

ECOMORPHOLOGY AND FOOD HABITS OF TELEOST FISHES *Trachinotus carolinus*
(TELEOSTEI: CARANGIDAE) AND *Menticirrhus littoralis*
(TELEOSTEI: SCIAENIDAE), INHABITING THE SURF
ZONE OFF NITERÓI, RIO DE JANEIRO, BRAZIL*

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ABSTRACT

The ecomorphology and food habits of juvenile *Trachinotus carolinus* and *Menticirrhus littoralis* caught in the surf zone of sandy beaches in Niterói, RJ, were investigated between July 2006 and May 2007. These fish species differ morphologically, but present similarities in their diet composition suggest some slight overlapping in their diet. The importance of food items was assessed using Kawakami and Vazzoler's feeding index. Morphometric variables were recorded to correlate with the diet composition of the different size classes for each species. A total of 210 fishes (*Trachinotus carolinus* - 122, *Menticirrhus littoralis* - 88), ranging between 24.2 mm and 112 mm total length, were analyzed, but the stomachs of only 84.8% of them contained food. *Trachinotus carolinus* presented mysids, Polychaetes and *Emerita* spp. as the predominant items in their diet. Formicidae and Isopoda were the most important items for class I individuals, whereas mysids and *Emerita* spp. were important for classes II and III. Class I individuals also showed smaller sized prey (amphipods and isopods) and clupeid fish larvae in their diet. *Emerita* spp. dominated the food items of *Menticirrhus littoralis* regardless of the size class. Polychaetes, the second most important item was better represented in class sizes II and III. The main morphometric variable correlated with such differences included mouth position and diameter of the eye.

RESUMO

A ecomorfologia e os hábitos alimentares de juvenis de *Trachinotus carolinus* e *Menticirrhus littoralis* capturados na zona de arrebentação de praias arenosas em Niterói, RJ, foram investigados entre julho de 2006 e Maio de 2007. Ambas as espécies diferem morfológicamente, mas apresentam semelhanças em sua dieta, sugerindo uma possível sobreposição alimentar. A importância dos itens alimentares foi avaliada utilizando o índice alimentar de Kawakami e Vazzoler. Variáveis morfométricas foram correlacionadas à dieta observada para diferentes classes de tamanho, para cada espécie. Um total de 210 peixes (*Trachinotus carolinus* - 122, *Menticirrhus littoralis* - 88), variando entre 24.2 mm e 112 mm de comprimento total, foram analisados, mas apenas 84.8% continham alimento. *Trachinotus carolinus* apresentou mysidáceos, poliquetas e *Emerita* spp. como os itens predominantes na dieta. Formicidae e Isopoda foram os itens mais importantes para a classe I de tamanho dos indivíduos, enquanto que mysidáceos e *Emerita* spp. foram importantes para as classes II e III. Indivíduos da classe I também apresentaram itens de menor tamanho (anfípodos e isópodos) bem como larvas de peixes clupeídeos na dieta. *Emerita* spp. dominou a alimentação de *Menticirrhus littoralis*, independentemente da classe de tamanho. Poliquetas, o segundo item mais importante, foi mais bem representado na classe II e III de tamanho dos indivíduos. As principais variáveis morfométricas correlacionadas com essas diferenças incluíram a posição da boca e o diâmetro do olho.

Descriptors: Diet, Surf zone, Morphometric analysis, Carangidae, Sciaenidae.

Descritores: Dieta, Zona de arrebentação, Análise morfométrica, Carangidae, Sciaenidae.

INTRODUCTION

Ecomorphology aims to establish a correlation between one or several morphological features, which would indicate a potential adaptation

of a particular species to a certain ecological niche (COSTA; CATAUDELLA, 2007; TEIXEIRA; BENNEMANN, 2007). Thus, one may determine which environmental or biological factors are influencing individual forms within an ecosystem, thus increasing their success in the exploitation of the available resources (MOTTA; KOTRSCHALL, 1992; CUNICO; AGOSTINHO, 2006).

