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Feeding activity and food habits of the shad, *Ethmalosa fimbriata* (Bowdich), in the coastal waters of Cape Coast, Ghana

J. BLAY JR* AND K. N. EYESON†

Department of Zoology, University of Cape Coast, Cape Coast, Ghana

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The monthly feeding activity and food habits of populations of *Ethmalosa fimbriata* occurring in the sea and an estuary in Cape Coast, Ghana district were investigated during a 14-month period. The juvenile fish, whose total length (T.L.) ranged from 5·3 to 14·7 cm, occur in the estuary and appeared to be more active feeders than the marine samples which measured 15·0–30·4 cm. The peak feeding activity in the marine population coincided with the onset of 'upwelling' in the sea, which period is characterized by high salinities, decreasing temperatures and high zooplankton production. The species is primarily a plankton feeder. The stomachs of the marine samples contained mainly protozoa, crustacea, molluscan larvae and a considerable amount of detritus while the stomachs of the estuarine fish contained mainly phytoplankton, protozoa, sand grains and organic detritus. These observations have been discussed in relation to other reports on populations occurring along the West African coast.

I. INTRODUCTION

Although *Ethmalosa fimbriata*, a West African clupeid fish, is a potential fish food in coastal waters of Ghana, only brief reports of its occurrence in the brackish waters and the sea have been recorded (Irvine, 1947; Ofori-Adu, 1974). At present, this fish is not as favoured as its related species *Sardinella aurita* and *S. eba*, but with the dwindling stocks of these sardines *E. fimbriata* could become an important marine food source. In some West African countries (Senegal, Gambia, Sierra Leone, Ivory Coast and Nigeria) *Ethmalosa* spp. are of commercial importance and various aspects of the biology in these areas have been investigated (Salzen, 1958; Bainbridge, 1957, 1961, 1963; Scheffers, 1971; Fagade & Olaniyan, 1972). The present investigation provides a fuller information on the food of a population occurring in Ghana, and forms part of a study of the biology of the group. Aspects of its reproduction will be reported in another paper.

II. MATERIALS AND METHODS

Sampling was restricted to fishing areas up to 8 km west of the University of Cape Coast, in the central region of Ghana. The juvenile fish occurred in the estuary of Kakum River while the sexually immature and mature adults were found in the sea.

*University of Ilorin, Nigeria.
†All communications are to be sent to K. N. Eyeson.

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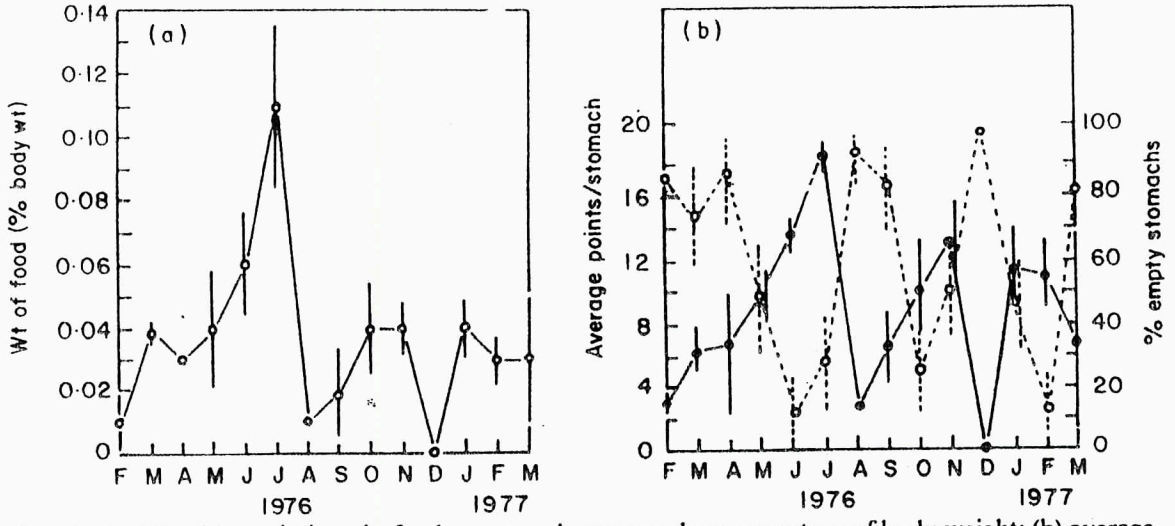

FIG. 1. (a) Monthly variations in food consumed, expressed as percentage of body weight; (b) average points per stomach (solid line) and percentage of empty stomachs (broken line) in marine *E. fimbriata*. Vertical lines represent 2 S.E.

