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Food and feeding habits of four species of juvenile mullet (Mugilidae) in a tidal lagoon in Ghana

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Juvenile mugilid fishes, *Liza falcipinnis*, *L. dumerilii*, *Mugil bananensis* and *M. curema*, which enter the Elmina Lagoon in the Cape Coast District of Ghana, have a similar diet comprising mainly bacteria, diatoms, blue-green/green algae, protozoans, detritus and particulate organic matter. No seasonal changes in the diet and feeding activity were observed. The relative gut length (intestine to standard length ratio) and diet showed no significant changes with size of fish in all the species. All four species were diurnal feeders, but their peak feeding times differed. Interspecific competition for food was possibly limited by species preferences for substrate particles of particular size range and differences in feeding chronology.

Key words: mullet; Elmina Lagoon; food habits; feeding chronology.

INTRODUCTION

Mullets (Mugilidae) are common fishes in the coastal waters of tropical and subtropical countries. Sixteen species have so far been identified in West Africa (Fowler, 1936; Cadenat, 1954), and these constitute an important proportion of the catches of commercial and subsistence fishermen in some countries in this area (Brulhet, 1975; Payne, 1976).

Worldwide, the potential of mugilids in aquaculture is well known (Bardach *et al.*, 1972; Nägel, 1979). This has aroused considerable interest in studies on the biology of many species from different geographical areas (e.g. Zismann *et al.*, 1975; Blaber, 1976, 1977; Blaber & Whitfield, 1977; De Silva & Silva, 1979; Al-Daham & Wahab, 1991).

A few reports are available on the biology of mullet species in the coastal waters of West Africa (Fagade & Olaniyan, 1973; Brulhet, 1975; Payne, 1976). Although these works dwelt principally on the food and feeding habits, similar investigations in other localities of the subregion are considered necessary for a fuller understanding of the feeding biology of the various mullet species.

The present investigation reports on the food spectrum and feeding chronology of four mugilid species entering a tidal (' open ') lagoon in Ghana.

MATERIAL AND METHODS

Using cast nets of 20 mm stretched mesh, mullets were caught monthly (November 1991–October 1992) from the Elmina Lagoon (approximately 1°23′ E, 5°06′ N) in the Cape Coast District of Ghana. All the monthly samples were taken during daytime, between 08.00 and 10.00 hours. It was not possible to sample in June because of a ban on fishing activities imposed in connection with an annual festival of the local people. Samples were also taken over two 24 h periods (23–24 September and 28–29 October

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TABLE I. Relative gut length and standard length of mullets from the Elmina Lagoon

Species	Number of specimens analysed	Range of standard length (cm)	Relative gut length	
			Range	Mean ± S.D.
Liza falcipinnis	111	3·5–14·9	1·4–5·5	3·8 ± 0·8
Liza dumerilii	83	5·3–11·2	1·7–4·7	3·5 ± 0·7
Mugil bananensis	38	4·9–11·8	2·7–4·8	3·4 ± 0·5
Mugil curema	48	6·1–13·6	2·8–4·2	3·6 ± 0·5

1992) at 4 h intervals for investigations on the diel feeding periodicities of the different mullet species. All samples were preserved in 10% formalin immediately after capture.

Fish were measured for total length (T.L.), standard length (S.L.) and body weight within 24 h after preservation before the preservative could cause any significant shrinkage and weight loss. The gut was removed and the length of the intestine was measured. Stomach contents were weighed and the various constituents were subsequently identified under the microscope. Using an eyepiece micrometer, measurements were taken of the longest axis of sand particles occurring in the stomachs. Analysis of the diet was carried out by the frequency of occurrence method (Hynes, 1950), and the daily and seasonal feeding activities were investigated by the index of stomach fullness (Hureau, 1966) expressed as:

$$\frac{\text{total weight of stomach contents}}{\text{total fish weight}} \times 100$$

During the 24 h samplings, tidal variations were noted, and salinity and water temperature of the lagoon were measured at 4 h intervals.

RESULTS

Juveniles of four species of mullet were found in the Elmina Lagoon: *L. falcipinnis* (Cuvier & Valenciennes, 1836), *L. dumerilii* (Steindachner, 1870), *Mugil bananensis* (Pellegrin, 1928) and *M. curema* (Cuvier & Valenciennes, 1836). Their respective length ranges in the samples were 4·5–20·2, 5·0–19·5, 6·2–15·4 and 5·9–17·9 cm T.L., and no specimens of each species with ripening or ripe gonads were encountered, although gonads of a few specimens larger than 15·0 cm were at the developing stage.

