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Diel feeding patterns, rate of gastric evacuation and foods of Indian sandwhiting, *Sillago sihama* in Mulki estuary, west coast of India

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Abstract
Diel feeding chronology of sandwhiting, *Sillago sihama* was examined from stomach collections taken during the months of April, July and December'99 in Mulki estuary along Dakshina Kannada coast, India. Significant differences in mean stomach content weight were found between several consecutive 3 hour periods with peak fullness occurring in early morning and evening hours. The rate of gastric evacuation of natural food (crustacea, polychaetes and fish) was measured in the field was best described by an exponential model, with an estimated evacuation time of 8.0 h at a temperature of 28.5 ±1.2°C. Stomach content analysis indicated that this species is a carnivore on a wide range of benthic, epibenthic and planktonic prey. The principal food items of *S. sihama* were crustaceans, polychaetes and fish. Fishes less than 100 mm TL preferred mainly crustaceans while larger ones depends on polychaetes, crustaceans and fish. The feeding activity of *S. sihama* was influenced by tidal cycle.
Key words: Diel feeding chonology, Gastric evacuation, *Sillago sihama*

Introduction

Fishes belonging to the family Sillaginidae (Order: Perciforms) commonly known as whitings/lady fish have a wide distribution in the tropical regions. Eight species belonging to the family sillaginidae have been reported from India (Mckay 1976, Dutt and Sujatha 1980). Of the eight species, the Indian sandwhiting, *Sillago sihama* is a highly esteemed table fish in coastal Karnataka locally known as 'Kane meenu'. This species has a great potential for mariculture because of its faster growth rate and high market price. The possibility of culturing this species has been reported by James *et al.* (1976) and Dhulkhed and Ramamurthy (1977).

Although the detail food habits of juvenile whitings in estuarine waters have been examined in several studies (Chacko 1949, Radhakrishnan 1957, Krishnamurthy 1969, Gowda *et al.* 1988), there are little information on dietary rhythm of juvenile whitings. The purpose of the present study is to describe the diel cycle of feeding, gastric evacuation rate and feeding habits of whitings in the tropical estuarine environment.

Materials and methods

Diel feeding pattern

Experiments were conducted in Mulki estuary, during pre-monsoon (April'99), monsoon (July'99) and post-monsoon (December'99) seasons. Sampling were done during 6 different 24-h sampling periods at different locations in the estuary using cast net and seine net. Eight to twelve collections were made during each 24 h sampling period, although not all were successful in catching juvenile sandwhitings. Water temperature was recorded during each sampling.

The sandwhitings were sorted from the catch and their total length and weight were measured to the nearest mm and nearest 0.1g respectively after removal of excess water. The stomach contents were excised and the contents weighed to the nearest 0.01g and preserved for later analysis. Fullness code between 0 (empty) and 5 (full distended stomach) was assigned to each stomach at the time of weighing as a measure of feeding intensity. In addition the stomach contents were also expressed as a % of body weight.

Estimation of evacuation rate

Juvenile whitings (size range: length, 7.5–13.5 cm) were collected from Mulki estuary during early monsoon. Approximately 50 fish were placed in each of four nylon net hapas [(# 200 μm), 2m x 1m x 1 m)] fixed in a nearby brackishwater pond. They were fed on natural feed (polychaetes, crustaceans, molluscan and fish meat) for 2-3 weeks before being used in the experiment.

Prior to experiment, fish were starved for a 12 hour period to ensure empty stomachs and then fed on natural feed for 20 minutes, later fish were transferred to food free hapas. A random subsample of 16 fish (not more than 4 fish from each hapa) were sacrificed immediately after feeding and the stomach contents and fish were weighed as stated earlier and percentage of food recovered was determined. This process was continued every 2 hour interval until most of the stomachs sampled were empty. Dry weights were determined by placing the contents in the pre weighed aluminum pans into an 80°C oven until they achieved a constant weight.

Linear, exponential and square root models (Jobling 1981 and 1986) were used to describe the depletion of stomach contents with time in the evacuation experiment. The co-efficient of determination (R^2) was used to evaluate the goodness of fit of the models. The data were statistically analyzed following One way ANOVA and Duncan Multiple range test.

