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FEEDING HABITS OF MARINE TUCUXI, *SOTALIA FLUVIATILIS*, AT CEARÁ STATE, NORTHEASTERN BRAZIL

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The marine tucuxi, *Sotalia fluviatilis* (Gervais, 1853), is one of the smallest cetaceans known, with the maximum length of 2.2 m (Jefferson *et al*., 1993), and is described as having coastal habits and a continuous distribution along most part of the Brazilian coast (Borobia *et al*., 1991).

According to the 2002 IUCN Red List of Threatened Species (IUCN, 2002), *S. fluviatilis* is classified as a Data Deficient (DD) species. In Brazil, marine tucuxi has been frequently by-caught in fishing activities along the northeastern coast (Siciliano, 1994). Monteiro-Neto *et al.* (2000) reported the death of 76 individuals in Ceará State, which were found stranded or entangled in fishing nets from January 1992 to December 1998.

Stomach contents analysis is a very useful and trusting tool to determine the species ingested by cetaceans (Barros and Wells, 1998). Recent works have reported the diet contents of marine mammals in Brazil (Ott, 1994; Bassoi, 1997; Di Beneditto *et al*., 2001a; Di Beneditto *et al*., 2001b), which can provide valuable information about different aspects of cetacean biology.

In order to assess feeding habits of marine tucuxi in Ceará State, stomachs from 26 *S. fluviatilis* specimens were collected from 1992 to 2000 and were deposited at the Associação de Pesquisa e Preservação de Ecossistemas Aquáticos (AQUASIS) collection. The animals were captured in fishing nets or stranded along four different beaches from Ceará State (Figure 1).

Food items were retrieved from the proximal esophagus to the distal pyloric stomach. The recovered material was passed through a 1.0mm-mesh sieve, carefully washed in current water and then stored in a 70% ethanol solution. Subsequently, stomach contents were individually spread on a tray, where traced (otoliths and cephalopod beaks) and non-traced items were separated (Gannon *et al*., 1997a). Analysis of trace items was conducted in order to address biases caused by differential rates of digestion.

A reference collection of otoliths, deposited at the Grupo de Ictiologia Marinha Tropical (IMAT)/Departamento de Engenharia de Pesca/Universidade Federal do Ceará (UFC), was used to identify ingested bony fishes. The identification key for otoliths proposed by Bastos (1990) was also used in this study.

Cephalopod beaks were used to identify and quantify cephalopods consumed by marine tucuxi, following Clarke (1986), Haimovici *et al.* (1994), and Sweeney and Roper (1998), and had their mantle length (ML) estimated through regression equations.

Non-traced prey were identified following Figueiredo and Menezes (1978, 1980), Menezes and Figueiredo (1980, 1985), Cervigón (1989, 1993, 1994, 1996), Freitas (1996) and Ruppert and Barnes (1996), and then measured and stored as previously described.

Prey items had their frequency of occurrence (FO) and numerical abundance (%num) analysed according to Gannon *et al.* (1997b).

In addition, the relationship between type of fishing gear and by-catch of dolphins was assessed through interviews with fishermen and the monitoring of fishing activities.

Dolphins collected are listed in Table 1. Four of the 26 samples were directly removed from fishing nets. Specimens 101214 and 101235 were found dead, entangled in gill nets for scombrids (mackerels) and carangids (jacks). Individuals 101251 and 101166 were captured in 60m-long x 2m-high bottom-set nets for lobster fishery. The other tucuxi specimens were found stranded and some of them had net scars and/or mutilation marks.

Solid food items were recorded in 25 stomachs and in one animal (101251) the stomach was empty. So, one dolphin was excluded from stomach content analyses.

Three prey categories (fishes, mollusks and crustaceans) were found in the stomach contents analysed (Table 2). We identified eight different families of Teleostei and two families of cephalopods. Crustaceans, represented by ten small shrimp and one crab, could not be identified beyond the level of order (Decapoda), neither precisely measured due to the damage caused by digestion.

We recovered a total of 573 otoliths from the 25 stomachs, which means that at least 287 fishes, besides the identified Teleostei, were eaten. Among these otoliths, we possibly identified 8 gerreids, 6 haemulids (*Pomadasys corvinaeformis*), 6 mullids and 1 sciaenid (*Larimus breviceps*). We did not include these findings among in Table 2, because we are not sure about the identification of some taxa and we have no regression equation in order to estimate their total length.