No significant change in the relative gut length with standard length was observed in any of the species ($P>0·05$) (Table I).

The stomach contents of 659 *L. falcipinnis*, 396 *L. dumerilii*, 248 *M. bananensis* and 125 *M. curema* gave no evidence of variations in the diet with season or with size in any given species. Hence, the monthly data for each species were pooled for the analysis of the stomach contents (Table II).

Sand particles and detritus were present in the stomachs of all species (Table II), and diatoms, blue-green algae, green algae, protozoans, poriferan spicules, particulate organic matter and bacteria were present in more than half the stomachs of each species.

Oscillatoria sp., *Lyngbya* sp. and *Merismopedia* sp. were the commonest blue-green algae eaten; the main diatoms in the diet were benthic forms, e.g. *Pleurosigma* sp., *Gyrosigma* sp., *Navicula* spp. and *Synedra* sp.; the green algae

TABLE II. Frequency of occurrence of food items in the different mullet species from the Elmina Lagoon

Food items	Frequency of occurrence (%)			
	Liza falcipinnis	*Liza dumerilii*	*Liza bananensis*	*Liza curema*
Bacteria (Bm)	100	98·3	100	100
Fungi (Bm)	7·5	10·3	21·0	60·3
Blue-green algae (Bm)	86·8	93·1	98·4	100
Diatoms (Bm)	83·0	93·1	100	100
Green algae (Bm)	75·5	63·8	95·2	90·6
Fragments of macrophytes (Bm)	60·4	58·6	37·1	10·0
Protozoans (Bm)	83·0	94·8	98·4	80·2
Poriferan spicules (Bm)	66·7	79·3	80·6	100
Hydrozoan coelenterates (B)	5·7	8·6	4·8	—
Nematodes (B)	52·8	13·8	35·5	70·5
Rofifers (Bm)	1·9	—	—	—
Ostracods (M)	9·4	37·9	4·8	—
Calanoid/cyclopoid copepods (M)	22·6	6·9	—	—
Fragments of crustaceans (Bm)	56·6	50·0	48·4	30·7
Crustacean eggs/larvae (P)	17·0	5·2	16·1	9·8
Annelid larvae (P)	9·4	—	—	—
Molluscan larvae (P)	15·1	41·4	30·6	11·2
Echinoderm larvae (P)	—	—	—	10·4
Fish scales	47·2	44·8	12·9	20·0
Fish flesh	86·8	6·9	—	—
Particulate organic matter (Bm)	92·5	86·2	100	100
Detritus	100	100	100	100
Sand particules (Bm)	100	100	100	100

B, benthic organisms measuring 0·5–1·0 mm; Bm, benthic organisms smaller than 0·1 mm/inorganic material; M, vertically migrating zooplanton; P, plankton.

were mostly unidentified filamentous algae, and desmids; and the commonest protozoans ingested were flagellates (*Prorocentrum* sp. and *Peridinium* spp.) and foraminiferans (*Pulvinulina* sp., *Globigerina* sp. and *Textularia* sp.).

Other food items occurred in fewer than 50·0% of the stomachs of the different species of mullet. However, unidentified nematodes were encountered in 52·8 and 70·5% of the stomachs of *L. falcipinnis* and *M. curema*, respectively, while fragments of crustaceans were seen in 56·6 and 50·0% of the stomachs of *L. falcipinnis* and *L. dumerilii*, respectively.

Sand particles in the range 150–200 μm were preponderant in the stomachs of both *L. falcipinnis* and *L. dumerilii* but the maximum particle sizes filtered (Fig. 1) reached 450–500 μm in the former, and 700–750 μm in the latter species. The particles most frequently ingested by *M. curema* and *M. bananensis* measured 25–75 μm and 100–150 μm, respectively, with maxima (Fig. 1) at 250–300 μm and 350–400 μm.

