DIEL CHANGES IN FOOD AND FEEDING ACTIVITY OF SCIAENID FISHES FROM THE SOUTH-WESTERN ATLANTIC, BRAZIL

SOARES, L. S. H. and VAZZOLER, A. E. A. de M.

Instituto Oceanográfico da Universidade de São Paulo, Praça do Oceanográfico, 191, Cidade Universitária, CEP 05508-900, São Paulo, SP, Brazil

Correspondence to: Lucy Satiko Hashimoto Soares, Departamento de Oceanografia Biológica, Instituto Oceanográfico da Universidade de São Paulo, Praça do Oceanográfico, 191, Cidade Universitária, CEP 05508-900, São Paulo, SP, Brazil, e-mail: lsoares@usp.br

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ABSTRACT

Food habits and daily feeding activity of fish populations are important ecological variables for understanding their role in the ecosystem. Diel changes in feeding activity and dietary composition of juvenile whitemouth croaker *Micropogonias furnieri*, shortfin corvina *Isopisthus parvipinnis*, shorthead drum *Larimus breviceps* and of juvenile and adult banded croaker *Paralonchurus brasiliensis* were investigated from samples taken over a 24 hours period from 4 to 5 September 1987 on the continental shelf off South-eastern Brazil. Whitemouth croaker and banded croaker had a benthic diet based on polychaetes and some caridean shrimps and showed no diel feeding pattern. Shortfin corvina and shorthead drum fed on crustaceans and teleostean fish, the former species primarily on pelagic sergestid shrimps and benthic caridean shrimps, and the latter mainly on pelagic sergestid shrimps, mysidacean and benthic caridean shrimps. Shortfin corvina is primarily a diurnal feeder, but preyed on some items only at night. Shorthead drum is a night feeder, with minimum stomach fullness values between dawn and daytime, and maximum values between dusk and night time.

Key words: diel feeding, food habits, Teleostei, Sciaenidae, South-western Atlantic.

RESUMO

Variações nictemerais na alimentação e na atividade alimentar de peixes Sciaenidae do Atlântico sudoeste, Brasil

Informações sobre o hábito alimentar e a atividade alimentar diária de populações de peixes são variáveis de fundamental importância para entender seu papel em um ecossistema aquático. Investigações sobre esses aspectos foram realizadas em jovens da corvina (*Micropogonias furnieri*), da tortinha (*Isopisthus parvipinnis*) e da oveva (*Larimus breviceps*) e em jovens e adultos de maria luiza (*Paralonchurus brasiliensis*), cujas amostras foram obtidas em um ciclo de 24 horas (4 a 5 de setembro de 1987), na plataforma continental do sudeste do Brasil. A corvina e a maria luiza se alimentaram, principalmente, de poliquetas e camarões carídeos e não apresentaram um padrão claro de atividade alimentar. A tortinha e a oveva apresentaram dieta semelhante, composta de crustáceos e peixes teleósteos; ambas tiveram como presas principais os camarões pelágicos sergestídeos e os camarões bentônicos carídeos, e a oveva, além dessas duas presas, misidáceos. A tortinha apresentou, principalmente, hábito alimentar diurno, mas se alimentou de algumas presas em períodos de escuro. A oveva apresentou hábito alimentar noturno, com registros dos maiores valores de repleção estomacal entre o anoitecer e o período de escuro.

Palavras-chave: atividade alimentar diária, hábito alimentar, Teleostei, Sciaenidae, Atlântico sudoeste.

INTRODUCTION

Sciaenid fishes are the most important component of the demersal fish community in the coastal waters of South-eastern and Southern Brazil (Vazzoler, 1975; Facchini, 1995; Haimovici, 1997). Eighteen sciaenid species occur in the coastal system off Ubatuba, in the study area (Rossi-Wongtschowski & Paes, 1993; Rocha & Rossi-Wongtschowski, 1998) and must, therefore, play an important role in the food web. Among them the major components considered in this study were the banded croacker *Paralonchurus brasiliensis* (Steindachner, 1875), whitemouth croacker *Micropogonias furnieri* (Desmarest, 1823), shortfin corvina *Isopisthus parvipinnis* (Cuvier, 1830) and the shorthead drum *Larimus breviceps* (Cuvier, 1830).

The banded croacker (Menezes & Figueiredo, 1980) and whitemouth croacker (Isaac, 1988; Vazzoler, 1991) are widely distributed along the Atlantic coast from Central to South America. The shortfin corvina and shorthead drum occur from Central America (Costa Rica) to the South of Brazil (Menezes & Figueiredo, 1980).

The whitemouth croacker is among the most important inshore bottom fishery resources of the southern and South-eastern Brazilian coast being of great importance in both artisanal and industrial fishery; the banded croacker is fished in a smaller proportion (Haimovici *et al*., 1997; MMA, 1997). The other species have been exploited as shrimp-bycatch fishery (Rodrigues & Meira, 1988).

The whitemouth croacker has been intensively studied (Isaac, 1988; Vazzoler, 1991) and there are some references to the diel feeding of this species (Puig, 1986; Aristizabal-Abud, 1990; Manickchand-Heileman; Ehrhardt, 1996; Figueiredo & Vieira, 1998). For the other species there is some information on food habits (Lowe-MacConnell, 1966; Braga *et al*., 1985; Rodrigues & Meira, 1988; Soares, 1989; Teixeira *et al*., 1992; Amaral *et al*., 1994), but none is available on diel changes.

The objectives of the present study were to describe and to compare the diel feeding pattern of the four sciaenid fish as well as to examine the diel changes in the dietary composition. As in the study area the most frequent are juveniles of the whitemouth croacker, shortfin corvina and shorthead drum, and both juveniles and adults of the banded croacker (Rocha & Rossi-Wongtschowski, 1998), the study was carried out on those groups.

The results of this study are a contribution to the understanding of the role of each species within the ecosystem and consequently of the energy flow and production. Further, the study of similarity of food composition over a day is important for monitoring the food composition study.

MATERIAL AND METHODS

Study area

The study site is located on the inner platform of the coastal system of Ubatuba (23°35'S, 45°00' W), Brazil (Fig. 1). The bottom substratum consists mainly of sand and mud (Furtado & Mahiques, 1990). Different water masses are present in this area during summer and winter. During summer, there is a high two-layer vertical stratification due to the seasonal thermocline: the upper layer consists of warmer and less saline Coastal Water (T = 22-24°C; S = 35-35.4), and the lower of colder South Atlantic Central Water (T = 14-15°C; S = 35.6-35.8). During the winter, only Coastal Water is present on the inner shelf (Castro-Filho *et al*., 1987).

Field sampling

Sampling was undertaken during a 24 hours period from 4 to 5 September 1987 at a 26 m deep station at the position 23°31.5'S and 45°1.5'W, on the Brazilian shelf of Ubatuba (Fig. 1). Fish samples were collected with a 9.7 m bottom trawl lined in the cod end with a 25 mm mesh. Eight consecutive 30 min hauls were carried out at approximately 3 h intervals. Fishes were immediately stored on ice on board, and transferred to the laboratory within 3 hours after catch and put in the freezer where they were kept until processing.

Laboratory methods

The fish were thawed in the laboratory and the total length to the nearest 1 mm and the total mass to the nearest 0.1 g were measured for each specimen. Fish with signs of stomach regurgitation were excluded from the analysis. The stomachs were removed and preserved in 10% buffered formalin solution. The stomach contents of 248 banded croacker specimens, 134 whitemouth croacker, 95 shortfin corvina and 59 shorthead drum were examined (Table 1).

