Food and feeding habits of the African lungfish, *Protopterus annectens* (Owens) (Pisces: Sarcopterygii) in the flood plains of River Niger in Etsako east of Edo State, Nigeria.

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ABSTRACT

An analysis of the gut contents of African lungfish *Protopterus annectens*(O) using the frequency of occurrence, numerical and volumetric methods show that the fish has selective preference for diets of other fishes, molluscs, insects, crustaceans, annelids and plant materials. The condition factor ranged from 0.30 to 0.68 with a mean value of 0.50. The length/ weight relationship showed a linear proportionality with a calculated r-value (0.9682, P = 0.01, df = 207) indicating a positive allometric growth. Histological sections revealed striking similarity between the structures of the tongue and the paired fins (pectoral and pelvic). Both have similar types of taste buds, implying similar and possibly related functions. There is therefore, clear evidence that the paired fins play definite and active role in the feeding process of this fish. Such roles may include food location or detection, determination of food suitability and possibly palatability.

Key words: Food, feeding habit, role, paired fins, *Protopterus annectens*.

INTRODUCTION

Studies of food and feeding habits of freshwater fishes have received considerable attention of recent. This is partly because it forms the basis for the development of successful capture as well as culture fisheries (Blake, 1977; Lauzanne, 1983; Brown, 1985; Ayinla, 1988; Ugwumba, 1988; Baer, *et al.*, 1992) and because of the increasing use of larvivorous species of fish as biological control agents for disease vectors such as aquatic larval stages (Daffalla, *et a.l.*, 1985; Ndome, 1986).

The African lungfish (Genus *Protopterus*), a close relative of *Lepidosiren* of America and *Neoceratodus* of Australia belongs to the order, Dipnoi. It has four species: *P. aethiopicus*, *P. amphibius, P. dolloi* and *P. annectens* with the last being the most widespread in the West African subregion (Holden and Reed, 1978). This fish (i.e. *P. annectens*) which naturally lives in waters subject to seasonal drought, is found in many parts of Nigeria where they form sought-after delicacies for the local people as they are regularly caught, sold and consumed annually. For example, large numbers of these fish are dug out of their aestivation spots annually during the dry season along the flood plains of River Niger in Etsako local government area of Edo State of Nigeria where the present work was done. The fish therefore forms an important part of our inland fisheries resources as well as a ready source of proteins.

Field observations from other parts of the globe indicate a great diversity in the food items of the lungfish including plant and animal diets. Some have, therefore, classified living lungfishes as omnivorous (Johnels and Svensson, 1954; Curry-Lindahl, 1956; Thompson, 1961, Baer *et al.*, 1992). The diet of P. aethiopicus is most completely known. Corbet (1961) showed that the fish has an antigenic shift towards preference for molluscs; though small individuals may feed on a variety of hard and soft food items (including insects, scavenged fish and plant materials).

Bemis and Lander (1986) had reported that complete feeding event in *Protopterus* includes five behaviours: (i) food detection, (ii) food intake, (iii) chewing-adduction, (iv) chewing-transport and (v) constriction. Food detection is said to be very rapid and the paired fins are believed to play important role in this regard (Johnels and Svensson, 1954; Curry-Lindahl, 1956; Derivot, *et al.*, 1979; Bemis and Lander, 1986).

The present study is aimed at establishing the food and feeding peculiarities of this fish found in this part of the world and also to, by histological preparations, ascertain the possible roles of the paired fins in the process.

MATERIALS AND METHODS

The study, which was conducted on the fish populations along the flood plains of River Orie (a tributary of River Niger in Etsako East local government area

of Edo State, Nigeria), spanned between the months of May through August 1997. The collection sites were visited twice each month for two to three days during when local fishermen were accompanied to the filed for fish collection using dragnets, fish traps, and long lines. Fish were immediately weighed (to the nearest gram) and both the total and standard lengths were measured. To arrest post-collection digestion and deterioration, the entire gut of each fish with its contents was extracted by dissection and deposited in situ in well-labeled specimen bottles containing 10% formaldehyde solution.

(1) The study in the laboratory of food of fish was centred on gut content analysis. The information on its food was obtained by the examination of the entire gut content under an optical microscope and magnifying lens. Identification of food items was by using (i) frequency of occurrence, (ii) numerical and (iii) volumetric methods as reviewed by Hynes (1950), Lagler (1956) and Hyslop (1980):

(i) Frequency of Occurrence Method: Here, the number of gut samples containing one or more individual of each food category was recorded and expressed as a percentage of all guts examined as in Fagade and Olaniyan (1972); Ayinla (1988) and Ugwumba (1988).