Qualitative and quantitative analysis

Fortnightly samples were collected from Mulki estuary using cast nets and seine nets to carry out stomach content analysis during April'99 to March'00. The stomachs with food contents were routinely examined under a low power stereo dissector microscope or where necessary, under high power magnification. The occurrence method (Hynes 1950) was used to quantify the diet, the number of stomachs in which

each food type occurred was expressed as a % of the total number of stomachs containing food.

Results

Diel feeding pattern

The results of the diel feeding activity are presented in Fig. 1a and 1b. To test for discontinuity in feeding, the sampling times were grouped into eight successive 3 h intervals after adjusting for minor differences in day-length between the sampling periods. The stomach weight / body weight ratios were found to be significantly different (One way ANOVA) over the eight intervals tested (Fig. 1a). Similar significant differences were noted among stomach fullness code over the diel periodicity (Fig. 1b). Feeding indices were generally found to be high during early morning (5.30 - 6.30 h) and evening (17.30-18.30h) hours with less percentage of empty stomachs. Fullness decreased after dawn and dusk hours. The tidal cycle had impact on its feeding intensity. The feeding activity of whitings increased or decreased *vis -a- vis* tidal fluctuation.

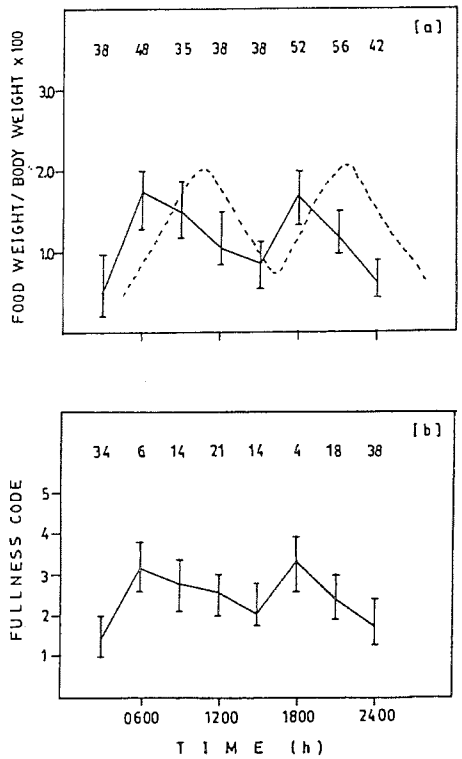

Fig. 1. The relationship between time at day and (a) the amount of food in the stomachs of sandwhitings expressed as % of wet body weight and (b) fullness code.
Data are means (±S.D) placed at the mid point of each 3 h interval. The number of stomachs examined in each time period is given at the top of (a) and the percent of empty stomachs at the top of the (b). * [--------- indicates tide in Fig. 1(a)] .

Gastric evacuation rate

The mean wet and dry weight proportions of the initial meals recovered from the stomachs clearly decreased with time (Fig. 2). Although the linear model gave a significant fit for both wet and dry relationships, F-test for linearity indicated that a non-linear function was more appropriate for both relationships. The exponential model had the highest coefficients of determination for both wet and dry weight relationships of the three models tested (Table 1). This model also yielded fairly close approximation of the initial meal size. These fishes required about 8.0 h to almost completely evacuate the stomach contents (Fig. 2). The values of the instantaneous rates of evacuation (r) and the times to various percentages of stomach fullness for the exponential model are given in Table 2.

