Food and Feeding Habit of *Sarotherodon melanotheron*, Rüppell, 1852 (Pisces: Cichlidae) in Sakumo Lagoon, Ghana

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Abstract

An investigation was conducted into the food and feeding habits of the blackchin tilapia *Sarotherodon melanotheron* (Rüppell, 1852) in the Sakumo lagoon in the Greater-Accra Region of Ghana. The food items covered a wide range of plankton and other accessory prey items suggesting that the fish is largely planktivorous. There were no clear differences among food items eaten by the juveniles and adults, with the Shannon-Wiener diversity index (H') being 1.1 and 1.2, respectively. This suggests that the diversity of food items exploited by the adults are similar to that of the juveniles, or that they exploited the same microhabitats. However, the juvenile fish had preference for the Cyanophyceae, Chlorophyceae and Rotifera, whilst the adults generally preferred Cladocera, Bacillariophyceae and Cyanophyceae, suggesting age-specific dietary preference. The majority (45.2%) *S. melanotheron* had 3/4 fullness of guts around 1200 GMT and between 1500–1800 GMT (40.5%), suggesting that the fish probably feeds mostly at this time during the day, even though the fish is known to feed largely in the night to avoid predatory birds. The greatest number of empty guts (90%) was observed between 0600–0900 GMT, suggesting that they probably reduce feeding during this period of the day. The ability of *S. melanotheron* to feed at different trophic levels, coupled with the potential for fast growth, makes this species a promising candidate for incorporation into locally-operated polyculture systems with minimal inputs of expensive animal protein in the feed.

Introduction

There are more than 90 lagoons of various sizes which fringe the nearly 550 km coastline of Ghana (Koranteng *et al.*, 1997). Many of these lagoons have been exploited over the years and form the basis for important small-scale fisheries. The lagoons also serve as nursery grounds for some marine fishes, molluscs and crustaceans. Cichlid fishes of the genus *Sarotherodon* contribute significantly to the fresh and brackish water fishery of West Africa (Lévêque *et al.,* 1992).

The known distribution of *S. melano-theron* in Ghana ranges from the lower reaches of Bia, Tano, Ankobra, Pra, Volta and most of the coastal basins (Dankwa *et al*., 1999). Thus, *S. melanotheron* could be said to be endemic to the coastal brackish water ecosystems in Ghana. Dankwa *et al*. (1999) reported that *S. melanotheron* in Ghana might not yet be considered as endangered, however, unchecked exploita-tion of the fish could easily offset its present conservation status. In Africa, tilapia harvest is an important component of subsistence fisheries. *Sarotherodon melanotheron* is widely used in aquaculture, especially in Israel, Indonesia and Malaysia. However, in Asia, the introduction of tilapias for fisheries development has threatened many of the native fishes.

Although the commercial culture of this fish in Ghana is not popular, recent trials on the fish by the Water Research Institute of the Council for Scientific and industrial Research (CSIR), Ghana, have yielded positive results as to its potential as a cultured food fish (Entsua-Mensah & Dankwa, 1997). For a successful culture operation of this species, a good understanding of its food and feeding habits is an important pre-requisite.

Various investigations have been conducted into the food and feeding habits of fish with the aim of determining their dietary requirements. For instance, Pauly (1976) found the stomachs of adult *S. melanotheron* to contain the fine fraction of bottom mud, comprising inorganic granules of 50–100 µ diameter, pennate diatoms and organic detritus. From this it may be inferred that coarser granule are rejected in the mouth and pharynx. The specific objectives of the study were to (i) describe the food resources used by the species and its feeding periodicity, and (ii) investigate the trophic status of the species in the Sakumo lagoon to facilitate its culture development in the country.