(ii) Numerical Method: The number of individuals in each food category was recorded for all guts and the total was expressed as a percentage of the total individual in all food categories as in Ikusemiju and Olaniyan (1977), Ayinla (1988) and Ugumba (1988).

(iii) Volumetric Method: The food items were first blotted with paper towels to eliminate superficial water as in Windell and Bowen (1978). These were then sorted into taxonomic categories, and the displacement of the group of items in each category was measured directly in a partially filled graduated measuring cylinder.

Other laboratory studies carried out were (2) feeding behaviour studies and (3) histology of the paired fins and the tongue.

(2) Feeding Behaviour Study: For this study, adult fish were carefully released into large aquarium tanks. These were fed with a combination of young tilapia (*T. melanopleura*) fish, snails (*Biomphalaria pfeifferi*) and dragon fly

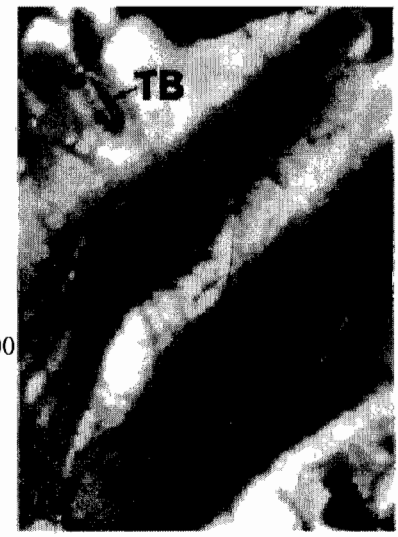
(*Libella lidae*) larvae. The set-up was allowed to stabilize before observations on feeding behaviour were carried out for three months (June through August, 1997).

(3) Histological Studies: The fish were later killed and the paired fins (pectoral and pelvic) were excised at their bases; so also were the tongues. These were fixed in Bouin's fluid for 24 hours, dehydrated, cleared in toluene and embedded in pure paraffin wax. Tissues were later sectioned (both transversely and longitudinally) at 7μ and stained in Heidenhain's (1986)-iron haematoxylin. Finally, the photomicrographs of the sections were taken.

RESULTS

(1) Length-weight relationship and condition factor

The total length distribution of 208 lungfish specimens ranged from 22.50cm to 82.60cm and weight of 50.0g to 3,025.0g. The log length – log weight relationship showed a straight line (see fig. 1)



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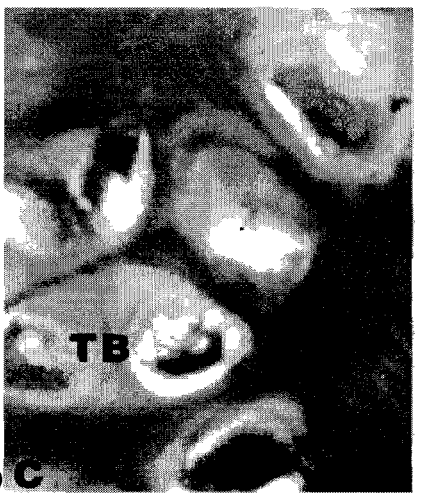

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Plates 1A-E. Sections of the tongue and the paired fins of *P. annectens* (0). A&B; L.S of tongue and pectoral fin respectively showing similar collagen fibres. C-E; T.S of tongue, pectoral and pelvic fins respectively showing similar type of faliate papillae with taste buds. TB. Taste buds; CM. Collagen fibres.

and the calculated r-value was 0.9682, P = 0.01, df = 207. This indicates a positive allometric growth. The condition factor, K, was calculated using the equation of Worthington and Ricardo (1930):

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

Where W = weight (g) and L = standard length (cm). The results showed a fair condition of the fish with K-value ranging from 0.30 to 0.68 (mean = 0.50). When the samples were divided into 10cm size groups to relate K-values to sizes of fish, only slight variations in the mean condition factors were observed in the different size groups (see Table Ib)

Table Ia. Mean monthly condition factor (K) of *P. annectens* (O)

Month	Number of fish Examined	Mean condition factor (K) value.
May	50	0.57
June	68	0.47
July	60	0.48
August	30	0.49
Total	208	0.50

Table Ib: Mean condition factor (K) in relation to size in *P. annectens* (O)

Standard length (cm)	Number of fish within range	Mean condition factor (K) value.
20.0 – 29.9	86	0.50
30.0 39.9	70	0.46
40.0 – 49.9	42	0.52
50.0 59.9	6	0.52
60.0 – 69.9	2	0.52
70.0 – 79.9	-	-
80.0 – 89.9	2	0.55
Total	208	