Monthly samples of *E. fimbriata* were obtained from fishermen at the Elmina fishing harbour and the juvenile fish were caught with cast nets in the Kakum River estuary. The specimens were weighed and the standard and total lengths (S.L. and T.L.) were measured. The stomachs were removed and each was opened to determine its degree of fullness according to an arbitrary 5-point scale—20, 15, 10, 5 and 2·5 points were awarded for full, 3/4, 1/2, 1/4 and 1/8 full stomach, respectively. The stomach contents were then weighed and preserved in 70% alcohol for further analysis. Identification of the contents was made with the aid of laboratory manuals (Davis, 1955; Newell & Newell, 1963; Wickstead, 1965) and further analysis of these stomach contents was based on the 'occurrence' and the 'points' methods (Hynes, 1950).

III. RESULTS

MONTHLY FEEDING ACTIVITY

The following criteria were used in determining the monthly feeding activity of *E. fimbriata*: (i) points scored for the degree of fullness of stomach, (ii) the weight of food expressed as a percentage of the body weight and (iii) the percentage of fish with empty stomachs.

(a) *Marine samples*

These fish measured 15·0–30·4 cm T.L. The monthly feeding activity is illustrated in Fig. 1(a) & (b). The variations in the weight of food as a percentage of body weight, and the mean points gained for fullness showed similar patterns. Figure 1(b) indicates a complementary relationship between the monthly average points per stomach and the monthly percentages of empty stomachs. Peak feeding activity in these specimens occurred in July 1976, but there was a sharp decline in August. Thereafter the level of activity remained low until the end of the study period.

(b) *Estuarine samples*

These constituted the juvenile population and their T.L. ranged from 5·3 to 14·7 cm. The graphs of their feeding activity shown in Fig. 2(a) & (b) indicate a higher level of activity than the marine population, except for a reduced feeding intensity in July and August 1976.

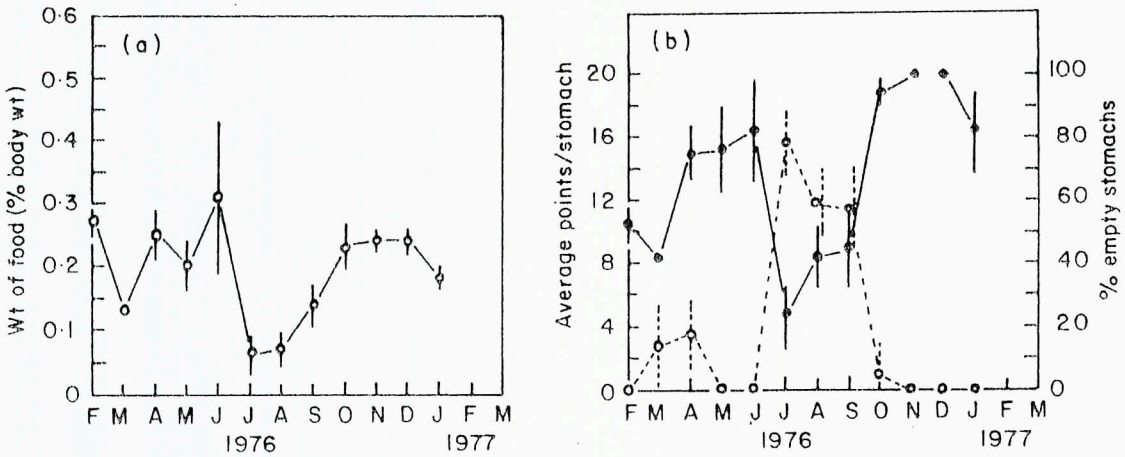

FIG. 2. (a) Monthly variations in food consumed, expressed as percentage of body weight; (b) average points per stomach (solid line) and percentage of empty stomachs (broken line) in estuarine *E. fimbriata*. Vertical lines represent 2 S.E.