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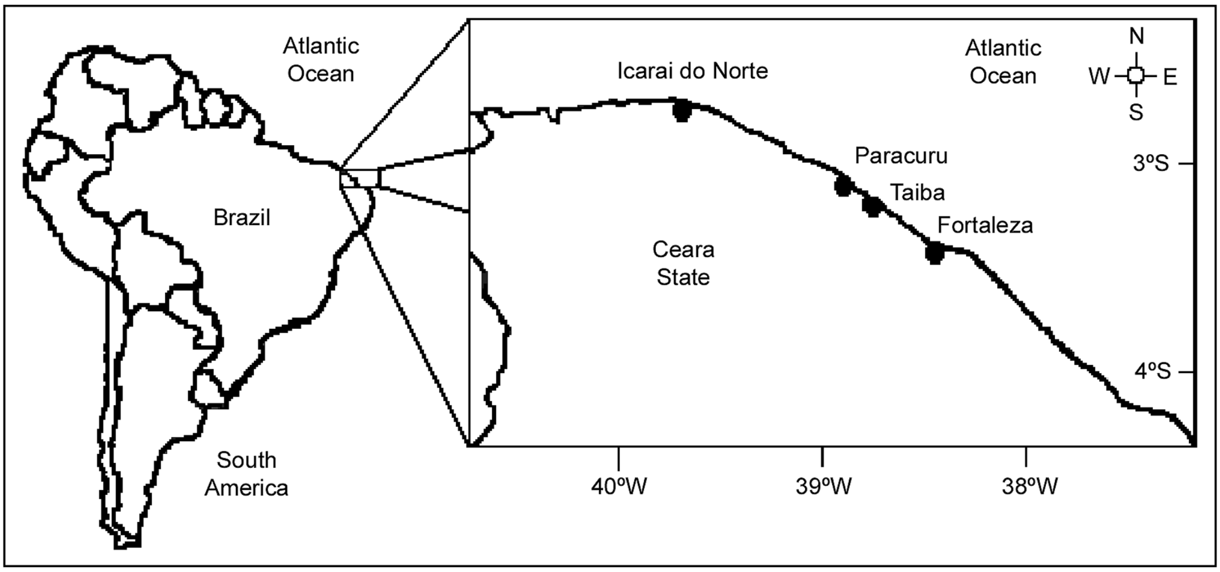

Figure 1. Map of Ceará State, Brazil, showing the collection sites of the *S. fluviatilis* specimens.

Table 1. Data from 26 *S. fluviatilis* specimens collected in Ceará.

DOLPHIN IDENTIFICATION NUMBER	SEX	TOTAL LENGTH (m)	COLLECTION SITE	COLLECTION DATE
10127 NS,MM	♀	1.77	Fortaleza	11 September 1992
Ind.	Ind.	Ind.	Ind.	1993
101018	Ind.	Ind.	Taíba	? August 1994
Ind.	Ind.	Ind.	Ind.	? December 1994
101131 NS,MM	♂	1.87	Fortaleza	19 January 1995
101223	♀	2.00	Fortaleza	11 December 1995
101232 NS	♀	1.28	Fortaleza	26 January 1996
Ind.	Ind.	Ind.	Ind.	3 May 1996
101214 NS,*	♀	1.28	Taíba	9 June 1996
101143 MM	♂	1.78	Taíba	22 June 1996
101150 NS	♂	1.89	Taíba	23 June 1996
101235 NS,*	♀	1.82	Fortaleza	1 July 1996
101137 MM	♂	1.65	Icaraí do Norte	Ind.
101251 NS,*	♀	0.96	Taíba	8 October 1996
101152 MM	♂	1.64	Fortaleza	9 October 1996
101166 NS,*	♂	1.38	Fortaleza	31 July 1997
101264 NS,MM	♀	1.81	Fortaleza	8 October 1997
101267 NS	♀	1.35	Fortaleza	16 January 1998
101268 NS,MM	♀	2.00	Fortaleza	21 February 1998
101273	♀	1.85	Fortaleza	2 August 1998
101280 MM	♀	1.66	Fortaleza	7 February 1999
101284	♀	1.92	Taíba	24 July 1999
101185 NS,MM	♂	1.69	Fortaleza	5 August 1999
101287 MM	♀	1.56	Fortaleza	30 September 1999
101188 NS	♂	1.64	Fortaleza	7 July 1999
101194 NS	♂	1.72	Paracuru	24 June 2000

(NS) net scars, (MM) mutilation marks, (*) removed directly from fishing nets, (Ind) indetermined.