Materials and methods

Study area

The lagoon under study was the Sakumo II lagoon found along the coast of Ghana, latitude 37' N and longitude 0^{o} 03' W (Fig.1). The site is situated beside the coastal road linking Accra and Tema, 3 km west of Tema township. The Sakumo II Lagoon was a typical closed lagoon (Kwei, 1974) until pipes were laid under the sand bar to enable the construction of the Accra-Tema road. The lagoon is now permanently connected to the sea, thus, representing a transitory stage between a closed and an open lagoon. The lagoon and its surrounding wetlands have been designated as one of the five Ramsar sites in Ghana, where important migratory birds may be found. Seventy species of water bird have been recorded at the site with estimated maximum numbers of some 30,000 birds (Birdlife International, 2003). Other common species include *Egretta garzetta*, *E. gularis* and *Glareola pratin-cola.* Other fish species found there include *Tilapia zilli, Oreochromis niloticus, Hemichromis bimaculants, Mugil* spp. and *Gerres melanopterus* (Koranteng *et al*., 1999).

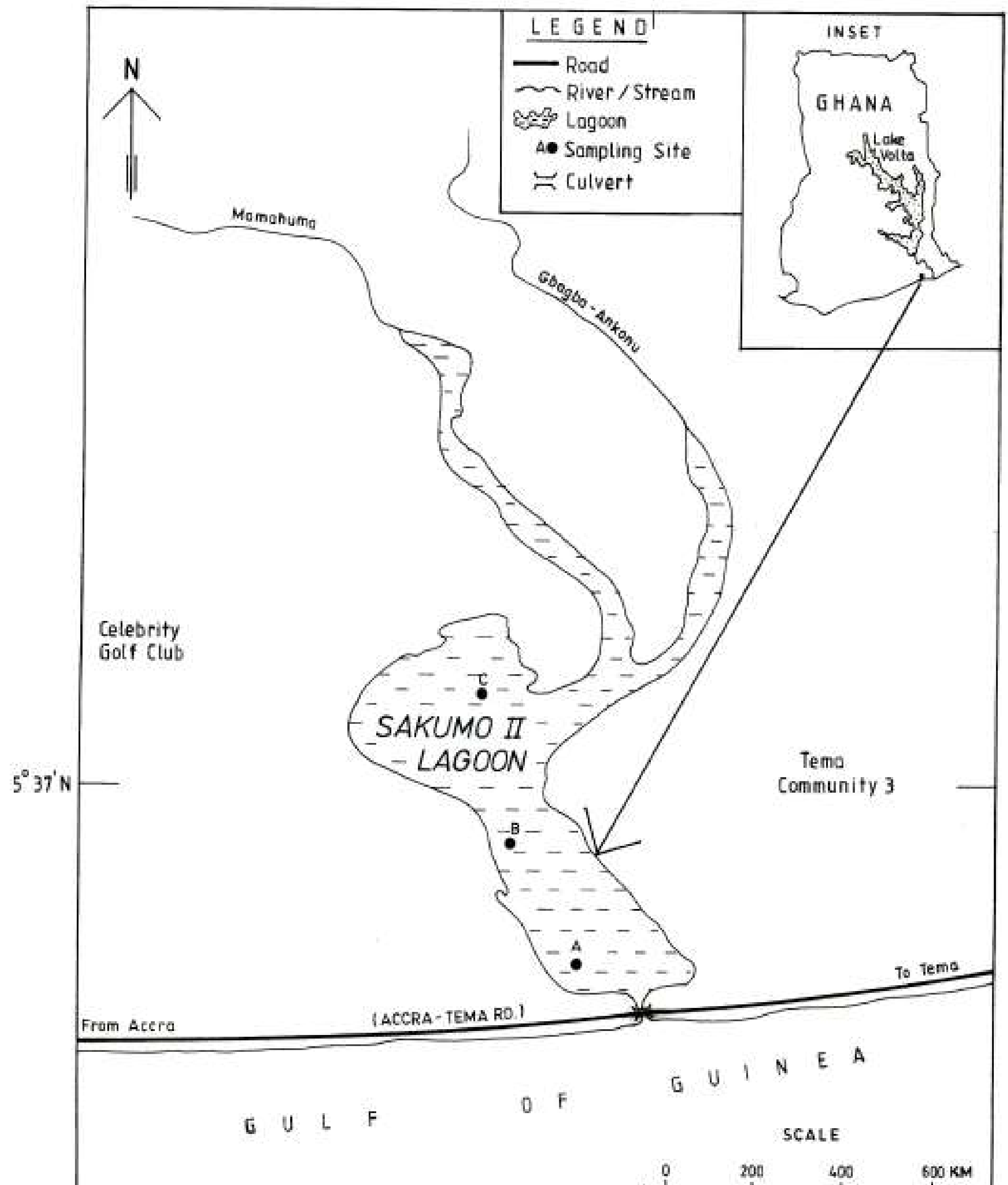

Fig.1. Map of showing the sampling stations for Sakumo II Lagoon in Greater-Accra region

The size of the open lagoon varies from 100 to 350 ha depending on the season. The lagoon is separated from the sea by a narrow sand dune, on which the Accra-Tema road is built, and is connected to the sea by a small, non-functional (permanently open) sluice, constructed to prevent flooding of the coastal road. There are also areas of freshwater marsh and coastal savanna grassland, the latter composed mainly of *Sesuvium portulacostrum* with various grass species associations.

Samples of *Sarotherodon melanotheron* were collected monthly from September 2004 to January 2005, from the catches of local fishermen using cast net of different mesh sizes ranging between 6.35–12.7 mm laterally stretched mesh sizes. Samples were collected from 06:00–18:00 GMT at 3-h intervals. Specimens caught were measured for standard lengths (S.L) to the nearest millimetre, weighed to the nearest 0.10 g and dissected for the gut contents.