TABLE I. A summary of feeding activity indices in marine and estuarine samples of *E. fimbriata*

Sample	Percentage with empty stomachs	Points for degree of fullness		$\frac{\text{Wt of food}}{\text{Body wt}} \times 100$	
		Total	Mean	Total	Mean
Marine	56·2 (264)*	2410 (206)	11·7	9·72 (206)	0·05
Estuarine	34·1 (137)	3580 (264)	13·6	53·91 (264)	0·22

*Number of fish in parentheses.

A comparison of the data on the marine and estuarine populations (Table I) shows a significant difference in the mean weight of stomach contents expressed as a percentage of body weight (at 0·1% level of probability, $t = 21{\cdot}25$).

FOOD OF *E. FIMBRIATA*

Figure 3(a) & (b) illustrates the monthly percentage composition and percentage frequency of occurrence of various items in the stomachs of the marine and estuarine samples. The organisms were grouped in their major divisions and wherever possible they were identified to genus and species.

(a) *Algae*

Phytoplankton occurred frequently in the stomachs of the two populations of fish but constituted 9·4–28·9% of the diet of the estuarine samples while it formed 1·7–17·3% of the diet of the marine fish. The diatoms, *Navicula* sp., *Gyrosigma* sp., *Coscinodiscus* sp. and *Stephanodiscus* sp. dominated the algal component of the food of the estuarine juvenile fish but in the marine samples *Stephanodiscus* sp. was predominant.

(b) *Protozoa*

Apart from August, September and November 1976, the monthly occurrence of protozoa in the stomachs of estuarine fish varied from 50 to 100%, but that