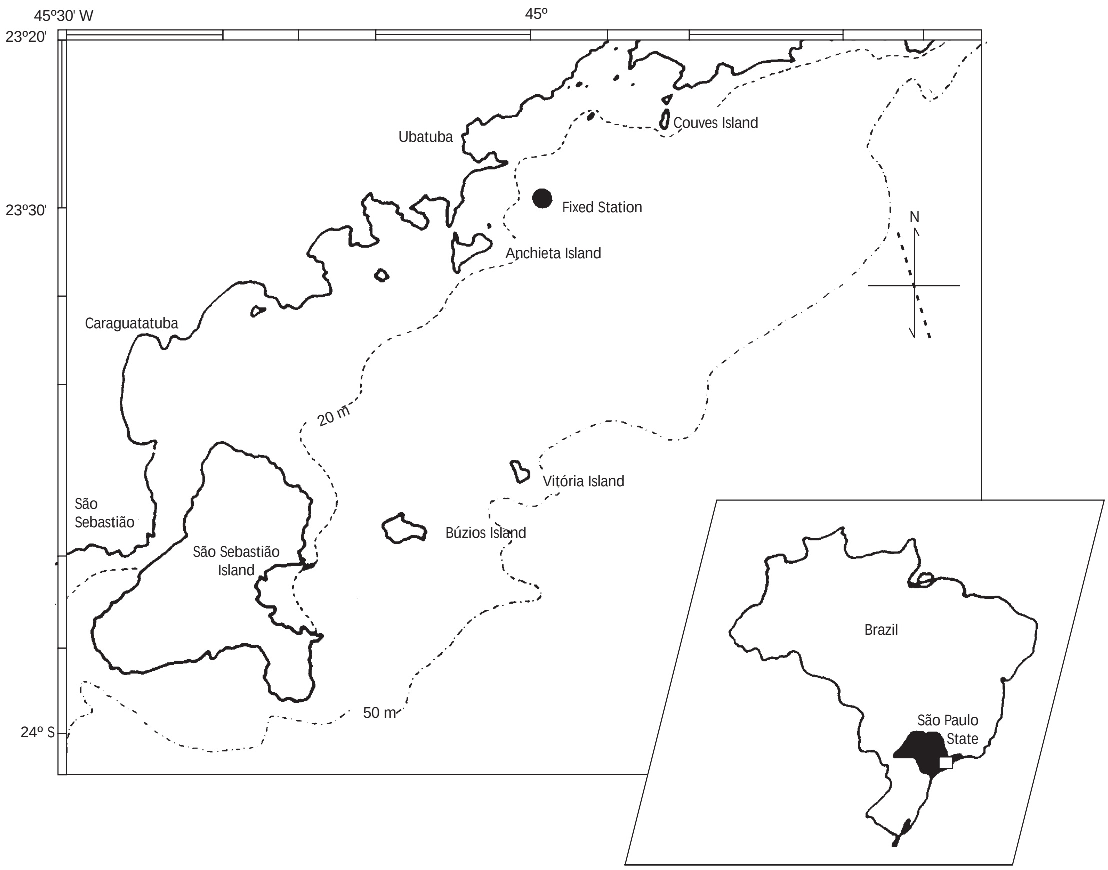

Fig. 1 — Location of study area off the Southeast coast of Brazil.

TABLE 1

Collection time, number (n) and size range of *Paralonchurus brasiliensis, Micropogonias furnieri, Isopisthus parvipinnis* and *Larimus breviceps* specimens sampled during 24 hours period on September 4-5, 1987 on the Brazilian continental shelf of Ubatuba (23º31.5'S; 45º1.5'W).

Species (Common name)	**Time (h)**								**Total**	**Length range** (mm)
	07:11	**09:09**	**13:05**	**15:08**	**18:41**	**21:05**	**24:37**	**03:03**		
	Number								**n**	
Paralonchurus brasiliensis (Banded croaker)	55 (40)	06 (04)	52 (40)	28 (18)	41 (33)	26 (20)	31 (26)	09 (09)	**248**	70-217
Micropogonias furnieri (Whitemouth croaker)	32	1	19	26	26	9	21	0	**134**	59-184
Isopisthus parvipinnis (Shortfin corvina)	10	5	17	17	15	11	5	15	**95**	57-124
Larimus breviceps (Shorthead drum)	20	2	3	8	13	5	6	2	**59**	58-100

( ) = Number of juveniles.

A fullness level between 0 (empty) and 4 (full) was assigned for each stomach and the stomach content mass (0.01 g) was measured.

The stomach content was sorted taxonomically and the state of digestion (1– fresh prey; 2 – partially digested prey; 3 – digested prey) according to Soares & Apelbaum (1994), was assigned for individual items. The occurrence and mass of the food items, grouped into taxa, were recorded.

Data analysis

For the investigation of diel feeding activity, data on fullness levels (%), on the stomach index of fullness (%BM) and the number of fresh prey were used. The stomach index of fullness (%BM) represents the wet mass of the stomach content expressed as a percentage of the total body mass. For fresh prey the total number and the number of the most important prey items were analyzed.

Variations in the %BM and number of fresh prey between sampling hours or sampling periods of the day (dawn, day, dusk, night) were tested by Kruskal-Wallis non-parametric test (Zar, 1996) to assess the influence of the sampling time on the discontinuity in feeding activity.

Stomach content data were analyzed by percentage of mass contribution and by frequency of occurrence of each prey category to assess the relative importance of individual prey taxa. Shoener's index (Linton *et al*., 1981) was used to analyze the diel changes in prey composition.

RESULTS

Paralonchurus brasiliensis

The banded croacker presented a low proportion of empty stomachs, recorded three times for the juveniles (Fig. 2) but none for the adults (Fig. 3), over a 24 hours period. Half, or more than half, of the stomachs of this species were full or almost full from morning (9:09 h) until night (00:37 h).

There were no significant differences in stomach index of fullness as between eight different times or the four periods of the daily cycle for juveniles and adults. Similar results were obtained for the numbers of fresh prey. These results showed no diel feeding pattern for this species (Table 2; Figs. 2, 3). Although it appears that the banded croacker eats all day long, there was an increase in the number of fresh prey during the afternoon hours, mainly for the adults, which indicates a diel tendency in the food intake (Fig. 3).

The diet composition over a 24 hours period is given in Table 3. Polychaetes belonging to Capitelidae and Maldanidae were the most important prey items. Among crustaceans, caridean shrimps, represented mainly by Ogyrididae, were important items. The diet composition was similar throughout the larger part of the day, both in the occurrence and the mass of the food items.

Micropogonias furnieri

Similarly to the banded croacker, the juveniles of the whitemouth croacker presented a low proportion of empty stomachs over a day (Fig. 4). More than 60% of the stomachs were at least half full all the time, and more than 50% were full in the afternoon (13:05 h and 15:08 h) and at dusk (18:41 h).

The trajectories of the stomach index of fullness and of the number of fresh prey items did not show a clear diel pattern in the food intake (Table 4; Fig. 4).

The whitemouth croacker fed mainly on capitelid polychaetes during the day, but also ingested a small proportion of small crustaceans and of some caridean and penaeidean shrimps (Table 5). The diet composition was similar over the day.

Isopisthus parvipinnis

A relatively small proportion of full stomachs occurred at dusk (18 h) and at night (21 h), a diel pattern appearing in the percentage of full stomachs. Fish with empty stomachs were taken in the same sample as others with full stomachs. It therefore appears that there is asynchronous feeding activity (Fig. 5).

The stomach index of fullness was not significantly different either in the analysis of the eight 3-hour intervals or in that of the 4 periods (Table 4; Fig. 5). In relation to the fresh prey, no diel pattern was observed in the total number, nor in the pasaepheid shrimps or mysidaceans but a diel chronology was observed in the sergestid shrimps and gammarideans. Fresh sergestid shrimps were more frequently ingested during daylight (13 h, 15 h) and at dusk (18 h) than during the night (21 h, 24 h) and were not ingested at dawn (7 h) or in the morning (9 h).