The occurrence of fishes, mollusks and crustaceans in stomachs from the *S. fluviatilis* specimens agrees with the prey categories described in the literature as components of the diet of marine tucuxi (Silva and Best, 1996; Di Beneditto, 2000).

Fishes from the families Gerreidae, Haemulidae, Ophichthidae and Sciaenidae have already been cited as prey of *S. fluviatilis* (Borobia and Barros, 1989; Barros and Teixeira, 1994; Oliveira *et al*., 1998). However, we could not find any previous records of the presence of the fish families Dactylopteridae, Gobiidae, Mullidae and Scaridae in the diet of the marine tucuxi. Several other families of Teleostei have previously been cited in stomach contents of *S. fluviatilis*, such as Ariidae, Centropomidae, Clupeidae, Congridae Engraulidae, Batrachoididae, Mugilidae, Paralichthidae, Serranidae, Stromateidae and Trichiuridae (Di Beneditto *et al*., 1998; Oliveira *et al*., 1998; Santos *et al*., 2002), but these were not recorded in this study.

Fishes identified in stomachs of marine tucuxi in the present work are commonly found in shallow waters of coastal environments. These also have a strong association with the bottom, either by having benthic habits or by being mid-water fishes which frequently feed on the bottom (Figueiredo and Menezes, 1978, 1980; Menezes and Figueiredo, 1980, 1985). In addition, almost all these fish groups are encountered in both sandstone reefs from intertidal zones and estuaries in Ceará State (Araújo *et al*., 2000a; Araújo *et al*., 2000b). Hence, a coastal distribution of *S. fluviatilis* in Ceará State is inferred based on the habits and habitats of ingested fishes, as wells as the possible usage of sandstone reefs and estuarine areas for foraging. In Ceará State, the same distribution for marine tucuxi was cited before (Oliveira *et al*., 1995; Monteiro-Neto *et al*., 2000). Also, the utilization of estuaries by marine tucuxi has already been reported (Reis *et al*., 1998). Borobia *et al*. (1991) suggested that the close association of marine tucuxis to estuaries might be related to physiological constraints.

Just demersal bony fishes were found in stomachs of *S. fluviatilis* in the present work, what suggest that in Ceará State marine tucuxi can dive near the bottom during feeding. This statement agrees with what was found by many authors, who have recorded the presence of both surface and demersal fishes in stomachs of marine tucuxi from elsewhere in Brazilian waters (Barros and Teixeira, 1994; Silva and Best, 1996; Santos et al., 2002) and suggested that *S. fluviatilis* can feed in different water depths (Borobia and Barros, 1989).

Regarding the cephalopods identified in this study, *Lolliguncula brevis, Loligo plei and L. sanpaulensis* have already been noted as prey of tucuxi (Santos and Haimovici, 2001; Di Beneditto 2000; Santos *et al*., 2002); however, no previous records of *Octopus* sp. in the stomachs of *S. fluviatilis* were found. These cephalopods occur in neritic environments and are commonly captured in beach seines performed in Mucuripe inlet, in Fortaleza, Ceará state (Freitas, 1996). *Octopus* sp. has benthic habits (Ruppert and Barnes, 1996), while *L. brevis* is commonly classified as an estuarine associated species (Borobia and Barros, 1989). *L. plei* is thought to have a more pelagic distribution when compared to the other squid species listed in this study (Ropper *et al*., 1984). The occurrence of these cephalopods in the marine tucuxi stomachs, also suggest that the tucuxi has a coastal distribution in Ceará state and possibly feed near the bottom in estuarine waters.

Though it was not possible to further identify the ingested decapods, we noted that shrimp were much more abundant than crab. The occurrence of crustaceans in stomachs of tucuxis has previously been recorded, including the presence of penaeid shrimp (Oliveira *et al*., 1998; Santos *et al*., 2002). Di Beneditto (2000) reported that crustaceans were less representative than other prey items in stomach contents of marine *S. fluviatilis*, what agrees with our findings in this work (Table 2).