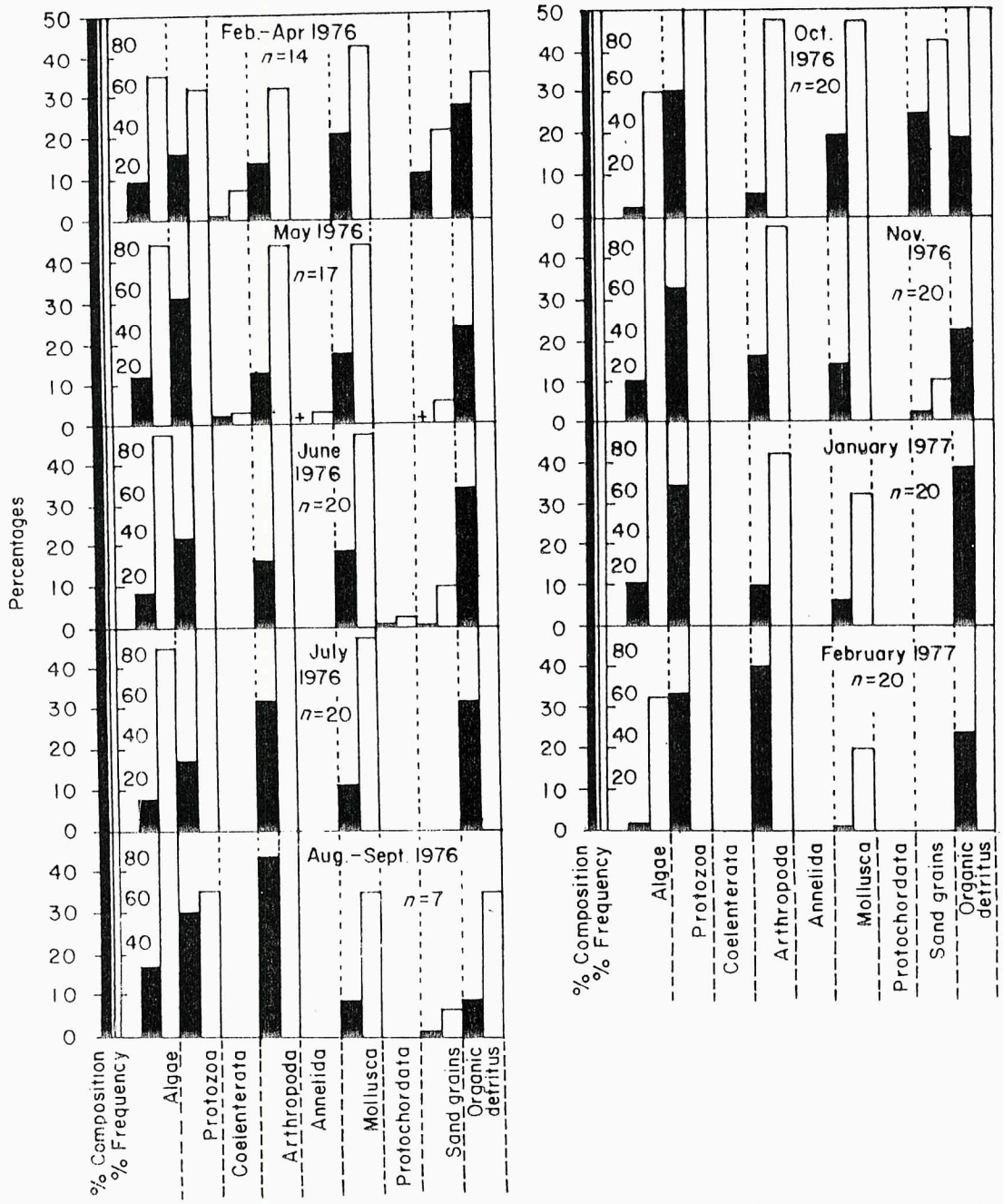

FIG. 3. (a) Monthly percentage composition and percentage frequency of occurrence of food items in the stomachs of marine *E. fimbriata*. No stomachs contained food in the December 1976 sample, (n = number of stomachs).

of the marine *E. fimbriata* ranged from 64 to 100% throughout the year. They constituted 3·3 to 26·1% of the diet of the juvenile population and consisted mainly of flagellates *Peridinium divergens, Prorocentrum micans*, and the tintinnids, *Helicostomella* sp. In the marine samples the protozoa formed 16·3–34·2% of the diet and they were mainly dinoflagellates *Ceratium candelabrum* and *C. longiceps*; the foraminiferans *Globigerina bulloides, Camerina elegans* and *Cribostomum bradyi*, and some unidentified radiolarians.