Analysis of data

Specimens were divided into two categories based on their maturity size (Kone & Teugels, 2003). Specimens with standard lengths ranging from 45 to 69 mm S.L were grouped as juveniles and those with S.L > 70 mm were considered as adults. The guts were removed, weighed and preserved in 8% formalin solution. In the laboratory, the samples were removed from the jar. The contents of each gut were mixed with 100 ml water per gram of gut contents to remove unpleasantness of the formalin and filtered through 500 µm and 100 µm mesh size. Caution was taken not to leave samples in the water for more than 48 h to prevent the samples from deteriorating.

For phytoplankton, the microscopic preparations per filtrate were observed under the microscope for taxonomic identification. Food items were identified to the genus level. The diet of *S. melanotheron* was then assessed using Numerical Percentage (%N) and Occurrence Percentage (%Oc), where $\%N = n_i \times 100/N_t$………… (1)

n_i = total number of a type of prey i, and N_t = total number of all prey (Hureau, 1970).

Occurrence Percentage $\%Oc = N_{ei} \times 100/Net$…………… (2)

where N_{ei} = the number of stomachs containing a type of prey i and Net using the total number of full stomachs examined (Hyslop, 1980). The %Cw was also calculated by the method of estimation. The index of preponderance was computed for each prey item using the formula:

Index of preponderance (Ip) =

$$\frac{\%Oc \times \%Cw}{\Sigma\ \%Oc \times \%Cw} \quad \text{……………… (3)}$$

where Oc = percentage occurrence and Cw = percentage weight (Marshall & Elliott, 1997). This index ranked the various food items in order of preference. Classification of prey items followed Simensted (1979), discussed by Rosecchi & Nouaze (1987). The cumulative values of these items with an index of preponderance of at least 15% were considered preferential. Those with cumulative value reaching 3% and above were the secondary prey and the others were considered additional prey.

