in Anambra river

Food species/group	%RF	%PP	IFS
Arachnida			
Water spider	0.48	0.65	0.03
Crustacea			
Ostracoda	2.31	2.48	0.53
Macrobrachium felicinum	2.31	2.73	0.58
Insecta			
Ephemeroptera nymph	6.45	6.66	3.97
Coenagrion sp.	0.10	0.11	+[a]
Water bugs	1.15	0.89	0.09
Dystiscidae	0.48	0.55	0.02
Formicoid Hymenoptera	1.06	0.99	0.10
Mosquito larvae	0.29	0.31	0.01
Chironomid larvae and pupae	17.90	22.33	36.95
Chaoborus larvae	0.29	0.29	0.01
Terrestrial Orthoptera	2.89	3.22	0.86
Neuroptera larva	1.25	1.03	0.12
Unindentified insecta	10.78	9.57	9.54
Fish			
Brycinus sp.	0.29	0.32	0.01
Barbus callipterus	0.10	0.11	+
Pellonula leonensis	0.38	0.60	0.02
Chrysichthys sp.	0.19	0.29	0.01
Fish remains	7.31	7.80	5.27
Algae			
Microcystis sp.	11.93	13.82	15.24
Spirogyra sp.	1.54	1.68	0.24
Diatom	1.35	1.47	0.18
Plant detritus	10.39	8.35	8.02
Mud	2.02	2.29	0.43
Sand	16.75	11.48	17.77

[a](+) < 0.01

Diet

Out of 550 stomachs examined, 56 (10.2%) had full stomachs (FS), 396 (72%) had partially-filled stomachs (PS), whereas 97(17.6%) had empty stomachs (ES). Full stomachs were highest in May (26, 46.43%) and lowest in September, January and March (0,0%). Among the partially–filled stomachs, 41(10.35%) were ¾ full, 120 (30.30%) ½ full, 193 (48.74%) ¼ full and 42 (10.61%) contained traces of food.

Twenty-five different food items were ingested (Table 6). Insecta (51.67%) was the dominant food group, followed by Algae (15.66%) and plant detritus (8.02%). Foods of primary importance were Ephemeroptera nymph, Chironomidae, unidentified insects, fish, *Microcystis* sp, plant detritus and sand grains. The most important food item was Chironomidae (IFS = 36.95%); it occurred more regularly in the stomach and constituted a large proportion of the food taken.

Of all the food items ingested, only Ephemetptera nymphs and chironomids were consumed in all the months. Food of primary importance varied from 1 in May to 6 in October (Table 7). The crustaceans were important only in October, whereas Ephemeroptera nymphs, chironomids, unidentified insects, fish, *Microcystis* sp., plant detritus and sand grains were important in at least four months. Except in May and June, the monthly dynamics in food richness and diet breadth showed moderate variability.

Qualitative food composition was higher in the rainy than the dry season. Ephemeroptera nymphs, chironomids and fish were significantly more in the rainy than the dry season (Table 8). The converse was true for the crustaceans, water bugs, plant detritus, and sand. The occurrence of other food items was not different between the seasons. Food richness and diet breadth were dependent on season.

Discussion

The numerical and gravimetric dominance of *P. leonensis* in the catch of *atalla* lift net in the Anambra river, like in clupeids from other African geographic areas (Reynolds, 1969; Lelek, 1973; Chifamba, 1993; Katonda, 1993; Marshall, 1993), may be influenced, to variable extent, by a number of factors, including early sexual maturity, all year round breeding, food availability, high growth rate, short life span, high natural mortality and environment. This dominance may be causally related to reproductive success, which is partly assured through early sexual maturity and all year round breeding. Abundant foods may also permit rapid growth and high recruitment. Early sexual maturity and all year round breeding in fishes are generally survival strategies and adaptations aimed at perpetuating the species in response to high fishing and/or natural mortality. The survivors prey on the rich variety of food available in the river, they grow fast and become recruited into the fishery. It seems probable that it is in this way that large numbers of *P. leonensis* are maintained in the Anambra river. Ezenwaji (1999, 2002) has recorded similar situations in *Clarias albopunctatus* and *C. ebriensis* in the same river system. While a fairly good knowledge of the breeding biology of *P. leonensis* is beginning to emerge in Nigerian lentic and lotic habitats, we still need, as Marshall (1993) noted in *Limnothrissa miodon,* to ascertain the environmental factors determining reproductive success, the effect of fishing on the sexually mature individuals and the relationship between stock and recruitment. Furthermore, a knowledge of other demographic characteristics (such as growth and mortality) of *P. leonensis* is also important in order to gain an overall understanding of factors determining its abundance in the Anambra river.