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Ecomorphology is an appropriate method for describing species ecology, including food preferences, diet overlap, and habitat use (TEIXEIRA; BENNEMANN, 2007). Fish diet studies provide the baseline data for the trophic organization of ecosystems, whereas feeding performance links fish morphology and diet (MOTTA; KOTRSCHALL, 1992), providing the tool for understanding the species' roles within fish communities. Thus, studies based on analysis of stomach contents are one of the few resources that can provide information on feeding ecology and many studies of stomach contents have, therefore, been made (e.g. MOTTA et al., 1995; AMUNDSEN et al., 1996; DELARIVA; AGOSTINHO 2001; CASATTI et al., 2005; TEIXEIRA; BENNEMANN, 2007).

Trachinotus carolinus is widely distributed in the western Atlantic from Massachusetts (EUA) to southeastern Brazil (FIGUEIREDO; MENEZES, 1980), with its young usually inhabiting the nearshore and surf zone habitats (MIGDALSK; FICHER, 1976; MONTEIRO-NETO et al., 2003). *Menticirrhus littoralis* (Teleostei, Sciaenidae) is also found near the coast within the 21 m isobath from southern Florida to southern Brazil (FIGUEIREDO; MENEZES, 1980), with juveniles frequently occupying the surf zone of sandy beaches (MONTEIRO-NETO et al., 2003). Studies have shown that the young of both species present great site fidelity, and often rank within the most abundant species in the surf zone (SALOMAN; NAUGHTON, 1979; MODDE, 1980; MODDE; ROSS, 1981; PETERS; NELSON, 1986; ROSS et al., 1987; ROSS; LANCASTER, 2002; MONTEIRO-NETO et al., 2003; 2008; VASCONCELLOS et al., 2007). Despite their distinct morphology, food habit

analysis of *Trachinotus* and *Menticirrhus* genera indicated a diet based on benthic organisms, especially small crustaceans (BELLINGER; AVAUT, 1971; NELSON, 1986; ROSS; MCMICHAEL, 1987; MONTEIRO-NETO; CUNHA, 1990; HELMER et al., 1995; WHEELER et al., 2002; BATISTIC et al., 2005), suggesting a possible diet overlap within their first year in the surf zone.

The present study addresses this hypothesis by qualifying and quantifying the diet of *T. carolinus* and *M. littoralis*, within the surf zone of several sandy beaches in Niterói, Rio de Janeiro, Brazil, describing the species' morphological characteristics most closely related to their feeding habits, and establishing the possible ecomorphological relationships.

MATERIAL AND METHODS

We collected fishes at eight different beach localities (Flexas, Icarai, São Francisco, Charitas, Adão, Eva, Forte, Imbuí) on the eastern margin and near the mouth of Guanabara Bay, Niterói, Rio de Janeiro (Fig. 1), monthly between July 2006 and May 2007. All the collections were conducted in the morning, from 8:00 to 12:00. We used a 16 m length beach seine with 2.5 m height and 10 mm mesh to collect the fish. The seine was hauled parallel to the shore for 20 m at depths ranging between 0.5 m and 1 m deep. Samples were cooled on ice and then fixed in 10% formalin in the laboratory. The two species were then separated, identified (FIGUEIREDO; MENEZES, 1980) and preserved in 70% alcohol for further study.