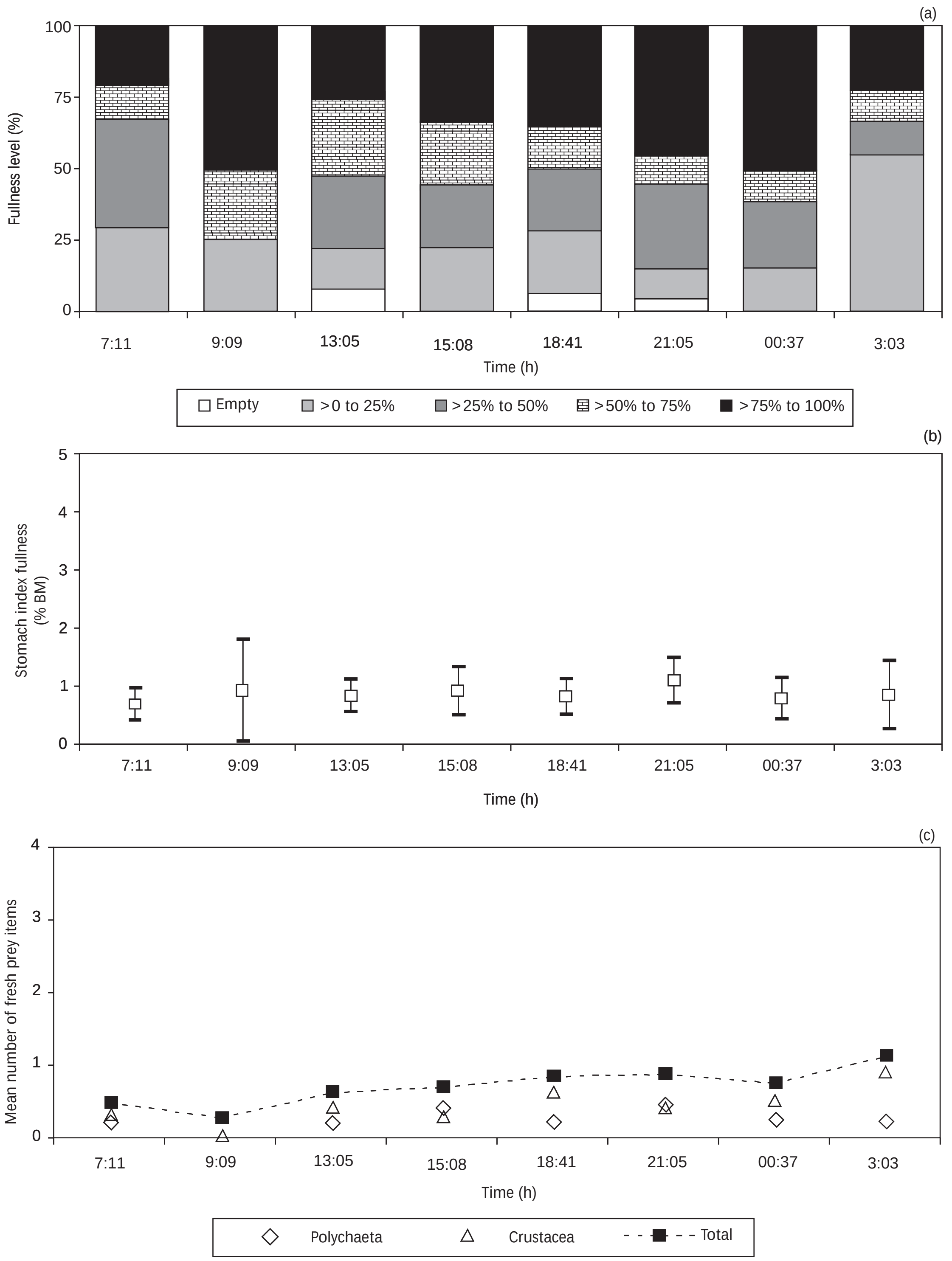

Fig. 2 — Proportion of the stomach fullness levels (a), mean stomach fullness expressed as % BM (b) and mean number of fresh prey items (c) for juveniles of banded croacker *Paralonchurus brasiliensis* by sampling time over a 24 hours period.

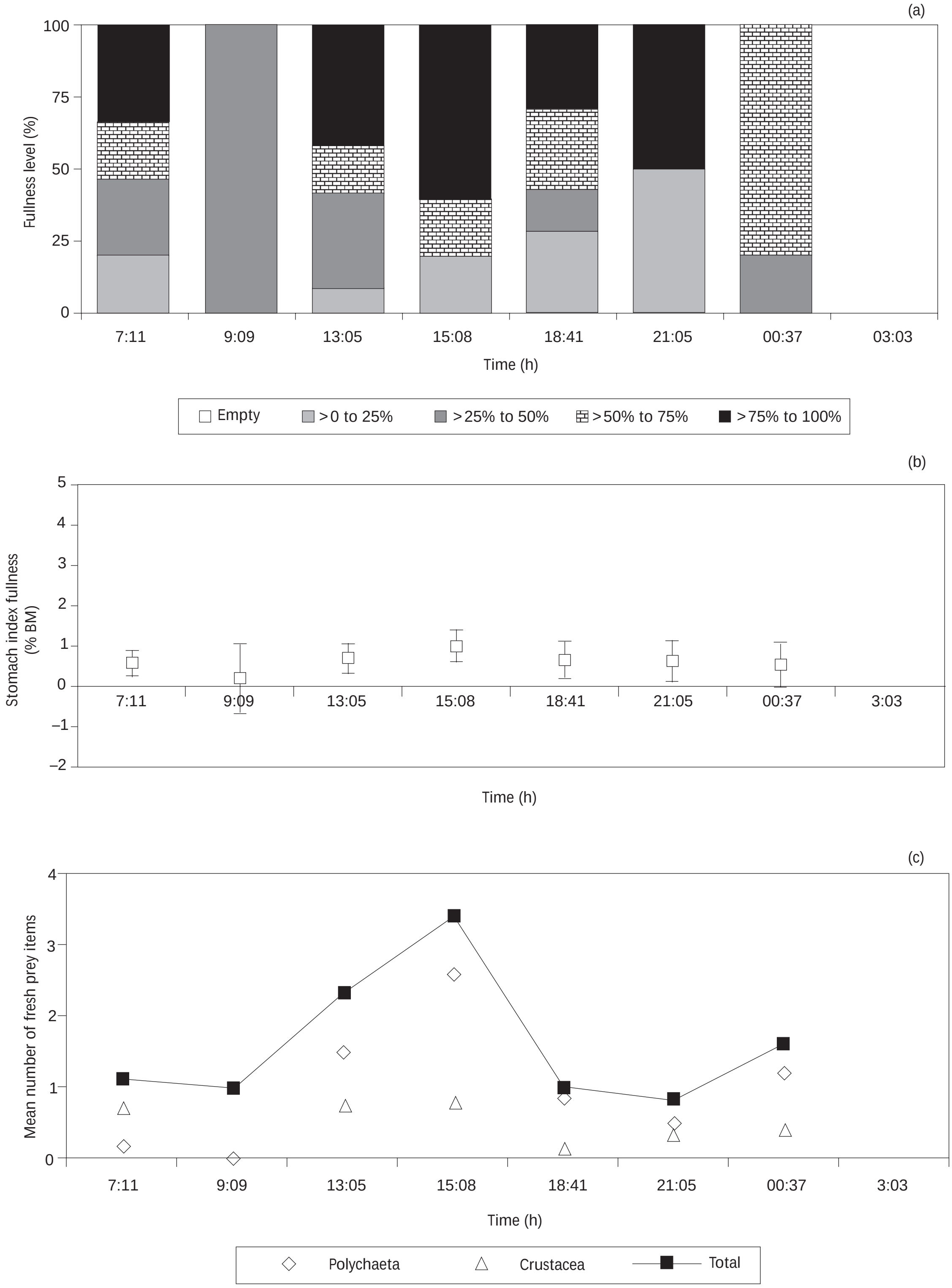

Fig. 3 — Proportion of the stomach fullness levels (a), mean stomach fullness expressed as % BM (b) and mean number of fresh prey items (c) for adults of banded croacker *Paralonchurus brasiliensis* by sampling time over a 24 hours period.