Table 7: The Monthly IFS of *Pellonula leonensis* in Anambra river

Food species/group	M	J	J	A	S	O	N	D	J	F	M
Arachnida											
Water spider	-	-	-	-	-	-	0.09	0.30	-	0.08	-
Crustacea											
Ostracoda	-	-	-	-	-	9.29	3.17	0.50	1.78	0.64	0.05
Microbrachium felicinum	-	-	-	0.01	-	11.29	0.87	0.12	-	0.28	10.10
Insecta											
Ephemeroptera nymph	0.43	41.38	0.49	3.75	0.78	0.29	0.29	0.56	6.12	5.28	6.13
Coenagrion sp.	-	-	-	-	-	1.10	-	-	-	-	-
Water bugs	-	-	0.11	0.01	0.05	-	-	9.78	0.44	0.05	-
Dytiscidae	-	-	-	-	-	0.86	-	-	-	-	0.34
Formicoid Hymenoptera	-	-	-	-	-	0.18	0.04	-	-	0.08	-
Mosquito larvae	-	-	-	-	-	0.86	-	0.08	-	-	-
Chironomid larvae & pupae	99.57	55.19	8.26	35.22	0.31	1.62	0.76	1.66	0.69	1.77	20.15
Chaoborus larvae	-	-	-	-	-	0.18	0.09	-	-	-	-
Terrestrial Orthoptera	-	-	-	-	-	-	-	-	0.55	0.53	1.79
Neuroptera larvae	-	-	-	-	-	2.02	0.55		0.52	0.08	0.46
Unidentified insecta	-	-	-	1.11	35.37	45.70	57.24	28.42	36.01	3.04	9.50
Fish											
Brycinus sp	-	-	0.22	0.03	-	-	0.09	-	-	-	-

Pellonula leonensis	-	-	2.32	0.05	-	-	-	-	-	-	-
Chrysichthys sp	-	-	0.54	0.09	-	-	-	-	-	-	-
Barbus callipterus	-	-	-	0.03	-	-	-	-	-	-	-
Fish remains	-	1.52	36.56	8.30	3.45	1.84	0.02	1.48	13.46	3.39	-
Algae											
Microcystis sp.	-	1.27	34.31	40.34	22.78	5.60	5.09	6.79	7.58	30.41	11.62
Spirogyra sp.	-	-	-	-	-	-	-	0.15	0.07	-	0.05
Diatom	-	-	-	-	-	1.47	-	0.32	1.18	0.05	0.25
Plant detritus	-	0.07	1.88	0.59	-	7.04	3.68	28.67	11.66	41.70	4.07
Mud	-	-	-	-	-	4.86	15.65	0.08	0.25	0.25	0.20
Sand	-	0.57	15.30	10.46	37.26	5.80	12.37	20.37	19.69	12.37	35.29
Food richness	2	6	10	13	7	17	15	15	14	16	14
Diet breadth	0.03	0.85	1.47	1.40	1.25	1.94	1.40	1.71	1.83	1.55	1.85

Table 8: Season variation in the IFS of *Pellonula leonensis* in Anambra river

Food Species/group	Dry	Rainy	P[c]
Arachnida			
Water Spider	0.05	-	
Crustacea			
Ostracoda	2.06	-	
Macrobrachium felicinum	2.06	+[a]	<0.05
Insecta			
Ephemeroptera nymph	2.92	8.18	<0.05
Coenagrion sp.	0.03	-	
Water bugs	0.58	0.11	<0.05
Dytiscidae	0.10	-	
Formicoid Hymenoptera	0.03	-	
Mosquito larva	0.04	-	
Chironomid larvae & pupae	3.73	67.40	<0.05
Chaoborus larva	0.02	-	
Terrestrial Orthoptera	0.28	-	
Neuroptera Insecta	0.48	-	
Unidentified Insecta	31.58	2.51	<0.05
Fish: *Brycinus* sp	43.96	0.02	NS[b]
Pellonula leonensis	-	0.10	
Chrysichthys sp	-	0.04	
Barbus callipterus	-	0.01	
Fish remains	2.33	5.63	<0.05
Algae: *Microcystis* sp.	12.68	13.80	NS
Spirogyra sp.	0.09	-	
Diatom	0.26	-	
Plant detritus	16.90	0.21	<0.05
Mud	2.54	-	
Sand	21.24	1.99	<0.05
Food richness	21	12.	
Diet breadth	1.94	1.11	

[a](+)<0.01
[b]No significant difference
[c] significance level of difference seasons for t-test

The size range of *P. leonensis* is a good reflection of its population structure. The preponderance of fish between 5 and 7 cm TL is probably because the shallow water habitat of fish less than 5 cm TL may not have been adequately sampled, and fish up to 9 cm TL would have been exploited as a result of the high fishing and natural mortality. A sex ratio favouring females obtained in this study agrees with the report of Reynolds (1969) in *P. leonensis* (=*P. afzeliusi*) in Volta lake but contrasts with the 1:1 sex ratio of the species in Kainji lake (Otobo, 1978).