All species fed mainly between sunrise (06.00 hours) and sunset (18.00 hours) (Fig. 2); stomachs were empty or nearly empty at night. In *M. curema*, however, there was reduced feeding activity from sunset. *L. falcipinnis* had a single peak

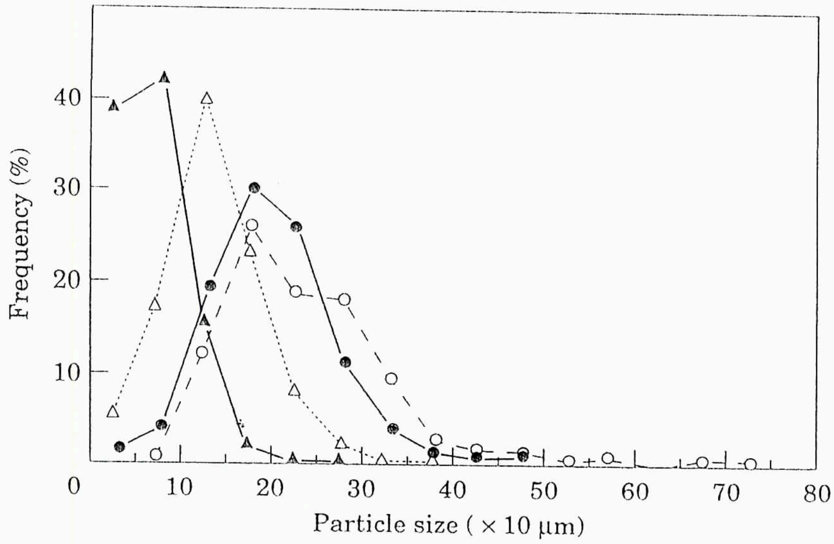

FIG. 1. Frequency distribution of sand particles in the stomach of *Liza falcipinnis* (●——●), *L. dumerilii* (○– – –○), *Mugil bananensis* (△ · · · △) and *M. curema* (▲——▲) from the Elmina Lagoon.

in feeding at 14.00 hours, while the other three species peaked twice daily: 10.00 and 18.00 h for *L. dumerilii*, 06.00 and 18.00 hours for *M. bananensis*, and 06.00 and 14.00 hours for *M. curema*. Feeding activity was more intense in October than in September.

The mean index of stomach fullness fluctuated between 0·15 and 2·75% in *L. falcipinnis*, 0·05 and 1·47% in *L. dumerilii*, 0·05 and 0·75% in *M. bananensis*, and 0·03 and 0·51% in *M. curema* during the study period (Fig. 3). As shown by the fluctuations there was little seasonality in the feeding activity of each species. None the less, *L. falcipinnis*, *M. bananensis* and *M. curema* showed the highest peak in July.

DISCUSSION

L. falcipinnis, *L. dumerilii*, *M. bananensis* and *M. curema* found in the Elmina Lagoon (Ghana) had a similar diet and diel feeding patterns. The dominance of algae, detritus and sand particles in the diet of these species complements the results of studies in the Lagos Lagoon in Nigeria (Fagade & Olaniyan, 1973) and the Black Johnson Estuary in Sierra Leone (Payne, 1976). Ingested sand particles presumably help in the grinding of food materials in the pyloric stomach (Thomson, 1966); as observed in the diet of south-east African mullets (Blaber, 1977), bacteria were also important in the diet of the Elmina Lagoon mullets.

In addition to the food items eaten by the mullets in the Sierra Leone River Estuary (Payne, 1976) and the Lagos Lagoon (Fagade & Olaniyan, 1973), the species in the Elmina Lagoon ate protozoans, hydrozoan coelenterates, nematodes, rotifers, larvae of annelids, molluscs and echinoderms, and pieces of fish flesh. Clearly, the mullets in this lagoon utilize a wider food spectrum than their counterparts in other West African waters, and these differences could be ascribed to variations in the productivity of the water, and hence the range of food items available to the fish (Truslé, 1981). The omnivorous diet of the species in Elmina is, however, similar to that of the mullet species in south-east