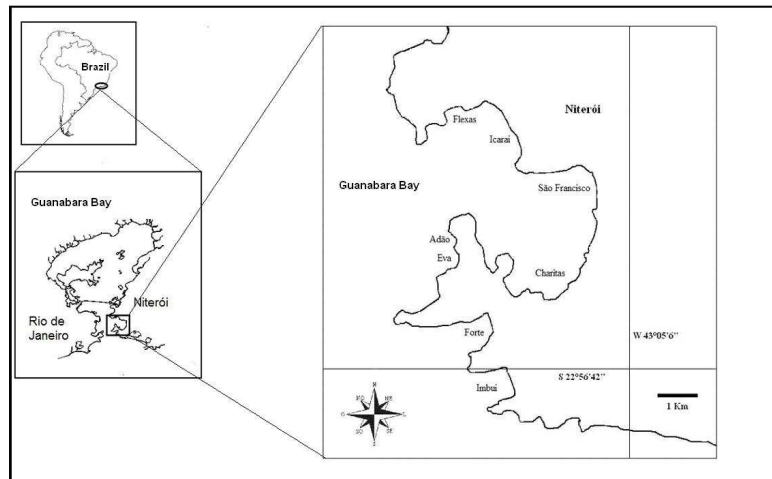


Fig. 1: Study area. On the left, South America and Brazil, the State of Rio de Janeiro being located within the circle; below, the full extent of Guanabara Bay, highlighting the study region; on the right, the data collection sites giving the names of the beaches sampled and their coordinates.

Individuals were weighed and the stomach and intestine removed for food analysis. Stomachs were weighed separately to calculate fullness index ($IR = W_e/W_t \times 100$, where W_e = stomach weight and W_t = total weight). Results were expressed as average IR within the size classes of each species. Stomachs were dissected, contents washed over a Petri dish and observed under a stereomicroscope for identification. All items were weighed on a precision scale (0.001 g). The importance of each food item was analyzed based on its frequency of occurrence and weight, and with the application of the feeding index ($FI_i = F_i V_i / \sum(F_i V_i)$, where FI_i = feeding index of the i^{th} food item, F_i = percentage frequency of occurrence, and V_i = percentage volume) proposed by KAWAKAMI and VAZZOLER (1980), replacing the percentage volume by percentage weight in all items.

The following morphometric measurements were taken (0.01 mm), in accordance with previous definitions (CAILLIET et al., 1986; SCHAFFER et al., 2002; WARD-CAMPBELL et al., 2005; FERREIRA 2007; TEIXEIRA; BENNEMANN, 2007): (a) standard length (SL); (b) maximum height (MH); (c) maximum width (MW); (d) length of the caudal peduncle (LCP); (e) height of the caudal peduncle (HCP); (f) width of the caudal peduncle (WCP); (g) height of the body below the lateral line (HBL); (h) head length (HL); (i) head height (HH); (j) position of the eye (PE); (k) diameter of the eye (DE); (l) mouth position (MOP); (m) mouth width (MOW); (n) mouth height (MOH); (o) nose closed length (NCL); (p) nose open length (NOL); (q) dorsal fin height (DFH); (r) dorsal fin length (DFL); (s) pectoral fin length (PFL); (t) pectoral fin height (PFH); (u) caudal fin length (CFL); (v) caudal fin height (CFH); (w) pelvic fin length (PEL); (x) anal fin height (ANH), and (y) anal fin length (ANL).

To verify possible ontogenetic changes in food habits within the size range of individuals collected, three size groups were defined for either of the two species: I ($T. carolinus < 45.1$ mm; $M. littoralis < 55.1$ mm), II (45.1 mm $\leq T. carolinus \leq$

70.0 mm; 55.1 mm $\leq M. littoralis \leq 65.0$ mm) and III ($T. carolinus \geq 71.1$ mm; $M. littoralis \geq 65.1$ mm).

A cumulative prey curve was constructed for each size class of the two species to ascertain whether an appropriate number of stomachs had been analyzed for an accurate characterization of the diets. The order in which the stomachs were analyzed was randomized ten times and the mean number of new prey found consecutively in the stomachs was plotted against numbers of stomachs analyzed (in accordance with FERRY et al., 1997).

Principal Component Analysis (PCA) was applied to explore the relationship between size class and food item within the species. The relationship between predominant food items for different size classes of each species, and the morphometric variables recorded were investigated by Canonical Correspondence Analysis (CCA) (LEGENDRE; LEGENDRE, 1998). The primary matrix consisted of the feeding index of food items (row) per size class of each species (column), and the secondary matrix consisted of morphometric variables 'a' to 'y'. This analysis was carried out exclusively on CANOCO by Windows 4.0 (TER BRAAK; SMILAUER, 1998).