For the feeding habit, the fullness of the gut was calculated using the formula:

$$\text{Gut fullness} = \frac{\text{Weight of gut (g)} \times 100}{\text{Body weight of fish (g)}} \quad \text{… (4)}$$

The percentage fullness of stomach was calculated and graded into five groups. Those with percentages in the ranges of 0–2 were graded as empty guts, those in the ranges of 3–4 were graded as ¼ full, those in the range of 5 were graded as ½ full, those in the ranges of 6–7 were graded as ¾ full and those around 8 and above were graded as full guts. The time was also grouped into three, namely mornings from 0600 to 0900 GMT, afternoons 1200 GMT and evenings from 1500 to 1800 GMT.

The Shannon and Weaver diversity index was used using the Primer Software with the formula given as:

$$H = -\Sigma[(n_i / N) \times In\ (n_i / N)] \quad \text{……… (5)}$$

where n_i is the number of individuals of each species (the i^{th} species), N is the total number of individual or amount for the site, and In is the natural logarithm (Shannon & Weaver, 1963). The Similarity Index was used to compute the similarity of the food items between juveniles and adults based on the species composition. The formula of this index is given as:

$$Sim = \frac{2\ \Sigma nc}{\Sigma n_1 + n_2} \quad \text{………………… (6)}$$

where nc is the common species between sites, n_1 is the species of site 1 and n_2 is the species of site 2 (Zar, 1974). The Species Richness was also determined by means of Primer Software using Margalef's Index (d) with the formula given as:

$$d = \frac{S-1}{In(n)} \quad \text{……………… (7)}$$

where S is the total number of species in the community and n is the total number of individuals (Margalef, 1968).

Results

It was generally observed that the gut content was least full between 0600–0900 GMT but considerable amount of food were found in the gut of fish caught around 1200 hours GMT and 1500–1800 hours GMT (Table 1). From the results obtained in Table 1, the number of guts which were 3/4 full was more than those of the empty guts. Also, the greatest number (45.2%) of gut of ¾ fullness was observed around 1200 GMT, followed by the hours between 1500–1800 GMT with a percentage of 40.5%. The least number (14.3%) of guts of ¾ fullness was encountered between the hours of 0600-0900 GMT.

TABLE 1

Comparison of the full and empty guts of Sarotherodon melanotheron *at different times and seasons at the Sakumo lagoon of Ghana*

Month	*3/4 Full*			*Empty*		
			GMT			
	0600–0900	*1200*	*1500–1800*	*0600–0900*	*1200*	*1500–1800*
September	3	8	8	1	0	1
October	4	8	7	1	0	0
November	2	9	10	2	0	0
December	1	8	4	3	0	0
January	2	5	5	2	0	0
Total	12	38	34	9	0	1
% Total	**14.3**	**45.2**	**40.5**			

From Table 2, there were about eight genera of plankton exploited by the juveniles. The diets of the juveniles were mostly Chlorophyceae (green algae, 21.94%) and Cyanophyceae (*Anabaena*, 18.90%, *Lyngbya*, 13.22% and *Oscillatoria*, 12.96%). On the other hand, there were about 11 genera of plankton and other accessory food items exploited by the adult *S. melanotheron*, indicating that the adults exploit more food items than the juveniles. The diets of the adults were mostly Bacillariophyceae *(Asterionella)* (20.83 %Ip), Cladocera *(Bosmina* 19.60 %Ip), Cladocera *(Moina* 14.9 %Ip), Chlorophy-ceae (green algae 14.60 %Ip), Cyanophy-ceae (*Lyngbya* 8.22 %Ip), and Diatomophy-ceae (*Pinnularia* 3.06 %Ip).