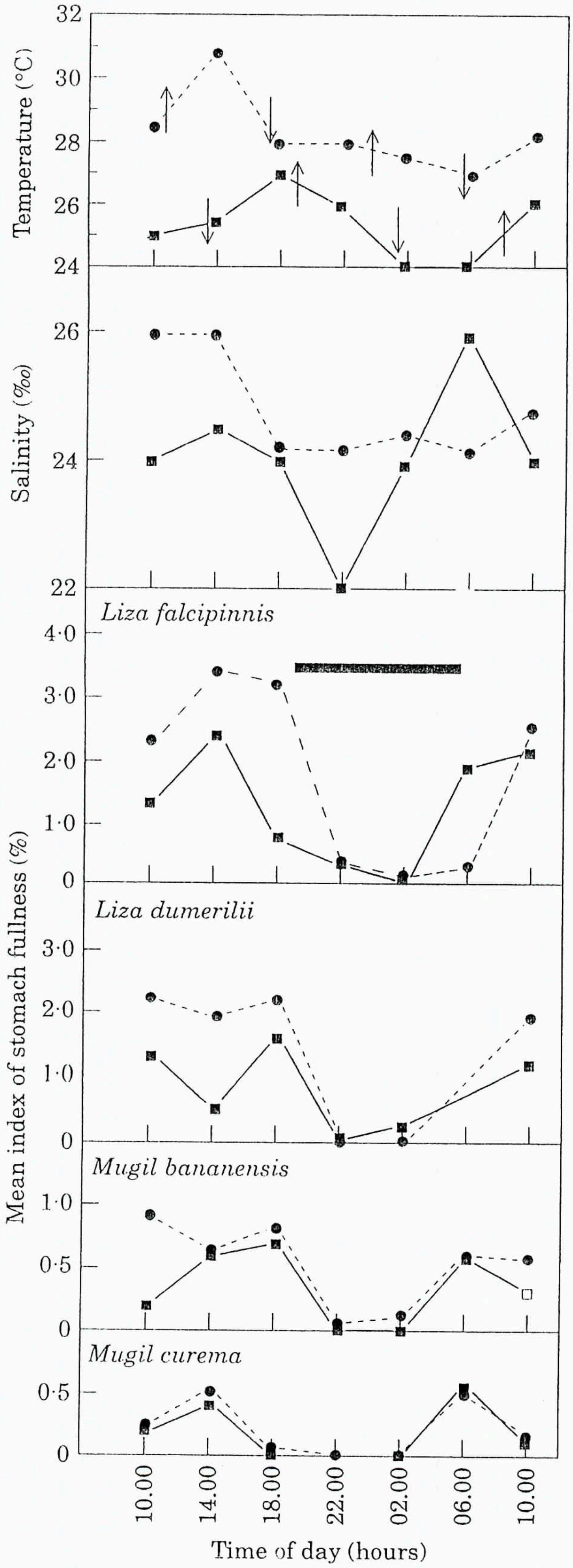

FIG. 2. Variation in temperature, salinity and feeding periodicity of mullet (*Liza falcipinnis*, *L. dumerilii*, *Mugil bananensis* and *M. curema*) in the Elmina Lagoon on 23–24 September (■——■) and 28–29 October 1992 (●– – –●). Arrows pointing upward and downward indicate periods of low and high tide, respectively. Bar represents dark period.

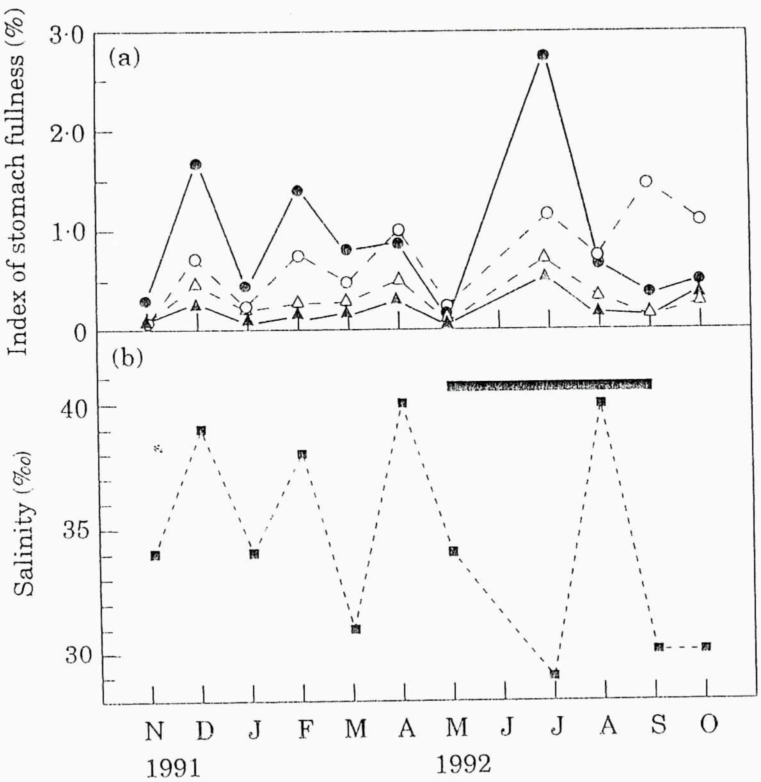

FIG. 3. (a) Monthly variation in feeding activity of *Liza falcipinnis* (●——●), *L. dumerilii* (○- - -○), *Mugil bananensis* (△ · · · △) and *M. curema* (▲——▲) from the Elmina Lagoon. (b) Monthly variation in salinity of the Elmina Lagoon. Bar indicates wet season.