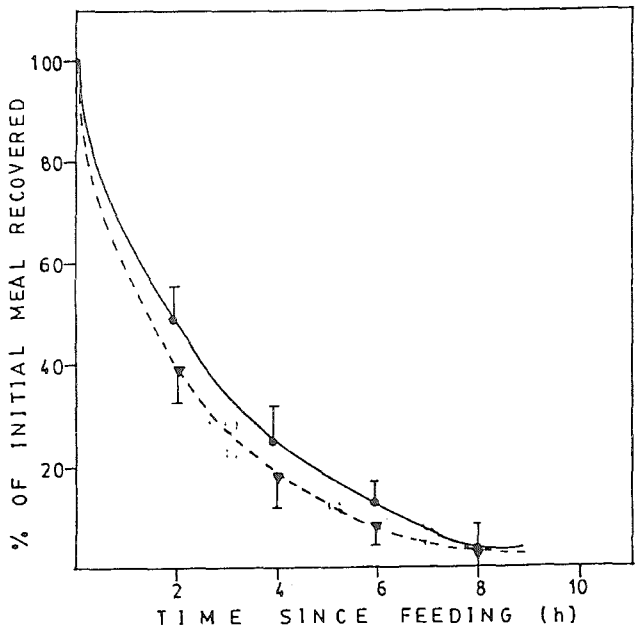

Fig. 2. Wet weight and dry weight recovered from the stomachs of sandwhitings at each sampling interval.

Table 1. Regression coefficients for the depletion curves obtained using different models

Food Condition	Model	a (±S.D)	r (±S.D)	R^2	% intercept
Wet	Linear	83.87±7.46	0.191±0.073	0.86	83.87
	Exponential	4.669±0.431	0.007±0.001	0.98	109.84
	Square root	9.416±1.021	0.016±0.010	0.97	88.66
Dry	Linear	79.064±9.13	0.188±0.036	0.80	79.06
	Exponential	4.613±0.837	0.006±0.001	0.99	100.79
	Square root	9.047±0.993	0.016±0.011	0.93	81.85

Table 2. The instantaneous rate of evacuation (r) and times to various stages of evacuation for the exponential model

Food Condition	r (h^{-1}) (±S.E)	Time (h) to % evacuation		
		50	75	90
Wet	0.007 (0.001)	1.87	3.52	5.70
Dry	0.006 (0.001)	1.94	3.88	6.41

Composition of the food

The results of the monthly stomach content analyses is given in Table 3. The most frequently occurring components in food of *S. sihama* were a wide range of crustacean, polychaetes and fish in the order of their abundance. Polychaetes belonging to 5 genera *viz., Glycera, Diopatra, Pectinaria, Nerieis and Dendronerieis* were recorded. Fish were not identified owing to their advanced state of digestion. Semidigested matter constituted major portion of the stomach content. Apart from this sand particles and miscellaneous items were also recorded.

Seasonal variation in food and feeding intensity

Crustaceans were recorded in all the months with peak in June followed by July and lowest in November. Among crustaceans shrimps and crabs remaining dominated. Polychaetes were recorded in almost all the months with peak during March and lowest in January. Fish were found to be dominant next to crustacea and polychaetes and recorded in all the months. Presence of sand particles and miscellaneous items in the stomachs indicates their bottom feeding nature.

Relationship between food and fish size

Percentage occurrence of food types in the diet of 20 mm size groups is shown in Fig. 3. In the smaller size groups (<100 mm) of *S. sihama,* crustaceans especially copepods, juvenile shrimps constituted major diet. In larger size groups (>100 mm) crustaceans and fish were recorded in various proportion in different size groups. Polychaetes recorded in all the larger size groups and showed increasing trend with increase in size. As the size increased the proportion of semidigested matter decreased. Sand particles and miscellaneous matter were recorded in almost all the size groups in lesser proportions.

Table 3. Monthly percentage composition of different items of diet recorded in the stomachs of sandwhitings, *Sillago sihama*

