TERTIARY FISHES FEEDING HABIT IN A TROPICAL ESTUARY IN BRAZIL

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ABSTRACT

The feeding habits of tertiary consuming fish was studied, aiming at to contribute for the knowledge of the ichthyofauna food web in the Santa Cruz Channel (SCC), Itamaracá, Pernambuco, Brazil. Samples were collected monthly in the SCC with a trawl net type, from 1995 to 1998. Also, data published since 1979 on fishes feeding habits in the area was used to complement the research. After the collections, samples were fixed with formaldehyde at 10%. In laboratory, the stomachs were taken out and preserved in formaldehyde at 4%. In the SCC occurred nearly 160 species, distributed in 2 classes, 60 families and 109 genera, being the consumers of third order represented by the species: *Centropomus parallelus*, *C. undecimalis*, *Scomberomorus brasiliensis* and *Sphyraena barracuda*. Among these species the most abundant were *C. parallelus* and *C. undecimalis*. The specie *Centropomus parallelus* presented the dominance of Crustacea (51%) followed by Teleostei (36%). *C. undecimalis* presented the dominance of Teleostei (58%) followed by Crustacea (31%). *Scomberomorus brasiliensis* and *Sphyraena barracuda* presented the dominance of Teleostei, with 74% and 62%, respectively. It can be concluded that the abundance of fish, crustaceans and mollusks in stomach contents showed the ability of trophic support of the SCC allowing the establishment of third order fish consumers. The function of tertiary consumers as top consumer in the trophic web, as well as its migration to surrounding ecosystems is a strong argument for the conservation of coastal areas of Pernambuco State.

Key words: Fishes, stomach content, terciary consumers

RESUMO

Hábitos alimentares de peixes consumidores terciários em um estuário tropical no Brazil. Os hábitos alimentares de peixes consumidores terciários foi estudado visando contribuir para a teia trófica da ictiofauna do Canal de Santa Cruz (CSC), Itamaracá, Pernambuco, Brasil. Amostras foram coletadas mensalmente no CSC com uma rede de arrasto, durante o período de 1995 a 1998. Para complementar a pesquisa, também foram pesquisados dados sobre hábitos alimentares desde 1979 na área. Após as coletas as mostras foram preservadas em formol a 10%. Em laboratório, os estômagos foram retirados dos exemplares e preservados em formol a 4%. No CSC ocorreram cerca de 160 espécies, distribuídas em 2 classes, 60 famílias e 109 genera, sendo os consumidores de terceira ordem representados pelas espécies: *Centropomus parallelus*, *C. undecimalis*, *Scomberomorus brasiliensis* e *Sphyraena barracuda*. Dentre estas espécies foram mais abundantes na área *C. parallelus* e *C. undecimalis*. A espécie *Centropomus parallelus* apresentou o predomínio de Crustacea (51%) seguido por Teleostei (36%). *C. undecimalis* apresentou o predomínio de Teleostei (58%) seguido por Crustacea (31%). *Scomberomorus brasiliensis* e *Sphyraena barracuda* apresentaram o predomínio de Teleostei, com 74% e 62%, respectivamente. Pode-se concluir que a ocorrência de peixes, crustáceos e moluscos no conteúdo estomacal mostrou a capacidade de suporte trófico do CSC, permitindo o estabelecimento de consumidores terciários. A função dos consumidores terciários como topo da teia trófica como também sua migração nos ecossistemas circunvizinhos é um forte argumento para a conservação de áreas costeiras do estado de Pernambuco.

Palavras chave: Peixes, conteúdo estomacal, consumidores terciários.

INTRODUCTION

Research on tropical estuarine fishes has increased noticeably in latest years and for this reason scientific knowledge about most aspects of these main fishes is known (Blaber, 2002), however there is a lack on feeding habits information and their trophic level. Fish are important in estuarine food webs because they are the dominant top and midlevel carnivores, and because they often regulate, through

predatory pressure, lower trophic levels (Day Jr *et al*., 1989). Thus, fish generally occupy higher trophic levels in the marine environment (Campos, 2000). Estuaries are presumed to enhance the growth and survival of individuals that find more favourable conditions within this ecosystem than in other nearby coastal habitat types (Boesch & Turner,1984; Vasconcelos Filho *et al*., 2004, 2008).

Fish are mobile and able to detect and react to changing environmental conditions. Tolerant fish remain in degraded coastal systems, whereas more sensitive species move to more habitable regions or simply succumb to the stress (Longhurst & Pauly, 1987). Abundant juvenile fish and diversity in species indicate that a system provides sufficient habitat to support reproduction and growth. Juvenile fish are sensitive to anthropogenic stresses and, therefore, their abundance may indicate how much contamination exists in a system (Campos, 2000). Because higher trophic levels in estuarine systems require a rich diversity of intact ecosystem functions to survive, grow, and reproduce, fish abundance and species richness can be a broad and useful indicator of estuarine health (Karr, 1981, 1987; EPA, 1998). Information on the diet of fishes is important to understand the basic functioning of fish assemblages and is widely used for ecological work and modeling and is becoming an increasingly important component in ecologically based management.