FO and %num analysis revealed fishes as being the most important prey category on the diet of marine *S. fluviatilis*, followed by mollusks and crustaceans (Table 2). Reis *et al*. (1998) reached similar conclusions studying five stomachs of marine tucuxi, in Bahia State, Brazil. According to our findings, both criteria also point families Gerreidae and Mullidae as being very representative on marine tucuxi diet. In other Brazilian States, some authors noted that clupeids (*Pellona harroweri*), trichiurids (*Trichiurus lepturus*), batrachoidids (*Porichthys porosissimus*) and sciaenids (*Stellifer* sp.) were frequent in stomach contents of marine tucuxi (Borobia and Barros, 1989; Barros and Teixeira, 1994; Di Beneditto, 2000), however the presence of gerreids (mojarras) was also common (Reis *et al*., 1998; Santos *et al*., 2002). *L. plei* appeared to be the most frequent and abundant species, compared to other cephalopods, when FO and %num are analysed. Borobia and Barros (1989) also found more *Loligo* sp. specimens in stomachs of marine *S. fluviatilis* than *L. brevis*.

The results obtained here suggest that marine tucuxi might have being threatened by the artisanal fishery performed in Ceará State, according to interviews with fishermen and the monitoring fishing boats for their fish landings. Fish groups such as gerreids, haemulids, mullids, scarids and sciaenids are commonly captured by gill nets for further commercialization in Mucuripe inlet, where most of the dolphins were by-caught. This is an indication of possible competition between tucuxi and fishermen for similar resources, which might explain entanglement of these cetaceans in gill nets. The fact that individuals 101214 and 101235 were found entangled in this kind of fishing gear supports this statement (Table 1).

Another threat to tucuxi in Ceará are bottom nets for lobster fishery which are also non-selective, capturing at least 30 different families of fishes, including Gerreidae, Haemulidae, Mullidae and Scaridae (Ivo *et al*., 2000). This suggests that, when searching for food, tucuxi can incidentally be entangled in those nets. Evidence of by catch in this fishery is shown by the two individuals (101251 and 101166) directly removed from bottom-set nets for lobster fishery in the present work (Table 1).

Table 2. Prey items identified in stomachs from 25 *S. fluviatilis* specimens.

PREY	N	MEAN TOTAL LENGTH (mm) {STANDARD ERROR (mm)} [RANGE (mm)]	FO (%)	%NUM (%)
Bony fishes	328	-	100	64.1
Gerreidae	12	127.6{32.5}[83.6-112.8]	24	2.3
Diapterus olistostomus (5)				
Diapterus sp. (2)				
Eucinostomus sp. (5)				
Mullidae	10	136.1{7.2}[134.9-157.9]	16	2.0
Pseudopeneus maculatus (10)				
Haemulidae	3	123.5{27.6}[97.4-164.9]	12	0.6
Pomadasys corvinaeformis (3)				
Ophichthidae	4	271.8{113.5}[156.1-406.0]	8	0.8
Myrichthys ocellacus (1)				
Unidentified ophichthids (3)				
Scaridae	3	203.5{23.7}[174.8-239.1]	4	0.6
Gobiidae?	7	90.3{11.9}[61.7-112.0]	4	1.4
Dactylopteridae	1	220.4	4	0.2
Dactylopterus volitans (1)				
Sciaenidae	1	157.0	4	0.2
Other fishes	287 (at least)	-	88	56.0
Otoliths (573)				
Mollusks	173	-	40	33.8
Loliginidae	128	-	36	25.0
Loligo plei (83)		100.9{34.7}[41.2-196.3]*		
Lolliguncula brevis (21)		47.6{5.8}[27.6-62.2]*		
Unidentified loliginids (24)		-		
Octopodinae	45	91.8{19.0}[37.3-143.9]*	16	8.8
Octopus sp. (42)		95.4{20.0}[55.5-143.9]*		
Unidentified octopuses (3)		41.6{4.3}[37.3-45.9]		
Decapod Crustaceans	11	-	8	2.2
Shrimp	10	-	8	2.0
Crab	1	-	4	0.2

(*) for traced mollusks, mantle length was estimated through regression equations.

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