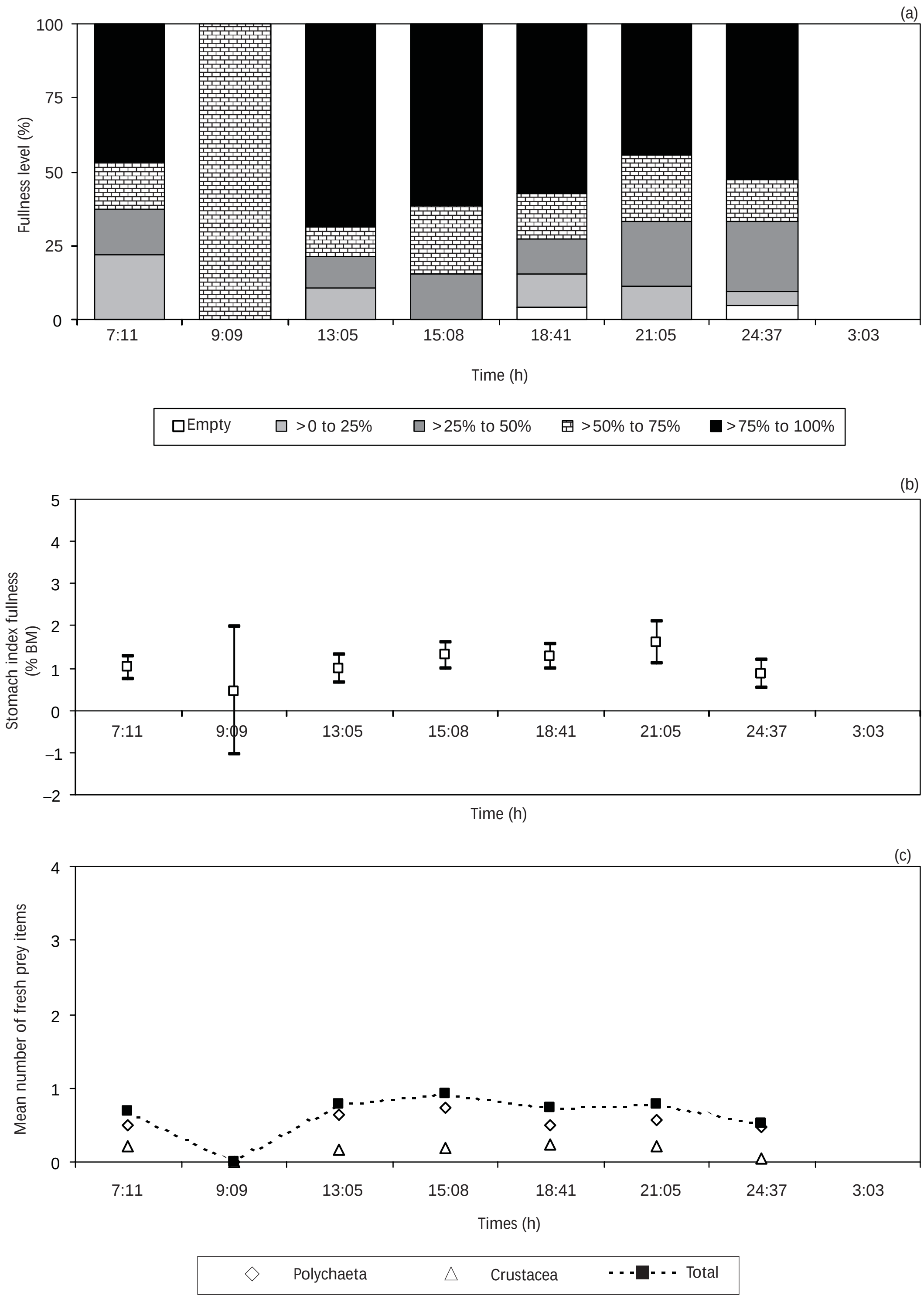

Fig. 4 — Proportion of the stomach fullness levels (a), mean stomach fullness expressed as % BM (b) and mean number of fresh prey items (c) for juveniles of whitemouth croacker *Micropogonias furnieri* by sampling time over a 24 hours period.

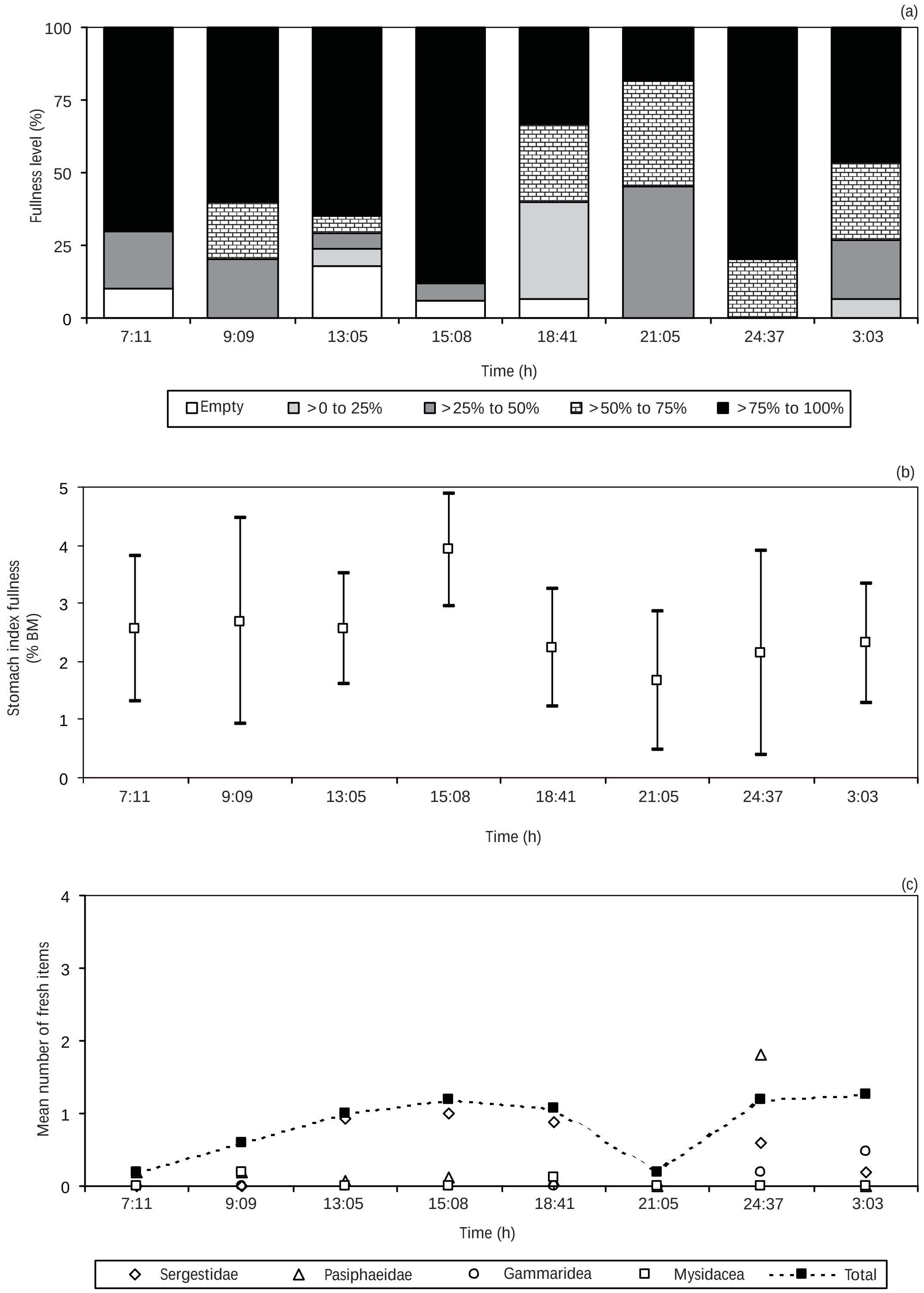

Fig. 5 — Proportion of the stomach fullness levels (a), mean stomach fullness expressed as % BM (b) and mean number of fresh prey items (c) for juveniles of shortfin corvina *Isopisthus parvipinnis* by sampling time over a 24 hours period.