TABLE 2

Food items in guts of juvenile (45-69 mm S.L.) of Sarotherodon melanotheron *from September 2004 to January 2005*

Food items	*Quantity (n)*	*Frequency (f)*	*Weight (w)/g*	*N%*	*%Oc*	*%Cw*	*%Ip*
PHYTOPLANKTON							
Cyanophyceae							
Anabaena	57	9	3	17.2	23.7	33.7	18.90
Lyngbya	65	7	2.7	19.6	18.4	30.3	13.22
Oscillatoria	61	9	2.3	18.4	23.7	32.1	12.96
Spirulina	12	3	0.4	36.	7.9	4.5	0.84
Trichodesmium	5	3	0.2	1.5	7.9	2.2	0.41
Calothrix	4	2	0.3	1.2	5.3	3.4	0.42
Total	**204**	**33**					
Bacillariophyceae							
Mastogloia	2	1	0.2	0.6	2.6	3.5	0.22
Thalassiothrix	1	1	0.1	0.3	2.6	7.1	0.44
Nitzschia	11	2	0.1	3.3	5.3	16.1	2.01
Total	**14**	**4**					
Diatomophyceae							
Synedra	21	3	0.3	6.3	7.9	23.2	4.34
Pinnularia	5	2	*0.6*	*1.5*	*5.3*	*28*	*3.49*
Total	**26**	**5**					
Chlorophyceae							
Chodatella	1	1	0.1	0.3	2.6	5	0.31
Green algae	24	11	1.9	7.2	28.9	32	21.94
Total	**25**	**12**					

ZOOPLANKTON							
Rotifera							
Trichocerca	10	3	0.3	3.0	7.9	20.3	3.8
Aspalachna	12	4	0.3	3.6	10.5	21.3	5.31
Total	**22**	**7**					
Cladocera							
Bosmina	9	1	1.1	2.7	2.6	24.4	2.14
Total	**9**	**1**					
Copepoda							
Sapphirina	1	1	0.1	0.3	2.6	16.7	1.04
Copepodite	1	1	0.1	0.3	2.6	16.7	1.04
Oikopleura	12	4	0.4	3.6	10.5	24.3	6.06
Total	**14**	**6**					
Accessory preys							
Bivalve larvae	2	1	0.3	0.6	2.6	2.6	0.16
Detritus		2	1.7	0.0	5.3	6.3	0.79
Fish eggs	6	1	0.1	1.8	2.6	0.3	0.02
Scale	6	7	0.4	2.4	10.5	0.6	0.15
Total	**14**	**11**					

From Fig. 2, the predominant genera of food items eaten by the juveniles were Cyanophyceae (46.75 %Ip) and Chlorophy-ceae (22.25 %Ip), which are phytop-lanktonic. This suggests that the juveniles feed more on phytoplankton than zoop-lankton. The adults seemed to exploit both zooplankton and phytoplankton (Fig.2).