(c) *Coelenterata*

Only a few of these were seen in the stomachs of the fish. They were present

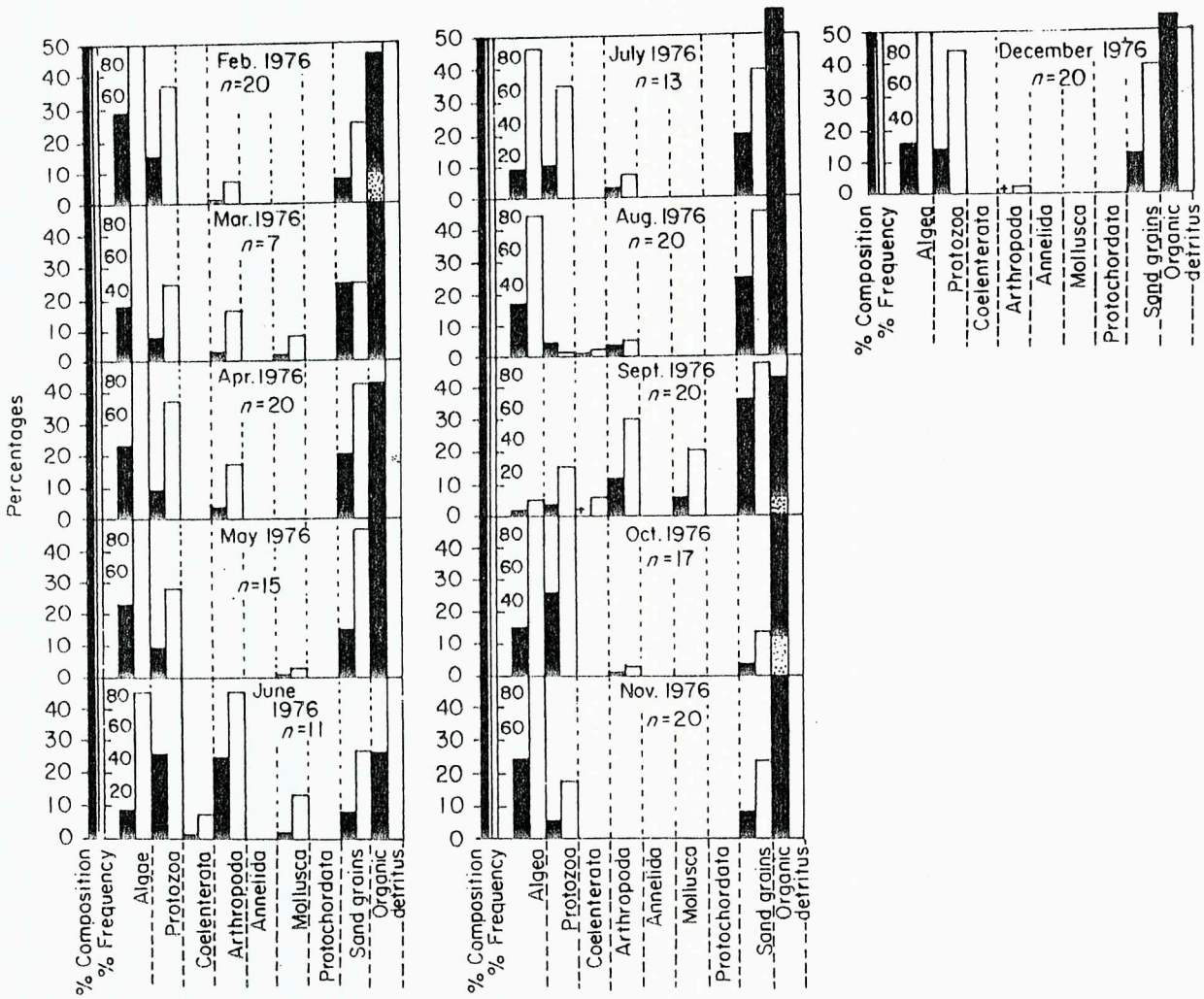

FIG. 3. (b) Monthly percentage composition and percentage frequency of occurrence of food items in the stomachs of juvenile *E. fimbriata* from the Kakum River estuary, (n = number of stomachs)

in the estuarine samples in June, August and September 1976, and consisted of *Lensia* sp. and *Obelia* sp. They occurred mainly in the June sample (18·2%) and constituted only 1·4% of the diet. *Galleta australis* was the only coelenterate found in the stomachs of the marine specimens caught from February to May 1976.

(d) *Annelida*

None was recorded in the food of the estuarine fish and it was of little significance in the diet of the marine samples. The only annelids observed were the larvae of the polychaete worm, *Tomopteris* sp.

(e) *Arthropoda*

These occurred more frequently in the marine fish (64·3–100%) than in the estuarine group (0–90%). In the marine *E. fimbriata* they constituted 5·7–44·0% of the diet and the maximum (31·4–44·0%) was observed in July to September 1976, and February 1977. In the estuarine fish the arthropoda formed 0·5–25·3% of the food and consisted mainly of the copepods *Calanus* sp. and cirriped larvae.

In the marine specimens, however, *Paracalanus* sp. was the commonest copepod; a few specimens of *Calanus* sp. and amphipods, *Hyperia* sp. were also encountered.

(f) *Mollusca*

Gastropod and Pelecypod larvae were the main groups identified and they occurred more frequently (40–100%) in the marine than in the estuarine (6·3–40·0%) fish.

(g) *Protochordata*

The only protochordates identified were the larvae of *Dollioleta* sp. in a few marine fish.

(h) *Sand grains and organic matter*

The presence of these items in the stomachs of *E. fimbriata* suggests that the species browses also on benthic deposits. Both items formed a large proportion of the stomach contents of estuarine fish but in the marine species organic matter seemed more prominent.

It could be inferred from these observations that the estuarine fish fed mainly on phytoplankton and organic matter. Protozoa appear to be of little significance. The marine population, on the other hand, fed mainly on zooplankton which largely consisted of protozoa, crustacea and molluscan larvae.