TABLE 2

Results of Kruskal-Wallis test (χ^2) comparing stomach content mass and number of fresh prey items of *Paralonchurus brasiliensis* for eight 3 h intervals and four periods (dawn, day, dusk, night) over a 24 hours period.

Variables	Juveniles		Adults		Total	
	Eight 3 h intervals					
	χ2	P value	χ2	P value	χ2	P value
	190		57		247	
Stomach content (% BM)	1.48	0.98	4.00	0.68	2.14	0.95
Total fresh prey	3.52	0.83	8.34	0.21	2.03	0.96
Crustacean fresh prey	5.35	0.62	5.86	0.44	1.26	0.99
Polichaet fresh prey	1.91	0.96	11.14	0.08	3.17	0.87
	Periods of day (dawn, day, dusk, night)					
Stomach content (% BM)	0.01	0.99	0.30	0.96	0.26	0.97
Total fresh prey	2.97	0.40	6.55	0.09	1.16	0.76
Crustacean fresh prey	3.60	0.31	5.02	0.17	0.55	0.91
Polichaet fresh prey	0.94	0.82	6.93	0.07	1.54	0.67

A few fresh gammaridean prey as well as cumaceans and ogyridid shrimps were ingested only at night (Table 4, Fig. 5).

Although there is no statistical difference it appears that the shortfin corvina has two periods of feeding activity during the day, taking in different prey items during daylight and during the night.

The shortfin corvina fed on crustacean groups and teleostean fish. Penaeidean shrimps, most of them sergestids, were the most important prey. Caridean shrimps and teleostean fish were also important.

There are three groups of diet composition over a day; one shown by the specimens collected in the morning (7 h and 9 h) in whose stomachs the proportion of the caridean pasiphaeid shrimps and teleostean fish was greater and that of the penaeidean sergestid shrimps smaller; the second group of the specimens caught during the afternoon and dusk, in which the proportion of sergestids was larger and that of the carideans smaller; and the third group, in which the carideans as well as the sergestids were both highly important. In the stomachs of this last group the food categories increased (Table 6).

Larimus breviceps

The proportion of the specimens with full stomachs is at its maximum at dusk and is high at night, periods during which no single specimen was found with an empty stomach. Fish with empty stomachs were registered only at dawn, although in this period of the day there was also a reasonable proportion of them with full stomachs, thus there appears to be asynchrony in the food ingestion of the population (Fig. 6). The diel variation in the stomach contents showed a clear pattern. The stomach index of fullness had a primary maximum at dusk and a secondary one at night (Fig. 6).

According to the statistics, the total number of newly ingested prey specimens is the same in all the four periods of the day. But there are differences in the fresh penaeidean prey, which were found in larger number in the stomachs at dusk (Table 4, Fig. 6). Thus the main feeding period of the shorthead drum is at dusk.

TABLE 3

Diet composition of the banded croaker, *Paralonchurus brasiliensis*, in the Ubatuba shelf ecosystem (Brazil) by sampling time over a 24 h period by frequency (O%) and percentage mass (M%). Similarity percentage (PS > 60%) of food items (†) by time of day: (O% and M%) one similar group, all sampled hours except 9:00 and 3:03 h.

	Time (h)																	
	Dawn		Day						Dusk		Night							
Food items	7:11		9:09		13:04		15:08		18:41		21:06		24:37		3:03		Total	
	O (%)	M (%)	O (%)	M (%)	O (%)	M (%)	O (%)	M (%)	O (%)	M (%)	O (%)	M (%)	O (%)	M (%)	O (%)	M (%)	O (%)	M (%)
NEMERTINEA	16.36	3.89			3.85	2.94	3.57	0.06	4.88	0.55	26.92	1.49	9.68	0.49			9.68	1.66
POLYCHAETA (Total)	**74.55**	**68.10**	**50.00**	**40.00**	**75.00**	**76.94**	**85.71**	**91.20**	**53.66**	**61.19**	**53.85**	**74.82**	**77.42**	**76.09**	**44.44**	**38.62**	**68.95**	**75.44**
Unid. POLYCHAETA	58.18	18.79	16.67	25.38	44.23	17.37	71.43	29.22	39.02	13.29	26.92	4.28	61.29	36.72	33.33	21.21	48.79	20.16
Capitelidae	16.36	46.42			21.15	52.17	32.14	59.17	19.51	44.76	19.23	68.13	22.58	33.94			19.76	50.79
Maldanidae	23.64	1.43	16.67	*	30.77	7.37	25.00	0.36	4.88	0.10	15.38	2.42	29.03	4.69	11.11	0.04	21.37	2.83
Gliceridae	3.64	0.97					7.14	0.04	2.44	0.96							2.02	0.30
Hesionidae	1.82	0.03															0.40	*
Onuphidae	1.82	0.18															0.40	0.03
Nereidae	1.82	0.28															0.40	0.05
Afroditacea			16.67	14.62													0.40	0.08
Goniadidae					1.92	0.04											0.40	0.01
Terebellidae							3.57	0.64									0.40	0.15
Flabelligeridae							3.57	1.79									0.40	0.42
Pilargidae									2.44	1.50							0.40	0.19
Sigalionidae									2.44	0.58			3.23	0.73	11.11	15.18	1.21	0.44
Serpulidae													3.23	*			0.40	*
CRUSTACEA (Total)	**65.45**	**25.74**	**100.00**	**54.62**	**61.54**	**18.91**	**71.43**	**8.44**	**60.98**	**38.03**	**80.77**	**23.50**	**58.06**	**22.69**	**44.44**	**61.16**	**65.32**	**22.00**
Unid. CRUSTACEA	7.27	0.59			3.85	0.15	7.14	0.23	4.88	*							4.03	0.19
MYSIDACEA	1.82	0.03			1.92	0.06			4.88	0.14	3.85	*	6.45	0.05	11.11	0.22	3.23	0.04
TANAIDACEA							7.14	0.04					3.23	*			1.21	0.01
CUMACEA	1.82	0.36			3.85	0.13					3.85	*			11.11	2.46	2.02	0.14
ISOPODA											3.85	7.88					0.40	0.93