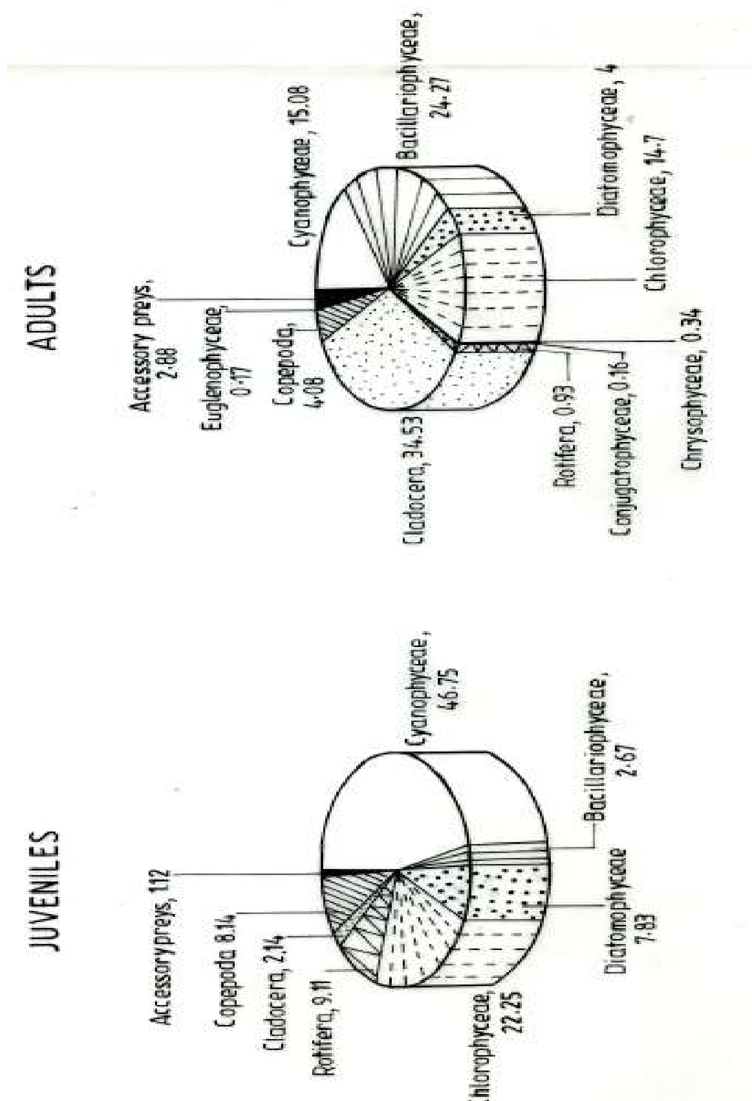

Fig. 2. Comparison of the food items in the gut of the juveniles and adults using Index of Preponderance

The Shannon and Weaver diversity index (H') for the juveniles was H' = 1.1 and H' = 1.2 for the adults (Table 4). This suggests that the food items of the adults and juveniles were similar. However, using Margalef's Species Richness index (d), the species richness of food items of *S. melanotheron* was 3.6 for juveniles and 5.3 for adults, indicating that the availability of food items was more readily in the adults than the juveniles. The Similarity index between the adults and juvenile *S. melanotheron* was 1.0, suggesting that the two food items greatly overlap.

Discussion

Food and feeding habit

Data presented in this study confirm that *S. melanotheron* is planktivorous (Pauly, 1976; Ugwumba & Adebisi, 1992) as the diet covers a wide spectrum of food ranging from phytoplankton to zooplankton, and other accessory prey (Tables 2 and 3). The dominant food items were phytoplankton and a few zooplankton with very few accessory prey. *S. melanotheron* feeds mostly around 1200 GMT and between 1500–1800 GMT during the day. Also, the occurrence of structureless organic matter originating in the mud suggests that *S. melanotheron* feeds mostly on the substratum.

TABLE 3

Food items in guts of adult (75-129 mm S.L.) of Sarotherodon melanotheron *from September 2004 to January 2005*