IV. DISCUSSION

Bainbridge (1957, 1963) has shown that *E. fimbriata* is a filter feeder and has an efficient filtering mechanism for its plankton diet. In the present investigation, an analysis of the stomach contents (Figs 1 & 2) suggests that the estuarine (juvenile) fish feed more intensely than the marine forms. This partly supports Bainbridge's (1963) assessment of average food volumes of 0·7 and 0·01 ml per stomach, respectively, for the estuary and marine samples of Sierra Leone. Bainbridge attributed the high feeding activity in the estuary to the development of a high standing crop of phytoplankton, but in the present studies the high intensity of feeding could also be due to the high physiological demands of growing juvenile fish.

The peak feeding activity in the marine population of Cape Coast was observed in July 1976, the end of the rainy season. This period also happened to be the 'upwelling' season (June to August) when temperatures are low; there is abundant zooplankton and large quantities of the clupeid fish *Sardinella* sp. also appear in the surface waters (Mensah, 1966; Dykhuizen & Zie, 1970; Ofori-Adu, 1975). It is possible that the high feeding intensity of the marine population in July 1976 was due to the abundance of its zooplankton food at the time. However food intake was reduced considerably in August and December, 1976. It is difficult to explain the reduced food consumption in December but that of August could be attributed to the prevailing low water temperature of 18·9° C. Water temperatures for May to October 1976 were 25·2, 23·6, 20·8, 18·9, 19·5 and 23·0° C, respectively (Fishery Research Unit, Ghana; unpublished).

Another reason for the reduced food intake in August 1976 could be an increased competition for plankton food with the related *Sardinella* sp. which

were abundant at the time. Bainbridge (1963) observed little or no competition in the Sierra Leone River estuary since the *Sardinella eba* entering the river during the dry season fed extensively on zooplankton while *Ethmalosa* in that habitat fed mainly on phytoplankton. In Ghana, the appearance of *Sardinella aurita* in the surface waters close to the shore coincides with the abundance of its zooplankton food which also constitute the main diet of *E. fimbriata*. There is therefore a possibility of competition and this would be pronounced in the latter part of the 'upwelling' season when the plankton population would probably be dwindling. In the estuary, however, feeding activity of the juvenile fish was high except in July to September 1976 when relatively low temperatures of 24·0, 22·5 and 24·0° C for the three months (Blay, 1977) probably affected feeding. It would thus appear that the juvenile fish are more susceptible to low water temperature than the adults.

The juvenile fish in the Kakum River estuary fed consistently on phytoplankton, mainly diatoms, for most part of the study period. The commonest diatoms belonged to the genera *Navicula, Gyrosigma, Cosinodiscus* and *Stephanodiscus*. The presence of large quantities of sand grains, organic detritus and the diatom *Navicula* in the stomachs of these fish suggests that they probably browse on benthic deposits. Similar observations were made by Bainbridge (1963) and Fagade & Olaniyan (1972), but the latter authors do not consider organic detritus an important contribution to the nutrition of the species since they might have been taken in accidentally during filtering. In the present investigation the main zooplankton food of the juvenile fish consisted of the dinoflagellates, *Peridinium divergens* and the tintinnids *Helicostomella* sp. Fagade & Olaniyan (1972) observed that the juveniles in Lagos lagoon fed more on zooplankton than phytoplankton and copepods; larvae of bivalves and gastropods, and dinoflagellates were the main components.

The adult *E. fimbriata* in the marine environment fed mainly on zooplankton but organic detritus also formed a considerable proportion of the stomach contents. The zooplankton comprised protozoa, crustacea and molluscan larvae. The commonest protozoa were the dinoflagellates *Ceratium* spp. and the foraminiferans *Globigerina bulloides, Camerina elegans* and *Cribostomum bradyi*. Other zooplankton seen were radiolaria, the copepods *Calanus* and *Paracalanus* spp., and gastropod and pelecypod larvae. The main phytoplankton in the diet were the diatoms *Stephanodiscus* sp. and the desmids *Netrium digitatus*. In the Sierra Leone River estuary, however, adult *E. fimbriata* fed mainly on diatoms of the genera *Actinocyclus* and *Coscinodiscus* (Bainbridge, 1963), while in the Lagos lagoon *Coscinodiscus* and *Biddulphia* spp. were highly represented in the stomachs of the adult fish (Fagade & Olaniyan, 1972). The presence of foraminiferans and radiolarians in the food of *E. fimbriata* from Cape Coast seems unique, since all the other main food items are also present in varying quantities in the samples from Sierra Leone and Nigeria.

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