TABLE 3 *(Continued)*

	Time (h)																	
	Dawn		**Day**						**Dusk**		**Night**							
Food items	**7:11**		**9:09**		**13:04**		**15:08**		**18:41**		**21:06**		**24:37**		**3:03**		**Total**	
	O (%)	**M (%)**	**O (%)**	**M (%)**	**O (%)**	**M (%)**	**O (%)**	**M (%)**	**O (%)**	**M (%)**	**O (%)**	**M (%)**	**O (%)**	**M (%)**	**O (%)**	**M (%)**	**O (%)**	**M (%)**
GAMMARIDEA	18.18	0.46	33.33	3.85	3.85	0.09	17.86	0.24	12.20	0.55	11.54	*	16.13	0.44			12.90	0.29
CAPRELLIDEA	1.82	*					3.57	*									0.81	*
Unid. DECAPODA									7.32	*			3.23	0.44			1.61	0.04
CARIDEA (Total)	**30.91**	**10.15**	**66.67**	**48.46**	**44.23**	**13.59**	**42.86**	**5.66**	**46.34**	**19.03**	**38.46**	**11.64**	**38.71**	**17.56**	**11.11**	**41.74**	**39.52**	**12.73**
Unid. CARIDEA	5.45	0.87	16.67	0.77	1.92	0.30			2.44	0.68	3.85	1.12					2.82	0.44
Ogyrididae	10.91	2.86	33.33	28.46	34.62	12.41	42.86	4.47	43.90	16.50	38.46	9.11	35.48	16.43	11.11	41.74	31.45	10.09
Pasiphaeidae	12.73	5.57	16.67	19.23	1.92	0.54	7.14	1.18	2.44	1.71	3.85	1.41					5.24	1.85
Processidae	10.91	0.84			5.77	0.35			2.44	0.14			12.90	1.12			5.65	0.35
PENAEIDEA (Total)	**7.27**	**7.26**			**5.77**	**3.11**	**3.57**	**1.05**	**12.20**	**13.29**			**6.45**	**0.98**	**11.11**	**16.74**	**6.45**	**4.34**
Unid. PENAEIDEA	1.82	1.00			1.92	0.31	3.57	0.56					6.45	0.98	11.11	16.74	2.42	0.79
Sicyoniidae	3.64	6.24					3.57	0.49	12.20	13.29							3.23	2.88
Penaeidae	1.82	0.03			1.92	2.04											0.81	0.49
Sergestidae					1.92	0.76											0.40	0.18
Unid. Shrimps	34.55	6.90	50.00	2.31	13.46	1.31	25.00	1.09	21.95	3.96	30.77	2.49	12.90	2.25			22.98	2.76
BRACHYURA					1.92	0.46	7.14	0.13	2.44	1.06	7.69	1.49	3.23	0.98			2.82	0.54
BRYOZOA	1.82	0.05			1.92	0.09	3.57	*									1.21	0.03
OPHIUROIDEA	36.36	1.92	16.67	5.38	15.38	1.11	7.14	0.30	4.88	0.14	11.54	0.19	6.45	0.73			15.32	0.80
HOLOTUROIDEA	1.82	0.31															0.40	0.05
TELEOSTEI									2.44	0.10					11.11	0.22	0.81	0.02
Total **	**55**	**3.912**	**6**	**0.130**	**52**	**5.400**	**28**	**5.319**	**41**	**2.927**	**26**	**2.689**	**31**	**2.045**	**9**	**0.448**	**248**	**22.870**

* Indicates presence but percentage < 0.01%; Total** are number of stomachs and wet mass (g) of prey.

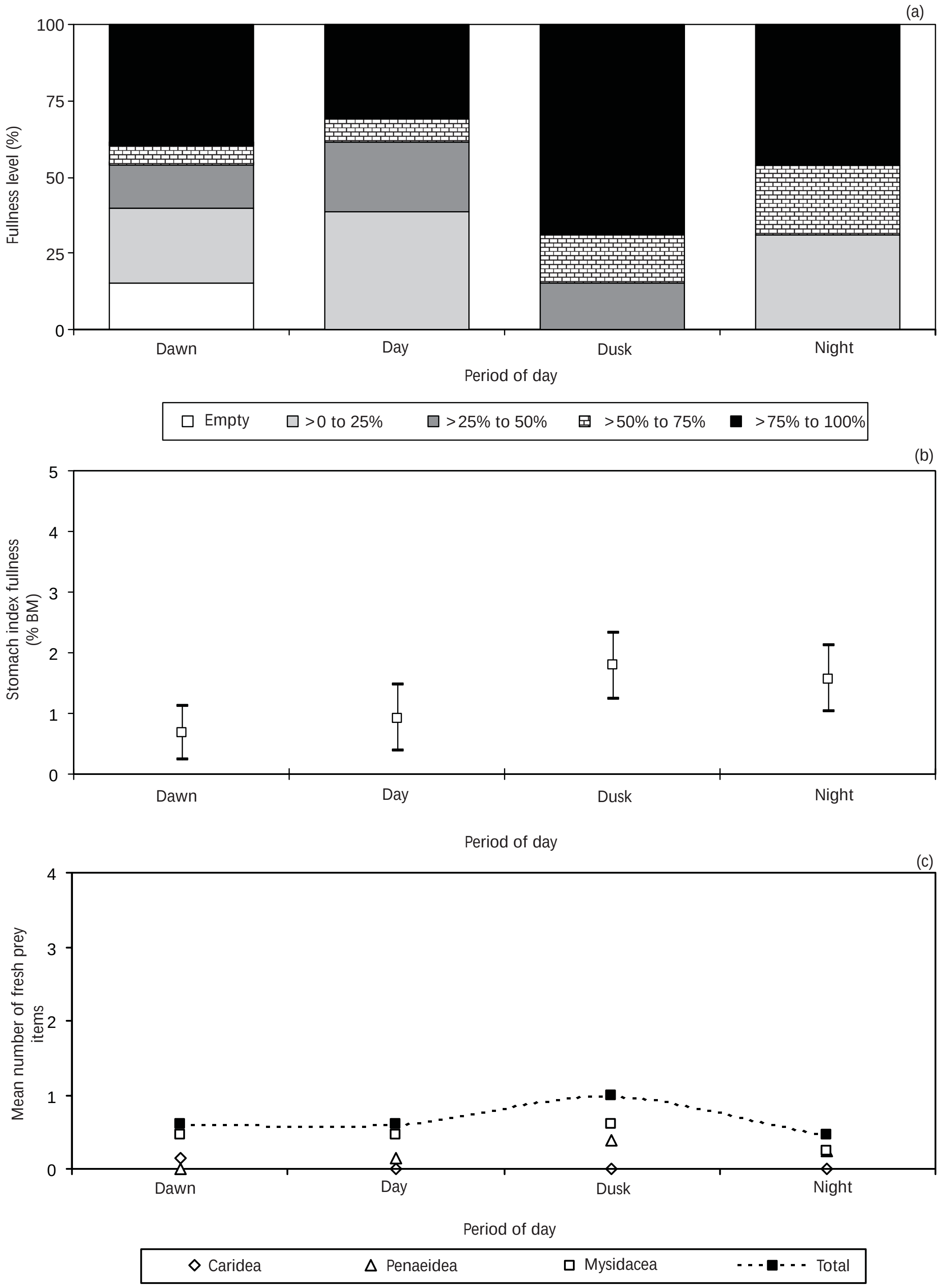

Fig. 6 — Proportion of the stomach fullness levels (a), mean stomach fullness expressed as % BM (b) and mean number of fresh prey items (c) for juveniles of shorthead drum *Larimus breviceps* by sampling time over a 24 hours period.

TABLE 4

Results of Kruskal-Wallis Tests (χ2) comparing stomach content mass and numbers of fresh prey items of *Micropogonias furnieri*, *Isopisthus parvipinnis* and *Larimus breviceps* for eight 3 h intervals and four periods (dawn, day, dusk, night) over a 24 hour periods. Significant values of χ2 are denoted by * p < 0.05; ** p < 0.01; *** p < 0.001.

	Eight 3 h intervals		Periods of day (dawn, day, dusk, night)	
Variables	**χ2**	**P value**	**χ2**	**P value**
***Micropogonias furnieri* (white croacker)**				
n = 134				
Stomach content (%BM)	9.55	0.15	2.72	0.44
Total fresh prey	6.16	0.41	2.78	0.43
Crustacean fresh prey	3.68	0.72	2.08	0.56
Polichaet fresh prey	6.14	0.41	3.68	0.30
***Isopisthus parvipinnis* (shorfin corvina)**				
n = 95				
Stomach content (%BM)	10.49	0.16	4.27	0.23
Total fresh prey	11.97	0.10	3.98	0.26
Sergestid fresh prey	21.12	0.004**	1.00	0.02*
Pasaepheid fresh prey	6.38	0.50	2.85	0.42
Mysidacean fresh prey	10.65	0.15	2.45	0.48
Gammaridean fresh prey	24.95	0.0008***	13.07	0.004**
***Larimus breviceps* (shorthead drum)**				
n = 59				
Stomach content (%BM)	not tested		12.26	0.007**
Total fresh prey	not tested		4.77	0.19
Penaeidean fresh prey	not tested		8.58	0.04*
Caridean fresh prey	not tested		6.06	0.11
Mysidacean fresh prey	not tested		3.90	0.27

The shorthead drum fed on crustaceans, chaetognates and teleostean fish.