In fishes, generally, the annual production of oocytes accounts for a large proportion of the body weight. *P. leonensis* of the Anambra river appears to be a notable exception. With an average of 2.05 ± 0.72%, the oocyte weight/ body weight ratio of this clupeid appears to be one of the lowest in fishes. This is slightly different from the average ovary weight/body weight ratio (4.6%) in *P. leonensis* (=*P. afzeliusi*) and 7.4% in *Sierrathrissa leonensis* in Kainji lake (Otobo, 1978), and 6.1 ± 2.5% (range 2.2 – 12.2%) in *C. ebriensis* in the Anambra river system (Ezenwaji, 2002). A similar situation obtains for *L. miodon* in the northwestern waters of lake Tanganyika (Mulimbwa, 1993). Thus, this phenomenon appears typical of fishes that mature early and breed all the year round.

The length (4.7 cm TL) at which 50% of the sample matured ensures that the largest number of the most fit fish (those in the 4 – 8 cm TL bracket) is in reproductive state. This agrees with the size at maturity in *P. leonensis* (*P. afzeliusi*) from Kainji lake (Otobo, 1978). As size at maturity of fish depends on the growth rate, it does seem that there are no significant differences in the size of this clupeid in Anambra river and in Kainji lake environments.

A large number of autochthonous and allochthonous insects constitutes important proportion of the food of many fish inhabiting the Anambra river system (Ezenwaji & Inyang, 1998; Ezenwaji, 1999). Thus, *P. leonensis* of this study, although omnivorous, subsists mainly on insects (Table 6). As ephemeropterans, chironomids, algae, fish, terrestrial Orthoptera and formicoid Hymenoptera are largely ingested, it implies that *P. leonensis* feeds in or on the substratum, in mid-water and in the air-water interface. Apart from eating other fish (eg. *Barbus callipterus*), the exhibition of the phenomenon of cannibalism by *P. leonensis*, even in the face of a rich variety of other high quality food items, is attributed to light attraction employed by fishers, which, Gliwicz (1984) points out, may lead to this kind of abnormal behaviour in fish. Thus, *L. miodon* inhabiting lake Kariba, Zimbabwe is omnivorous, feeding predominantly on plankton, followed by insects (particularly chironomids, ephemerpterans, trichopterans and hemipterans) and fish, and exhibits cannibalism (Chifamba, 1993). *Microthrissa acutirostris* is omnivorous in lake Mweru-Wantipa, Zambia (Mubamba, 1993); it feeds mainly on zoo- and phyto-plankton and rotifers. In Kanji lake, Otobo & Imevbore (1979) report that *P. leonensis* (=*P. afzeliusi*) and *S. leonensis* are omnivorous feeding on plankton, fish, ostracods and rotifers. It appears, therefore, that clupeids are able to exploit all food niches (bottom, midwater and water surface) in their habitats. Thus, they exhibit wide plasticity in their feeding, primarily consuming a combination of two or more of insects, crustaceans, plankton, fish, algae, plant detritus and rotifers, depending on availability and abundance of these food items.

Clupeids are in turn forage species for other piscivores, and are important links between producers and consumers in food inter-relationships in the aquatic ecosystem. Thus, *P. leonensis* is preyed upon by *Schilbe mystus*, *Parailia pellucida*, *Hepsetus odoe*, and *Hydrocynus* spp. in the Anambra river system (pers. obs.). Similarly, *Lates* spp. and *Hydrocynus* spp. prey on *L. miodon*, *S. tanganicae*, *P. leonensis* and other clupeids in various African lakes (Ogutu-Onwuya, 1983). This predation contributes largely to the high natural mortality in clupeids.

The conclusion may be reached, therefore, that the plasticity and resilience of the biological attributes of *P. leonensis* enable it to survive and thrive in both remote sahelian and coastal basin environments. Early sexual maturity, rapid growth and high recruitment compensate the high mortality of the species resulting from predation and fishing. Thus, the high abundance of *P. leonensis* in the Anambra river is sustained.

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