	Month												
	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Total
No. of Fish Examined	90	110	120	105	127.0	140.0	121.0	117.0	112.0	101.0	119.0	95.00	1357
No. of stomachs with food	51	70	88	57	49	41	28	37	52	45	45	50	613
Food Item													
I Crustacea	24.08	19.96	33.05	30.43	29.40	17.74	13.82	10.54	16.53	12.41	24.03	15.14	20.59
Shrimp remains	8.25	11.53	10.5	15.10	15.15	9.00	4.15	5.75	8.00	4.85	12.27	9.87	9.54
Penaeus sp	1.60	1.53	0.70	4.30	0.50	1.14	0.38	-	0.70	0.73	1.75	2.15	1.96
Metapenaeus sp	2.25	-	2.18	3.75	3.75	-	1.23	-	0.75	0.60	1.75	1.50	1.48
Acetes sp	-	-	-	-	-	-	-	-	0.38	0.75	0.50	-	0.15
Crabs and their larvae	10.18	6.10	18.43	6.15	8.87	7.25	7.38	4.45	6.20	4.50	7.43	3.60	7.55
Mysids	0.85	-	0.25	-	-	-	-	-	-	0.50	-	0.50	0.18
Amphipods	0.25	-	-	-	-	-	-	-	-	-	-	0.25	0.04
Copepods	0.70	0.80	1.00	1.13	1.13	0.35	0.68	0.34	0.50	0.48	0.33	0.75	0.68
II Polychaetes	13.58	14.55	18.58	16.83	26.47	16.80	17.77	23.39	22.49	9.21	12.29	32.63	18.72
III Fish	5.49	13.06	7.47	2.01	0.98	0.55	1.38	2.03	3.82	1.73	2.09	5.21	3.82
IV Semidigested Matter	40.81	38.84	29.36	41.51	35.53	46.77	52.25	55.46	49.57	70.23	52.37	36.68	45.79
V Sand particles	14.50	11.50	8.02	8.20	4.83	14.91	7.76	6.92	4.69	4.20	5.86	8.36	8.31
VI Miscellaneous Items	1.55	2.09	3.54	0.98	2.80	3.24	7.05	1.68	2.91	2.24	3.37	1.89	2.78
Nematodes	-	0.30	0.58	-	0.40	0.73	0.35	0.25	0.25	0.38	-	0.23	0.32
Molluscan shell pieces	0.53	1.35	1.55	0.65	1.43	1.71	2.08	0.75	1.01	1.38	1.76	1.18	1.28
Seaweeds	0.40	-	0.74	0.14	-	0.48	0.35	-	-	-	-	-	0.18
Diatoms	0.63	0.44	0.68	0.19	0.60	0.33	0.58	0.28	0.38	0.49	0.13	0.59	0.44
Unidentified Matter	-	-	-	-	0.38	-	3.70	0.40	0.75	-	1.25	-	0.59

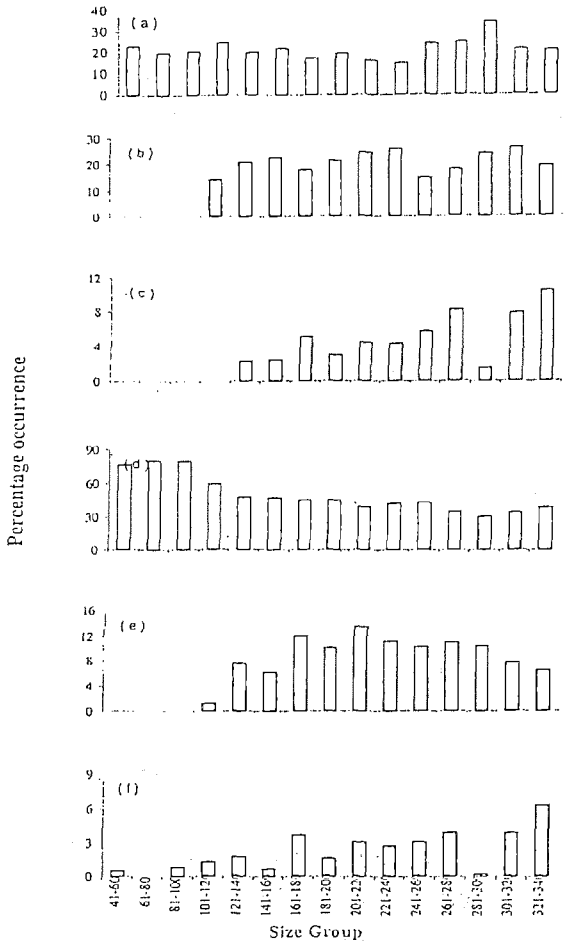

Fig. 3. Percentage occurrence of major food items in the stomachs of 20 mm size groups of *S. sihama*. (a) Crustacea (b) Polychaetes (c) Fish (d) Semidigested matter (e) Sand particles (f) Miscellaneous matter.