The most important item was the penaeidean (mainly sergestid) shrimps, but the mysidaceans and caridean shrimps were also important.

Sergestid shrimps were important through the dark period but they did not occur in the daytime, when the mysidaceans were important (Table 7).

DISCUSSION

The banded croacker and the whitemouth croacker did not show a clear diel feeding pattern. Similar results were obtained for the whitemouth croacker in the Patos Lagoon Estuary, Southern Brazil, where the juveniles did not show a daily food chronology in all the four seasons of the year (Figueiredo & Vieira, 1998).

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TABLE 5

Diet composition of the whitemouth croaker, *Micropogonias furnieri* in the Ubatuba shelf ecosystem (Brazil) by sampling time over a 24 h period by frequency (O%) and percentage mass (M%). Similarity percentage (PS > 60%) of food items (†) by time of day: (O% and M%) one similar group except sample of 9:09 h. * Indicates presence but percentage < 0.01%.

	Time (h)															
	Dawn		**Day**						**Dusk**		**Night**					
Food items	**7:11**		**9:09**		**13:04**		**15:08**		**18:41**		**21:06**		**24:37**		**Total**	
	O (%)	**M (%)**	**O (%)**	**M (%)**	**O (%)**	**M (%)**	**O (%)**	**M (%)**	**O (%)**	**M (%)**	**O (%)**	**M (%)**	**O (%)**	**M (%)**	**O (%)**	**M (%)**
POLYCHAETA (Total)	**78.13**	**88.19**	**100.00**	**100.00**	**94.74**	**96.11**	**96.15**	**97.36**	**76.92**	**93.35**	**88.89**	**96.80**	**85.71**	**96.04**	**85.82**	**94.07**
POLYCHAETA (Others)	46.88	21.54	100.00	100.00	52.63	25.63	69.23	22.53	15.38	12.93	44.44	1.70	52.38	23.96	47.01	18.95
Capitelidae	56.25	66.65			84.21	70.48	80.77	74.84	57.69	80.43	55.56	95.10	52.38	72.07	64.18	75.11
CRUSTACEA (Total)	**59.38**	**11.21**			**36.84**	**3.89**	**57.69**	**2.64**	**76.92**	**6.65**	**77.78**	**3.20**	**42.86**	**3.96**	**57.46**	**5.79**
Unid. CRUSTACEA	9.38	0.14					7.69	*	23.08	1.23	11.11	0.21			8.96	0.29
COPEPODA	3.13	*					3.85	0.02							1.49	*
MYSIDACEA	3.13	0.04			10.53	0.14	23.08	0.08	19.23	0.17	22.22	0.09	23.81	0.22	15.67	0.11
TANAIDACEA					5.26	*									0.75	*
CUMACEA	3.13	0.08							3.85	0.07	22.22	0.09			2.99	0.04
ISOPODA							3.85	1.25							0.75	0.28
GAMMARIDEA	9.38	0.10			10.53	0.04	23.08	0.02	7.69	0.02	11.11	0.04			10.45	0.04
CARIDEA (Total)	**46.88**	**4.00**					**11.54**	**0.42**	**34.62**	**4.34**	**22.22**	**1.96**	**4.76**	**1.34**	**22.39**	**2.23**
Unid. CARIDEA	18.75	0.73			5.26	0.64			3.85	0.02					5.97	0.26
Hippolytidae	3.13	*													0.75	*
Ogyrididae	25.00	1.75					7.69	0.02	15.38	2.89	22.22	1.41	4.76	1.34	12.69	1.27
Pasiphaeidae	6.25	1.40					3.85	0.40	7.69	0.69					3.73	0.55
Processidae	9.38	0.12							19.23	0.74	11.11	0.55			6.72	0.23

TABLE 5 ***(Continued.)***

	Time (h)															
	Dawn		**Day**						**Dusk**		**Night**					
Food items	**7:11**		**9:09**		**13:04**		**15:08**		**18:41**		**21:06**		**24:37**		**Total**	
PENAEIDEA (Total)	**12.50**	**3.51**					**3.85**	**0.84**	**3.85**	**0.29**			**4.76**	**1.34**	**5.22**	**1.22**
Sicyoniidae	9.38	3.39					3.85	0.84							2.99	0.99
Penaeidae									3.85	0.29					0.75	0.06
Sergestidae	3.13	0.12			15.79	2.96							4.76	1.34	3.73	0.56
Unid. Shrimps	21.88	1.97							11.54	0.52	22.22	0.81	14.29	1.07	11.19	0.77
Larvae	3.13	*							7.69	*	11.11	*			2.99	*
ANOMURA	3.13	1.38													0.75	0.33
BRACHYURA					10.53	0.11	3.85	*							2.24	0.01
SCALES	9.38	0.59			10.53	*									3.73	0.14
Total **	**32**	**5.074**	**1**	**0.060**	**19**	**2.805**	**26**	**4.781**	**26**	**4.077**	**9**	**2.347**	**21**	**2.245**	**134**	**21.389**

Total** are number of stomachs and prey wet mass (g).

TABLE 6

Diet composition of the shortfin corvina, *Isopisthus parvipinnis* in the Ubatuba shelf ecosystem (Brazil) by sampling time over a 24 h period by frequency (O%) and percentage mass (M%). Similarity percentage (PS > 60%) of food items (†) by time of day: (O%) three similar groups – 21:06, 3:03; 7:11, 9:09, and other sampling hours; (M%) two similar groups – 7:11, 9:09, and other sampling hours.

*** Indicates presence but percentage < 0.01%.**

	Time (h)																	
	Dawn		**Day**						**Dusk**		**Night**							
Food items	**7:11**		**9:09**		**13:04**		**15:08**		**18:41**		**21:06**		**24:37**		**03:03**		**Total**	
	O (%)	**M (%)**	**O (%)**	**M (%)**	**O (%)**	**M (%)**	**O (%)**	**M (%)**	**O (%)**	**M (%)**	**O (%)**	**M (%)**	**O (%)**	**M (%)**	**O (%)**	**M (%)**	**O (%)**	**M (%)**
CRUSTACEA (Total)	**80.00**	**62.83**	**100.00**	**39.39**	**64.71**	**81.80**	**94.12**	**100.00**	**80.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**93.39**	**87.37**	**88.27**
Unid. CRUSTACEA	20.00	17.04					5.88	0.63	13.33	*	18.18	*			6.67	0.43	8.42	1.65
MYSIDACEA	20.00	0.62	60.00	2.12			5.88	0.04	6.67	0.20	45.45	1.66			33.33	1.71	17.89	0.40
CUMACEA											27.27	0.41			33.33	0.64	8.42	0.07
GAMMARIDEA									13.33	0.20	18.18	0.41	20.00	0.72	33.33	0.85	10.53	0.12
CARIDEA (Total)	**50.00**	**31.01**	**60.00**	**26.06**	**17.65**	**6.38**	**17.65**	**2.73**	**33.33**	**19.19**	**27.27**	**25.31**	**40.00**	**29.71**	**53.33**	**33.69**	**33.68**	**12.60**
Unid. CARIDEA	10.00	5.13			5.88	1.31	5.88	0.09	13.33	1.21					20.00	6.61	8.42	1.42
Ogyrididae											9.09	11.20	40.00	29.71	20.00	16.42	6.32	2.42
Pasiphaeidae	40.00	25.87	40.00	20.61	5.88	1.63	11.76	2.64	26.67	17.98	18.18	10.79			26.67	9.17	20.00	7.29
Processidae			20.00	5.45	5.88	3.44					9.09	3.32			6.67	1.49	4.21	1.47
PENAEIDEA (Total)	**20.00**	**3.90**	**60.00**	**7.27**	**41.18**	**67.92**	**88.24**	**78.94**	**46.67**	**55.56**	**54.55**	**46.47**	**60.00**	**34.78**	**66.67**	**43.50**	**55.79**	**58.92**
Sergestidae	20.00	3.90	60.00	7.27	41.18	67.92	88.24	78.94	46.67	55.56	54.55	46.47	60.00	34.78	66.67	43.50	55.79	58.92
Unid. Shrimps	20.00	10.27	60.00	3.94	23.53	7.50	35.29	17.65	26.67	24.85	36.36	25.73	80.00	34.78	40.00	12.58	34.74	14.51
TELEOSTEI	50.00	37.17	80.00	60.61	11.76	18.20									6.67	6.61	12.63	11.73
Total **	**10**	**0.487**	**5**	**0.330**	**17**	**1.599**	**17**	**2.232**	**15**	**0.495**	**11**	**0.241**	**5**	**0.138**	**15**	**0.469**	**95**	**5.991**

Total** are number of stomachs and prey wet mass (g).