Food items	*Quantity (n)*	*Frequency (f)*	*Weight (w)/g*	*%Cn*	*%Oc*	*%Cw*	*%Ip*
PHYTOPLANKTON							
Cyanophyceae							
Anabaena	32	3	7.7	2.4	7.9	21.0	0.96
Oscillatoria	52	4	2.9	3.9	10.5	21.1	2.48
Lyngbya	134	9	0.5	10.1	23.7	59.7	8.22
Spirulina	27	11	2.6	2.0	28.9	8.8	1.48
Trichodesmium	6	3	0.1	0.5	7.9	2.1	0.10
Calothrix	42	4	0.1	3.2	10.5	28.1	1.72
Microcystis	4	1	1.0	0.3	2.6	0.67	0.01
Microchaeta	1	1	15.9	0.1	2.6	0.67	0.01
Glaucocystis	15	1	2.4	1.1	2.6	6.7	0.10
Total	**229**	**30**					
Bacillariophyceae							
Asterionella	291	22	3.1	22.0	57.9	61.9	20.83
Cyclotella	63	7	2.7	4.8	18.4	9.3	1.0
Surirella	40	7	0.3	3.0	18.4	12.1	1.30
Gyrosigma	30	6	1.3	2.3	15.8	10.5	0.96
Chaetoceros	6	1	0.6	0.5	2.6	1.2	0.02
Mastogloia	17	2	0.8	1.3	5.3	5.1	0.16
Total	**447**	**45**					
Diatomophyceae							
Synedra	10	3	0.2	0.8	7.9	15	0.69
Pinnularia	11	4	0.1	0.8	10.5	50	3.06
Eucampia	2	2	0.5	0.2	5.3	8.3	0.25
Total	**23**	**9**					
Chlorophyceae							
Gonatozygon	1	1	0.2	0.1	2.6	2.1	0.03
Chodatella	10	1	4.2	08	2.6	4.1	0.06
Actinotaenium	4	1	0.9	0.3	2.6	0.9	0.01
Green algae	51	14	0.1	3.9	36.8	68.2	14.60
Total	**66**	17					
Chrysophyceae							
Brown algae	6	2	1.0	0.5	5.3	11.2	0.34
Total	6	**2**					
Conjugatophyceae							
Closterium	2	1	6.1	0.2	2.6	10.2	0.16
Total	**2**	**1**					
ZOOPLANKTON							
Rotifera							
Trichocerca	14	4	11.4	1.1	10.5	15.2	0.93
Total	**14**	**4**					
Cladocera							
Bosmina	149	16	0.6	11.3	42.1	80.1	19.60
Moina	173	15	07	131	39.5	65.1	14.93
Total	**322**	**31**					

Table 3 cont'd.

Copepoda							
Oikopleura	7	3	1.3	0.5	7.9	21.1	0.97
Copepodite	5	2	0.6	0.4	5.3	26.9	0.82
Thermocyclops	21	3	0.1	1.6	7.9	50	2.29
Total	**33**	**8**					
Euglenophyceae							
Dinobryon	4	1	0.1	0.3	2.6	11.2	0.17
Total	**4**	**1**					
Accessory preys							
Brachyuran larvae	1	2	1.2	0.1	2.6	0.2	0.00
Brachyuran megalopa	1	1	11.3	0.1	2.6	0.2	0.00
Fish larvae	13	10	0.2	1.0	26.3	2.5	0.38
Detritus	7	7	0.4	0.5	18.4	23.2	2.48
Bivalve larvae	1	1	4.0	1.0	2.6	0.8	0.01
Fish eggs	10	1	0.4	0.8	2.6	0.8	0.01
Scale	54	18	2.3	4.1	47.4	8.2	2.26
Leaves	6	2	1.8	0.5	5.3	0.8	0.02
Total	**588**	**67**					

TABLE 4

The diversity index, species richness and similarity index of the juvenile (45 mm-69 mm S.L.) and adult (>70 mm S.L.) Sarotherodon melanotheron *in the Sakumo lagoon of Ghana from September 2004 to January 2005*

Food items	*Quantity (n) Juveniles*	*Quantity (n) Adults*
PHYTOPLANKTON		
Cyanophyceae		
Anabaena	57	32
Lyngbya	65	134
Oscillatoria	61	25
Spirulina	12	27
Trichodesmium	5	6
Calothrix	4	42
Microchaeta	4	
Microcystis	1	
Glaucocystis	15	
Total	204	286
Bacillariophyceae		
Mastogloia	2	1
Thalassiothrix	1	
Nitzschia	11	
Asterionella		291
Cyclotella		63
Gyrosigma		30
Chaetoceros		6
Surirella	40	
Total	14	447
Diatomophyceae		
Synedra	21	10
Pinnularia	5	11
Eucampia	*2*	
Total	26	23
Chlorophyceae		
Chodatella	1	10
Green algae	24	51
Gonatozygon		1
Actinotaenium		4
Total	**25**	**66**
Chrysophyceae		
Brown algae		6
Total		6
Conjugatophyceae		
Closterium		*2*
Total		2
ZOOPLANKTON		