RESULTS

A total of 210 fishes ($T. carolinus$ – 122, $M. littoralis$ – 88), ranging between 24.2 mm and 112.0 mm total length, were analyzed. One hundred and seventy-eight stomachs (84.8%) presented food contents, whereas thirty-two (15.2%) were empty. For size classes I, II and III of $T. carolinus$ 34, 39 and 26 were analyzed and of $M. littoralis$ 24, 31 and 24, respectively.

Cumulative prey curves showed a rapid approach to an asymptote mainly for $M. littoralis$ and $T. carolinus$ sizes I and II, suggesting that for these species a sufficient number of stomach were analyzed. For size III of the two species the curve reached an asymptote slowly, since new prey items constantly appeared in the diet of the biggest individuals (Fig. 2).

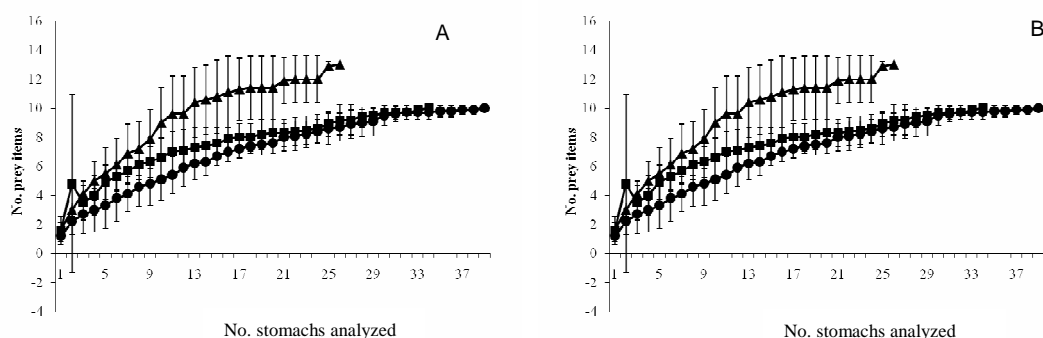


Fig. 2. Cumulative prey curves for: a) *Trachinotus carolinus* (n = 99), and b) *Menticirrhus littoralis* (n=79). Symbols are: square for size class I (n = 34 for *T. carolinus* and 24 for *M. littoralis*), circle for size class II (n = 39 for *T. carolinus* and 31 for *M. littoralis*), and triangle for size class III (n = 26 for *T. carolinus* and 24 for *M. littoralis*).

Average fullness index ranged between two and three percent, with highest averages occurring in size class I for *T. carolinus* (3.2%) and II for *M. littoralis* (3.0%). Size class III individuals showed the lowest averages around 2.3 for *T. carolinus* and 2.5 for *M. littoralis* (Fig. 3).

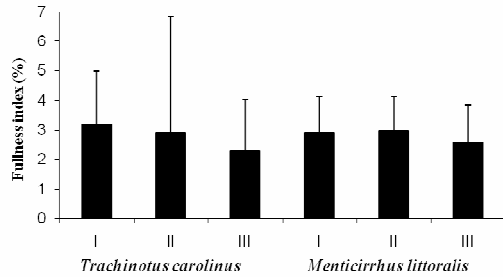


Fig. 3. Mean and standard deviation of the fullness index by size class of *Trachinotus carolinus* and *Menticirrhus littoralis*.

Table 1 shows the average of morphometric measurements by size class for each species, whereas Table 2 shows food items arranged in phylogenetic order and Kawakami and Vazoller's feeding index by size class for each species. *T. carolinus* showed mysids, *Emerita* spp. and polychaetes as the predominant items in the diet, whereas *Emerita* spp. dominated the food items of *M. littoralis*, followed by polychaetes.

Principal Component Analysis showed that the feeding of size class I *T. carolinus* was strongly influenced by Isopoda, Formicidae and Amphipoda. Size class II shared *Emerita* spp. and mysids with size class III. Class III showed the greatest diversity of food items, including *Emerita* spp. and Mytilidae (Fig. 4a). Size class I *M. littoralis* showed an association with amphipods, unidentified crustacean remains and mysids. Nematods were associated with size class II individuals and Formicidae, Decapoda, Mytilidae and copepods with size class III. *Emerita* spp., present in all classes, showed no association with any particular size class of *M. littoralis* (Fig. 4b).