(2) Food of *P. annectens*: The monthly breakdown of percentage full stomachs (Table II) shows that feeding intensity was highest in May (90%, 45 out of 50 samples examined) and lowest in August (33%, 22 out of 30 samples examined). Analysis of the gut contents shows that *P. annectens* is primarily omnivorous feeding on both plant and animal diets but showing higher selective preference for diets of flesh such as other fishes, molluscs, insects, crustaceans and annelids (see Table III and fig. 2). Plant diets include grains such as rice. On the whole, other fishes form the most important diet of *P. annectens* scoring 39.36% by volumetric analysis and 28.08% of all lungfish samples examined.

Table II: The monthly percentage analysis of the stomach of *P annectens* (O)

Month	No. of stomachs examined	No. of stomach with food items	%	No of stomach that were empty
May	50	45	90	5
June	68	56	82	12
July	60	45	75	15
August	30	22	73	8
Total	208	163	78	45

Table III: Summary of the percentages of the food items of *Protopterus annecteus* (O)

Class of food items	Frequency of occurrence		Numerical		Volumetric	
	No.	%	No.	%	Volume	%
Insect parts and remains	33	21.73	182	11.74	5.70	2.59
Crustacean remains	21	20.19	118	7.61	4.15	1.88
Annelids	17	16.35	79	5.10	5.20	2.36
Mollusc remains (shells)	28	26.92	229	14.77	19.55	8.87
Fish remains (scales, bones; eggs, etc)	24	23.08	441	28.45	86.75	39.36
Plant materials	45	13.27	396	25.55	26.50	12.02
Unidentified items	38	16.54	105	6.77	10.50	4.76
Sand, bottom deposits and organic debris	69	16.35	-	-	62.05	28.15

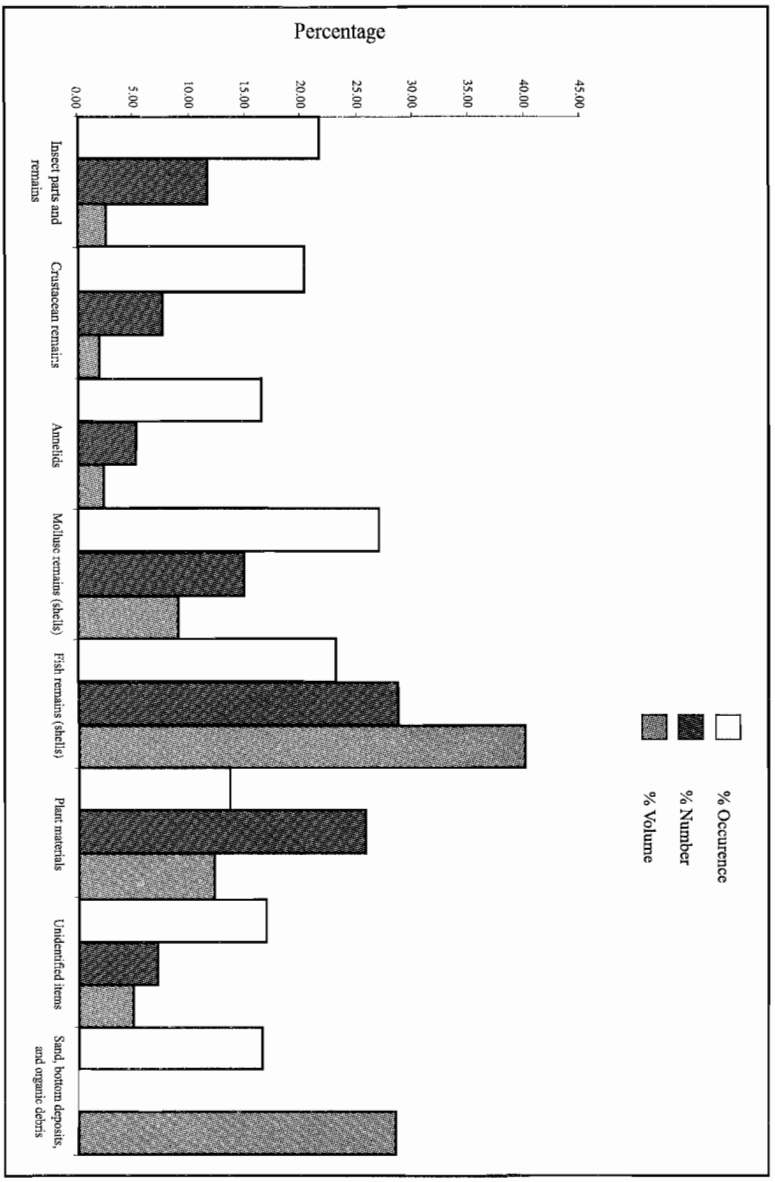

Fig 2. Relative imprtance of food items using frequency, numerical and volumetric methods