TABLE 7

Diet composition of the shorthead drum, *Larimus breviceps*, in the Ubatuba shelf ecosystem (Brazil) by sampling time over 24 h period by frequency (O%) and percentage mass (M%). Similarity percentage (PS > 60%) of food items (†) by period of day: (O%) one similar group-dawn, dusk and night; (M%) one similar group-dusk and night. * Indicates presence but percentage < 0.01%.

	Period of Day									
Food items	**Dawn**		**Day**		**Dusk**		**Night**		**Total**	
	O(%)	**M(%)**	**O(%)**	**M(%)**	**O(%)**	**M(%)**	**O(%)**	**M(%)**	**O(%)**	**M(%)**
CRUSTACEA (Total)	**85.00**	**88.75**	**100.00**	**98.73**	**100.00**	**99.66**	**100.00**	**98.74**	**94.92**	**96.88**
Unid. CRUSTACEA	5.00	0.25			23.08	0.17			6.78	0.11
OSTRACODA	5.00	*							1.69	*
COPEPODA	10.00	0.25							3.39	0.05
MYSIDACEA	80.00	25.50	92.31	36.83	100.00	14.60	100.00	5.05	91.53	17.87
CUMACEA			30.77	0.63	7.69	*	7.69	0.00	10.17	0.11
GAMMARIDEA	20.00	1.25			15.38	0.17	38.46	1.62	18.64	0.81
Unid. DECAPODA	5.00	*			7.69	*	23.08	*	8.47	*
CARIDEA (Total)	**45.00**	**48.50**	**7.69**	**4.76**	**7.69**	**1.36**	**15.38**	**9.03**	**22.03**	**14.37**
Unid. CARIDEA	5.00	6.50	7.69	4.76					3.39	2.21
Ogyrididae	10.00	2.25							3.39	0.48
Alpheidae	5.00	9.00							1.69	1.94
Pasiphaeidae	15.00	26.50							5.08	5.71
Hippolytidae							7.69	0.90	1.69	0.27
Processidae	10.00	4.25			7.69	1.36	15.38	8.12	8.47	3.77
PENAEIDEA (Total)	**15.00**	**2.25**			**84.62**	**82.34**	**53.85**	**77.62**	**38.98**	**59.31**
Unid. PENAEIDEA							7.69	12.45	1.69	3.71
Sicyoniidae	5.00	0.50					7.69	24.01	3.39	7.27
Sergestidae	10.00	1.75			84.62	82.34	38.46	40.97	33.90	48.28
Larvae							7.69	0.18	1.69	0.05
Unid. Shrimps	15.00	10.75			23.08	1.02	38.46	5.42	18.64	4.25
CHAETOGNATA	25.00	1.00	7.69	1.27			30.77	0.72	16.95	0.65
TELEOSTEI	10.00	10.25			7.69	0.34	7.69	0.54	6.78	2.48
Total **	**20**	**0.400**	**13**	**0.315**	**13**	**0.589**	**13**	**0.554**	**59**	**1.858**

Total** are number of stomachs and prey wet mass (g).

Although there is no strong evidence on the diel pattern, there is some increase in the feeding activity between afternoon and late evening for both croackers, as was shown for the whitemouth croacker in the Patos Lagoon Estuary (Figueiredo & Vieira, 1998). This is much in line with the feeding pattern observed for this species in Trinidad, West Indies, which presented one feeding period a day, between mid-day and late evening (Manickchand-Heileman & Ehrhardt, 1996). Quite a different pattern was shown for this species in Argentina (Puig, 1986) with three periods of intensive feeding per day based on sampling performed from 4-20 h over a day. This may be due to latitudinal differences (Boujard & Leatherland, 1992) and also to differences in oceanographic conditions or in behavioral patterns between populations, as was argued by Manickchand-Heileman & Ehrhardt (1996).

These two croackers fed on a variety of benthic invertebrates, most heavily on polychaetes, mainly capitelids, tubiculous detritivores living in the bottom subsurface and no changes in the diet composition occurred over a day. As may be seen they are bottom feeders feeding in the lower portion of the water column, in accordance with the references in the literature (Braga *et al*., 1985; Vazzoler, 1991; Amaral *et al*., 1994; Guevara *et al*., 1995; Chagas, 1997).

One can question whether they feed constantly throughout the day or whether the difficulty lay in obtaining evidence for circadian activity from field data, at a subtropical site, due to the asynchrony of the food intake in the population or to the pattern of food evacuation. Dos Santos & Jobling (1991) reported on the species that it could be ingesting food during the gastric evacuation and Figueiredo & Vieira (1998) suggested this pattern for the whitemouth croacker. As there is some evidence of circadian activity it may be advisable to perform laboratory experiments or even to repeat the field study to obtain more data as to the feeding time of this specie.

The shortfin corvina and shorthead drum appear to have a "circadian-like" pattern in their feeding activity and also show changes in diet composition over the day, probably reflecting changes in this activity. They fed on similar prey items, mainly sergestid shrimps and may be classified as pelagic feeders feeding in the upper portion of the water column as was suggested by Chao & Musick (1977) and Chagas (1997).

It appears that the shortfin corvina is primarily a diurnal feeder feeding during the afternoon and dusk, but showing some activity at night. This species fed largely on crustacean groups, mainly on sergestid shrimps as was reported by Soares (1989).

The shorthead drum showed greater feeding activity at dusk and at night in accordance with the results for banded drum *Larimus fasciatus* in North Carolina where Ross (1989) hypothesized the most intensive activity in the water column during low light intensity periods. Its major prey items are sergestid shrimps and mysidaceans as was reported for three sites (Lowe-MacConnell, 1966; Rodrigues & Meira, 1988; Teixeira *et al*., 1992) and also for the banded drum (Ross, 1989).

A temporal organization of the feeding activity of the four sympatric sciaenids was observed in the overall analysis. The two pelagic feeder species show a daily pattern of activity and the two benthic feeder species clearly do not. It appears that these characteristics are related to the availability of the prey and to the energy budget.

The major prey items of the shorthead drum and shortfin corvina exhibit diurnal migration (Stickney *et al*., 1975; Ross, 1989), so they are time restricted and most available when they are off the bottom. Thus it may be suggested that sergestid shrimps are available to the shortfin corvina during their daytime migration and to the drum during their rising and sinking movements at dusk and during the night. The above facts are obviously related to the morphological traits of the fish which may be a guide to the trophic ecology because the traits determine how and what a fish feeds on (Chao & Musick, 1977; Wooton, 1995) and must be synchronized in accordance with the daily light/dark alternation (Boujard & Leatherland, 1992). But the ultimate causal factors may be hidden in the past (Chao & Musick, 1977; Gerking, 1994).

Hyatt (1979) pointed out that species which use chemical receptors do not express great variations in their feeding during the daily cycle as is the case of the bottom feeders banded croacker and whitemouth croacker which prey mainly on polychaetes, which may be vulnerable in the course of the day. On the other hand the two drums have functional morphology related to visual perception of prey which could explain the temporal organization in the food intaking.

The results of the present study are probably examples of food, habit and time partitioning between the four coexisting sciaenid species exploiting the available resources in an efficient way in a given habitat (Gerking, 1994). However further work is required to produce better knowledge on the daily food activity of the species studied.

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