Table 1. Average \pm standard deviation of morphometric measurements by size class of *Trachinotus carolinus* and *Menticirrhus littoralis*.

Morphometric Measures	Acronyms	<i>Trachinotus carolinus</i>			<i>Menticirrhus littoralis</i>		
		I	II	III	I	II	III
Standard length	SL	35.5 \pm 5.2	59.4 \pm 7.6	83.6 \pm 8.8	45.4 \pm 6.7	59.7 \pm 2.8	75.3 \pm 11.2
Maximum height	MH	12.9 \pm 2.4	23.2 \pm 3.7	35.3 \pm 5.3	9.0 \pm 1.5	12.1 \pm 1.6	15.7 \pm 2.7
Maximum width	MW	4.8 \pm 1.2	8.8 \pm 1.5	12.1 \pm 2.0	6.3 \pm 1.2	8.3 \pm 0.8	11.3 \pm 2.3
Length of the caudal peduncle	LCP	2.9 \pm 0.8	6.7 \pm 1.8	9.7 \pm 1.8	11.7 \pm 2.0	15.8 \pm 1.4	20.3 \pm 3.7
Height of the caudal peduncle	HCP	2.8 \pm 0.6	4.9 \pm 0.7	7.1 \pm 1.2	3.8 \pm 0.6	5.0 \pm 0.6	6.6 \pm 1.2
Width of the caudal peduncle	WCP	0.5 \pm 0.2	1.5 \pm 0.4	2.8 \pm 1.6	0.6 \pm 0.3	1.1 \pm 0.4	1.8 \pm 0.6
Height of the body below the lateral line	HBL	10.1 \pm 1.8	17.4 \pm 2.8	24.0 \pm 3.5	7.4 \pm 1.4	9.8 \pm 1.3	12.5 \pm 2.1
Head length	HL	11.9 \pm 1.6	18.3 \pm 2.6	24.3 \pm 2.2	14.2 \pm 2.1	17.9 \pm 0.9	22.3 \pm 3.7
Head height	HH	7.3 \pm 1.4	12.5 \pm 2.0	17.3 \pm 3.1	6.5 \pm 1.0	8.4 \pm 0.7	10.6 \pm 1.8
Position of the eye	PE	4.1 \pm 1.0	7.3 \pm 1.4	9.6 \pm 1.4	3.7 \pm 0.7	5.2 \pm 0.7	6.6 \pm 1.5
Diameter of the eye	DE	2.8 \pm 0.6	4.6 \pm 0.6	6.0 \pm 0.6	2.7 \pm 0.6	3.5 \pm 0.4	4.1 \pm 0.6
Mouth position	MOP	1.0 \pm 0.0	1.0 \pm 0.0	1.0 \pm 0.0	2.0 \pm 0.0	2.0 \pm 0.0	2.0 \pm 0.0
Mouth width	MOW	2.3 \pm 0.7	4.4 \pm 1.0	6.3 \pm 1.3	2.6 \pm 0.7	3.4 \pm 0.4	4.2 \pm 1.1
Mouth height	MOH	4.6 \pm 0.7	6.8 \pm 1.4	8.6 \pm 2.1	3.8 \pm 1.2	4.9 \pm 1.0	5.6 \pm 1.5
Nose closed length	NCL	3.7 \pm 0.6	6.3 \pm 1.3	8.7 \pm 1.0	5.1 \pm 0.8	6.6 \pm 0.5	7.9 \pm 2.2
Nose open length	NOL	6.3 \pm 1.1	10.1 \pm 1.8	12.7 \pm 2.3	6.6 \pm 1.0	8.3 \pm 1.1	10.2 \pm 2.9
Dorsal fin height	DFH	8.1 \pm 1.9	14.4 \pm 3.0	21.0 \pm 4.1	9.7 \pm 1.4	12.2 \pm 1.2	16.2 \pm 3.1
Dorsal fin length	DFL	21.3 \pm 3.8	34.6 \pm 5.8	43.4 \pm 10.1	27.7 \pm 3.7	35.6 \pm 2.3	45.4 \pm 8.2
Pectoral fin length	PFL	7.1 \pm 1.3	12.4 \pm 2.0	17.3 \pm 1.5	8.0 \pm 1.5	10.6 \pm 1.3	13.6 \pm 3.9
Pectoral fin height	PFH	2.9 \pm 0.8	5.5 \pm 1.4	8.1 \pm 1.3	2.1 \pm 0.6	3.0 \pm 0.5	4.2 \pm 1.4
Caudal fin length	CFL	10.8 \pm 1.9	18.0 \pm 3.0	24.0 \pm 6.5	11.3 \pm 2.6	14.8 \pm 1.8	18.8 \pm 3.2
Caudal fin height	CFH	9.6 \pm 2.6	15.7 \pm 4.6	21.8 \pm 7.4	4.7 \pm 1.4	6.7 \pm 1.2	9.0 \pm 2.3
Pelvic fin length	PEL	5.3 \pm 1.0	8.8 \pm 1.5	11.7 \pm 1.6	8.2 \pm 1.3	10.6 \pm 1.3	13.9 \pm 2.3
Anal fin height	ANH	7.4 \pm 1.5	12.9 \pm 2.6	18.2 \pm 3.9	9.3 \pm 1.6	11.7 \pm 1.3	14.6 \pm 2.3
Anal fin length	ANL	12.8 \pm 2.4	22.2 \pm 3.7	29.1 \pm 4.9	5.1 \pm 0.8	6.6 \pm 0.9	8.3 \pm 1.5