Discussion

The results of the study suggest that the diel feeding behaviour of juvenile sandwhitings is usually characterized by two main feeding periods. A morning feeding period (dawn) begins before sunrise and an evening period (dusk) around sunset. The activity of feeding was positively correlated with tidal cycle with intensive feeding during high tide. Similarly Gunn and Milward (1985) reported that the feeding activity of *Sillago analis* is limited by the tidal cycle, a factor which may be a form of temporal partitioning. Tidal cycle at the time of feeding probably plays a major role in determining the availability of prey / food items for fish. Odum (1968) also observed a relationship between the state of the tide and feeding intensity in case of *Mugil cephalus*. Al-daham *et al.* (1977) also observed a similar diel feeding periodicity in catfish, *Heteropneustus fossilis* from southern Iraq. They reported that stomach of the

fish contained food almost thoughout the 24 h period with two peaks at 05.00 h and 17.00 h. Brodeur and Pearcy (1987) reported that juvenile coho salmon *Oncorhynchus kisutch* showed two peak feeding periods one in the early morning and the other around dusk. Kim and Kang (1991) reported that the daily feeding activity of rock trout, *Agrammus agrammus* was more intense at sunrise and sunset and it decreased in the late morning at noon and during the night.

The exponential model provided the best fit to data obtained in the experiment with whiting at temperature of 28.5±1.2°C. Although a number of factors including food particle size, food quality, meal size, and in some cases predator size have been shown to affect evacuation rates, temperature appears to be paramount importance (Fange and Grove 1979, Durbin *et al.* 1983). Higher temperature can lead to substantially increased evacuation rates (Brett and Higgs 1970, Tyler 1970). One shortcoming of the exponential model is that the stomach contents would theoretically begins to level off when stomachs are nearly empty, but fullness never reaches zero. This leads to overestimate of the amount of food remaining in the stomach at the later stages of evacuation.

S. sihama is a carnivore feeding on a wide range of benthic, epibenthic and planktonic prey. The principal foods of *S. sihama* are crustaceans, polychaetes and fish. Presence of sand particles and miscellaneous food items indicates its bottom feeding nature (Chacko 1949, Radhakrishnan 1957, Krishnamurthy 1969, Gowda *et al.* 1988). Large number of empty stomachs observed in the monthly samples may be due to disgorging of stomach contents as a result of shock sustained at the time of capture (Pillay 1952, Jayaprakash 1976).

The considerable variation observed in the percentage occurrence of crustaceans, polychaetes and fish may be related to factors such as seasonal variation in abundance of food items, its consumption rate, age of the fish and diurnal variation in feeding. Among crustaceans, shrimps and crabs were dominated in most of the months. The occurrence of amphipods in the stomach indicates the bottom feeding nature of the fish (Radhakrishnan 1957). Polychaetes dominated over all other items of food in March and August to December. According to Bhat (1978) and Ramachandra (1981) the polychaetes are most abundant in the Netravathi-Gurpur and Mulki estuaries during the pre-monsoon and post-monsoon months. Presence of fish in the stomach was also reported by Radhakrishnan (1957) and it was not possible to identify all of them owing to their advanced state of digestion.

Fishes of less than 100 mm TL seem to prefer crustaceans (juveniles of shrimps, crabs and their larvae along with mysids, copepods and amphipods) whereas fishes larger than 100 mm TL preferred polychaetes followed by crustaceans (*Penaeus sp. Metapenaeus sp.* and crabs), other fishes and miscellaneous food items. It is also evident that irrespective of size both smaller and larger fishes prefer larvae, juveniles and adults of shrimp which form a favorite food. A similar change in composition of the diet with age of the fish has been reported by Krishnamurthy (1969). Gunn and Milward (1985) observed size related dietary shifts in *S. sihama*, from predominantly planktonic crustaceans in fish less than 80 mm TL to polychaetes, penaeid and brachyuran crustaceans and molluscs at larger size. Burchmore *et al.* (1988) reported that the

observed variation in the diet were due to fish size and temporal and spatial habitat differences within and among the species.

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