African estuaries (Blaber & Whitfield, 1977), in consisting of microbenthos, meiobenthos, plankton and vertically migrating zooplankton.

A significant increase in the relative gut length with size of mullet has been observed by various workers, and this has been used as an indication of an increase in herbivorous diet of some species. Hickling (1970), found that larger *Crenimugil labrosus* Risso are herbivorous and have a high relative gut length, while Odum (1970) has reported that the intestine to fish length (S.L.) ratio of 3·2 in *Mugil cephalus* L. from Hawaii (U.S.A.) is adequate for assimilating diatoms. By contrast, although the relative gut length changes significantly with size in south-east African *M. cephalus* (Blaber, 1976) and *Liza* spp. from Sri Lanka (Wijeyaratne & Costa, 1987*a,b*), no appreciable variation in the diet occurs. In the mullet species investigated in the Elmina Lagoon, no significant relationship between the relative gut length and standard length was observed, and the diet did not vary significantly with size of fish. These findings are similar to those of Wijeyaratne & Costa (1986) on *M. cephalus* in the Negombo Lagoon in Sri Lanka. The large intestine length to standard length ratio of the mullet specimens from Elmina is, nevertheless, typical of mugilids. Hickling (1970) noted that relative gut length of fish is fairly high when large quantities of indigestible materials occur in the food.

Mullets obtain their nutrition from the microorganisms associated with the sediment particles (Hickling, 1970; Odum, 1970). Particle size selection has been reported among mullet species in some localities, and according to Blaber (1976), the consumption of the various food items may depend upon their occurrence on substrata of the preferred particle size. Studies by Masson and Marais (1975) in

South Africa, and Payne (1976) in Sierra Leone, showed that *L. dumerilii* ingests larger particles than other species of mullet in its habitat, as was the case in the Elmina Lagoon. Furthermore, Blaber (1977) working in south-east Africa suggested that sympatric mullet species with similar diet probably avoid competition by selecting sand particles of different sizes. It is conceivable that the mullet species at Elmina may be minimizing competition for food by showing preferences for different sand particles.

The present data suggest a strong diurnal feeding activity for the four species, as reported in other mullets (Blaber, 1976; De Silva & Wijeyaratne, 1977). Blaber (1976) suggested that differences occurring in the peak feeding time among sympatric mullet probably is a mechanism for averting competition. In view of the similarity in the diet of the mullet of the Elmina Lagoon, the variations recorded in the peak feeding time could also ensure a reduction in competition among the different species.

Odum (1970) observed a relationship between the state of the tide and feeding intensity of *M. cephalus*, but no such relationship was apparent for the species in Elmina Lagoon, a situation which is similar to that reported for *M. cephalus* in the Negombo Lagoon (Sri Lanka) (De Silva & Wijeyaratne, 1977).

Salinity and temperature regimes of the lagoon were higher on 28–29 October than on 23–24 September, a rainy day. Feeding intensity of the different mullet species was generally higher in October than in September. However, at 06.00 hours, the salinity of the lagoon was 26·0‰ on 23–24 September, and 24·2‰ on 28–29 October, and the mean index of stomach fullness of *L. falcipinnis* was 1·85 and 0·22%, respectively. Hence food uptake may increase with salinity in this species, as in other mullet species (De Silva & Perera, 1976).

The lack of seasonal variations in the feeding activities of the mullet reported in this study may be attributed partly to the unstable environmental conditions in the lagoon engendered by the haphazard fluctuations in the transparency, salinity and dissolved oxygen content (E. A. Obodai, unpubl. obs.). Another possible factor is the frequent fishing and other human activities in the lagoon, which could interfere with the feeding rhythm of the fishes.

I conclude that the mugilids in the Elmina Lagoon are omnivorous, and the wide range of their food is probably engendered by the high productivity of the lagoon. There is a lack of seasonality in the feeding intensity of the different species, but all show a clear diurnal feeding habit. Although the diet of these mugilids is similar, differences in their feeding periodicity and preferences for different sizes of sand particles filtered from the substratum could be the factors favouring coexistence of the various species of mullet in the lagoon.

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