Table 2. Feeding index of KAWAKAMI and VAZZOLER (1980) (X 100), of each food item by total length size class (I, II and III) of *Trachinotus carolinus* and *Menticirrhus littoralis* and the total feeding index value of each food item. Blank = 0; 0 < 0.0 < 0.1.

Food Items	Acronyms	<i>Trachinotus carolinus</i>				<i>Menticirrhus littoralis</i>			
		I	II	III	Total	I	II	III	Total
Nematoda	NEM	0.0	0.0	0.0	0.0		0.0	0.0	0.0
Mollusca									
Mytilidae	MYT		0.1	0.8	0.3			0.0	0.0
Annelida									
Polychaeta	POL	55.0	8.1	23.5	23.8	4.9	11.7	20.8	14.1
Arthropoda									
Hymenoptera									
Formicidae	FOR	4.8	0.0	0.0	0.3			0.0	0.0
Vespidae	VES			0.0	0.0				
Arachnida	ARA							0.0	0.0
Crustacea									
Amphipoda	AMP	0.9	0.1	0.0	0.1	0.3	0.0	0.1	0.1
Decapoda	DEC			0.0	0.0			0.1	0.0
Copepoda	COP	0.0	0.0		0.0			0.0	0.0
Cumacea	CUM							0.0	0.0
<i>Emerita</i> sp.	EME	6.2	3.7	20.7	9.8	91.1	88.2	76.0	84.7
Isopoda	ISO	27.1	0.2		1.4		0.0	0.0	0.0
Mysidacea	MYS	5.5	87.5	36.6	59.9	2.1	0.1	0.9	0.6
Larvae	LAR		0.0	0.0	0.0				
Unidentified	UND	0.1	0.1	18.3	4.2	1.5		0.7	0.3
Teleostei									
Clupeidae	CLU	0.4	0.1	0.2	0.2			0.0	0.0
Unidentified Contents									
Larvae	UNL		0.0		0.0				
Eggs	UNE			0.0	0.0				
Organisms	UNO					0.0		1.3	0.3