Some of the limitations to this study include:

(i) the effects of feeding rhythms which occur at irregular intervals;

(ii) the capture methods (dragnets, fish traps and long lines) which could stimulate regurgitation; possibly the reason for the high proportions of empty stomachs;

(iii) there is the habit of food mastication by this fish with its attendant problem of grinding of food items beyond recognition as well as promoting accelerated digestion.

(3) Feeding peculiarities of *P. annectens*: Lagler *et al.*, (1977) categorizedswimming movements in fishes into three type: anguilliform, ostraciform and carangiform. While the first is the snake- like (or eel-like) type of movement the second is a wag-wag type and last is intermediate between the first two. Movement in *P. annectens* is anguilliform type and the paired fins have been seen to be habitually very active, always lashing in every direction, apparently in search for prey. There is no indication whatsoever that the tiny piercing eyes are used for this purpose. Thus when the fish touches a prey with one of its paired fins, it makes an extremely rapid anguilliform dive to the direction of such prey. In a few seconds, the prey is reached and swiftly drawn into the mouth. A complete summary of feeding behaviour can be classified into six stages: (i) food detection, (ii) food capture, (iii) food intake, (iv) adduction and chewing, (v) transport chewing and (vi) swallowing. The rapidity and high level of accuracy with which prey is detected shows that the paired fins are extremely sensitive. Even if these are touched ordinarily, the fish reacts swiftly to such touch. According to Bemis and Lander (1986), olfaction may be important in prey location.

From the above account, the importance of the paired fins in feeding is apparent. The longer and more slender these are, the more sensitive they appear to be. Histological sections through these and the fish tongue reveal a most striking similarity between these two structures. Both have an outer fibrous coat enclosing bundles of collagen fibres. The coat is further enveloped in a stratified squamous epithelium lined by an outer mucous membrane that is modified at various points to form elevations or papillae. According to Beveland and Ramaley (1979), four types of papillae are found in higher vertebrates (especially man): filiform, fungiform, foliate and vallate; and these possess taste buds to varying degree. The tongue of *P. annectens* possesses only the first two and these have many taste buds (see plate 1a). Surprisingly similar papillae were clearly visible in the structure of the paired fins (especially that of the pectoral fin) and these had a large number of taste buds that were similar to those found on the fish tongue (see plates1b– e).

DISCUSSION AND CONCLUSION

The present study shows that *P. annectens* feeds on a variety of food items ranging from flesh to plant material. This agrees with the reports of earlier

investigators who had worked on lungfish species from other parts of Africa (such as Gambia, Kenya, Uganda, Sudan, etc.) that the lungfishes (*Protopterus* species in particular) are primarily omnivorous (Johnels and Svensson, 1954; Thompson, 1969; Daffalla *et al.*, 1985). While a number of investigators had reported that *Protopterus* species (*P. aethiopicus* in particular) shows selective preference for molluscan diets (Worthington, 1932; Poll and Damas, 1939; Hoier, 1950; Corbet, 1951; Marlier, 1954), the present study shows that *P. annectens* shows preference for feeding on other fishes. This may probably be due to the fact that the study period coincided with the breeding period of many fishes as a result of which young fish species would be available in large numbers to be preyed upon easily.

The presence on the paired fins of taste buds that are similar to those of the fish tongue raises some salient questions. Could the two structures have similar or same functions? Since the primary functions of taste buds in the tongue are to detect taste and flavour, could those of paired fins do the same? Curry-Lindahl (1956) reporting his observations in the laboratory on the feeding behaviour of *P. aethiopicus* said, " The two paired fins which take the form of rope-like appendages of the otherwise motionless fish on the bottom of the tank are almost always constantly moving slowly in different directions like independent living beings. If these sensitive organs come into contact with some hidden object in the mud such as a fish or some other prey, *Protopterus* rapidly turns towards this and sucks it into its mouth". Johnels and Svensson (1954) had in a similar observation earlier reported that the paired fins play vital role in food location.

One can, therefore, conclude presently that the taste buds on the paired fins of *P. annectens*(O) must have the ability to detect as well as ascertain the suitability and palatability of a particular object or food items for consumption.

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