Rotifera		
Trichocerca	10	14
Aspalachna	12	
Total	**22**	**14**
Cladocera		
Bosmia	9	149
Moina	173	
Total	**9**	**322**
Copepoda		
Thermocyclops	21	
Sapphirina	1	
Copepodite	1	5
Oikopleura	12	7
Total	**14**	**33**
Euglenophyceae		
Dinobryon		4
Total		**4**
Accessory preys		
Bivalve larvae	2	1
Detritus	2	7
Fish eggs	6	10
Scale	8	54
Brachyuran megalopa		*1*
Brachyuran larvae		1
Leaves		6
Fish larvae		13
Total	**18**	**93**
SUMMATION (Σ)	**322**	**1296**
Diversity index (H')	**1.1**	**1.2**
Species richness (d)	**3.6**	**5.3**
Similarity index (Sim)		**1.0**

The behaviour of most fishes is highly structured within the diel cycle (Nielsen & Johnson, 1983). During non feeding hours, fish often seek shelter in lowrisk environ-ments. Just prior to feeding, they move into habitats where suitable food is available. Some fish feed intensively during a single extended feeding period lasting 6 h or longer. Others may feed intensively for only 1 or 2 h, followed by low levels of feeding activity for several hours (Nielsen & Johnson, 1983). Still other fish are known to feed intensively at dusk and dawn with little evidence of feeding at other hours, and this possibly explains the changes in availability of food items both in the juvenile and adult *S. melanotheron*.

In this study, most specimens of *S. melanotheron* fed around 1200 GMT and between 1500 and 1800 GMT. However, Pauly (1976) recorded that feeding of *S. melanotheron* in the Sakumo lagoon is nocturnal, with intermittent daytime feeding. This may be to elude predatory birds, to whom the fish would be dangerously visible in the clear shallow waters during the day, implying that fish may be compelled to feed during the day probably due to possible reduction in number of predatory birds. Comparatively, *S. melanotheron* fed mostly around 1200 GMT than between 1500–1800 GMT considering the 12-h cycle. Little or no feeding seemed to occur between the hours of 0600 and 0900 GMT probably because of the availability of the food items, as the food items also exhibit a life-cycle which could probably be different from that of the fish. This possibly explains why fishes mostly come out to feed during the hours of 1200 and between the hours of 1500–1800 GMT but not between 0600-0900 GMT.

Diversity of food items

The Diversity Index (H') of the food items in the adults (H' = 1.2) was similar to that of the juveniles (H' = 1.1), and this suggests that the adult and juvenile *S. melanotheron* probably feed on similar food items or microhabitats. Also, the Margalef Species Richness (d) of the food items of adults were higher (d = 5.3) than that of the juveniles (d = 3.6), which could be attributed to the fact that the adults are more efficient in feeding than the juveniles as a result of the well-developed structure of the mouthparts and gill rakers. These ontogenic changes in African fishes have been reported by Paugy & Lévêque (1999). For some cichlid fishes, the food variation with size has been found to be related to the dentition (Paugy & Lévêque, 1999). Adults and juveniles considered in the present study have a similar food spectrum as obtained from the results of the Similarity Index (Sim). This similarity could probably be related to the fact that the differentiation process of the gill rakers, in those considered as juveniles (45 mm < SL < 70 mm) could have already been accomplished.

The slight variations in the food items of the same species (*S. melanotheron*) with respect to the two categories (adults and juveniles) suggested age-specific dietary preferences in order to avoid intra-specific competition for available food. This is possibly an important strategy for survival and an advantage over the fish species competing for a specific food item. The food resources of the adult fish probably suggest that it is planktivorous, and could either be a primary or secondary consumer (probably because it feeds on some amount of zooplankton) in the food web depending on the food availability. As the species is widely used as human food throughout Ghanaian coastal areas, it could be recommended for incorporation into locally-operated poly-culture systems with minimal inputs of expensive animal protein in the feed.

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