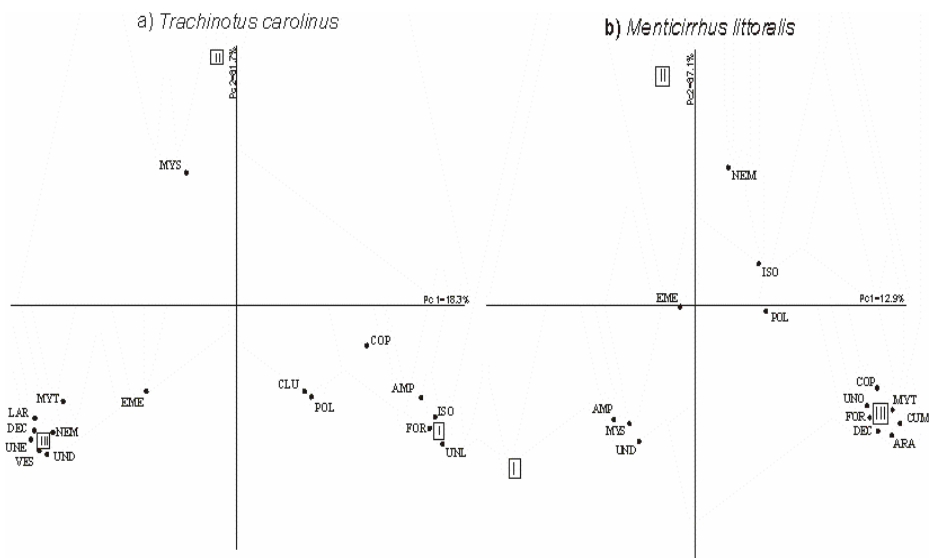


Fig. 4. Principal Component Analysis of food items and size class (I, II, III) of (a) *Trachinotus carolinus* and (b) *Menticirrhus littoralis*.

The presence of some planktonic food items in the diet of *T. carolinus* and only benthic items in the diet of *M. littoralis*, suggests that despite the similarities, both species are probably feeding in different strata of the water column. Also, the terminal position of the mouth of *T. carolinus* and the subterminal position in *M. littoralis*, are an indication of how these species catch their prey within the surf zone.

Strong wave action is one of the physical factors that control sandy beach communities, because of the frequently disturbed unconsolidated sediment of these localities (McLACHLAN, 1990). The ability to burrow rapidly in this type of sediment is very important for the success of the species that inhabit the swash zone (DUGAN et al., 2000). According to some studies on burrowing efficiency, crabs of the super family Hippoidea (e.g. *Emerita* spp.) and misids are very good and fast burrowers in the swash zone of sandy beaches (NEL et al., 1999; DUGAN et al. 2000; BORZONE et al., 2007). This means that they can be found both in the water column and in the substrate. This high breaking wave energy, which is responsible for resuspending a large amount of sediment, easily dislodges polychaetes that adhere to the substrate up into the water column, so that they thus become a prey available to some pelagic fishes (DOMENICO et al., 2009).

MONTEIRO-NETO and CUNHA (1990) observed that *T. marginatus* swimming in the shallow water surf and the swash zone, fed on benthic prey (e.g., *Emerita brasiliensis* and *Donax hanleyanus*) lifted from the sediment into the water column, which appears to be the case of *T. carolinus* in the present study. Moreover, our study has shown that *M. littoralis* feed almost exclusively on bottom dwellers, thus presenting the typical demersal feeding mode of Sciaenidae (ZAHORCSAK et al., 2000).

The position of the mouth and the nose open length have further corroborated the hypothesis of distinct feeding niches. FUGI et al. (2001) found these morphometrics important to explain the diet patterns of five benthivore teleosts. These characteristics are linked with the type of growth exhibited by each species. *M. littoralis* shows a marked increase in body length resulting in an elongated ventrally depressed body enabling the species to swim, hover and even rest on the bottom, thus facilitating benthic feeding. *T. carolinus*, on the other hand, shows a greater growth in height, resulting in a compressed body which increases maneuverability. A narrow caudal peduncle and furcated caudal fin provide the necessary tools for fast swimming in the surf zone, making active swimming for feeding in the shallow water column possible.

Studies show the influence of morphology on the feeding of different species of teleosts (FUGI et

al., 2001; WARD-CAMPBELL et al., 2005; RUSSO et al., 2007; TEIXEIRA; BENNEMANN, 2007). In this study, the two species fed primarily on small crustaceans and polychaetes, but different morphological traits have led to a divergent feeding mode to maximize the use of similar resources, reducing interspecific competition.

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