Recent studies suggest that, although the species composition of the fish fauna can differ significantly between estuaries, similar feeding guilds can be distinguished over wide geographical ranges (Costa & Elliott, 1991).

Most estuarine fish species are opportunistic feeders, although their diet is more or less restricted to part of the total available prey spectrum as dictated by their capability to capture and ingest specific prey species. Therefore, most dietary shifts (ontogenetic, seasonal, or shifts towards the most profitable prey) are related to the trophic adaptability of the fish species, food partitioning and/or seasonality in the availability of prey (Gerking, 1994).

The Itamaracá estuarine system is used as nursery grounds by many commercially important species and this has generally been attributed to the

abundant food supply in comparison to adjacent marine areas (Schwamborn, 1997). It is also a diverse area containing many different types of habitat suitable for fish. This variety of habitats, along with the complexity of fish community interactions and the migratory nature of many species makes it extremely difficult to assess the overall condition of the fish community in a estuary. Because of this problem, this paper focuses on specific, commercially and ecologically important species rather than the fish community as whole. Thus, studies on tertiary fish stomachs content from open environments were carried out to assess the diet composition and to use them as indicator of the Santa Cruz Channel health, a tropical estuary in South-western Atlantic. The chosen species in this study are those which present higher sizes at Santa Cruz Channel as per example the family Centropomidae, also used in fishculture.

MATERIALS AND METHODS

The Itamaracá estuarine system is located at 7°34'00"- 7°55'16" S and 34°48'48" - 34°52'24" W, about 50 km north of Recife, Pernambuco State, Brazil. It consists of the U-shaped Santa Cruz Channel with 20 km length; and there are two connections to the South Atlantic Ocean and five tributaries draining into the channel (Figure 1). Climate is warm-humid with mean annual temperature 25°C and rainfall 1300-1800 mm.yr^{-1}, concentrated from March to August.

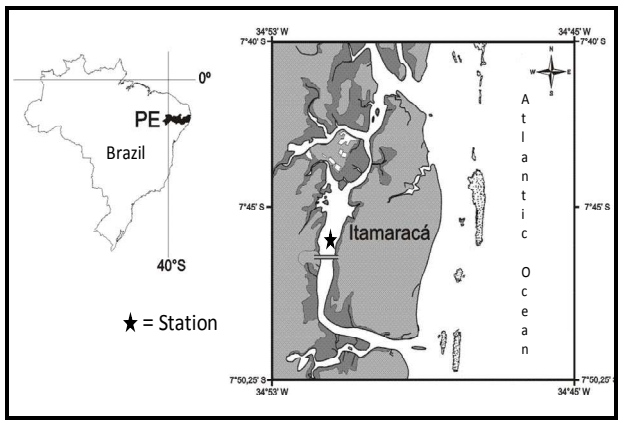

Figure 1. Itamaracá estuarine system, coast North of Pernambuco, tropical Brazil.

Samples were monthly collected along Santa Cruz Channel with a trawl net, from 1995 to 1998, besides published data since 1979. A total of 740 fishes stomach content were analysed under a compound microscope and stereomicroscope according to Rounsefell & Everhart (1953) and Hyslop (1980) methodology. Based on the local and seasonal patterns in the species composition and on the length-frequency distributions of

the dominant species in the artisan fisheries 4 fish species were selected for stomach content analysis. All prey items were identified to the lowest feasible taxonomical level.

RESULTS

The most abundant third order consumer species was *Centropomus undecimalis* with 393 individuals followed by *Centropomus parallelus* with 229 individuals; *C. undecimalis* was also longer in length and heavier (Table 1).

The terciary order consumer fishes presented the following food items in their stomach:

- *Centropomus parallelus* Poey, 1860 – Crustacea (Alphaeidae, Penaeidae, Porcellanidae, Grapsidae, Ocypodidae, Portunidae, Xanthidae, Sphaeromatidae, Cymothoidae, Bopyridae) (51%), Teleostei (Gobiidae, Gerreidae and Engraulidae) (36%), Mollusca (2%) and other organisms (11%).
- *Centropomus undecimalis* (Bloch, 1792) – Teleostei (Gerreidae, Atherinidae, Haemulidae, Soleidae, Polynemidae, Eleotridae, Elopidae, Engraulidae e Clupeidae (58%), Crustacea (Grapsidade, Ocypodidae, Portunidae, Penaeidae, Aphaeidae, Palaemonidae, Cymothoidae, Calianassidae) (31%), Mollusca (2%) and other organisms (9%).
- *Sphyraena barracuda* (Edwards, 1771) – Teleostei Gobiidae (74%), Crustacea (11%), Mollusca (9%), superior plants (3%) and other organisms (3%).
- *Scomberomorus brasiliensis* Collette, Russo & Zavala-Camin, 1978 – Teleostei (Engraulidae, Clupeidae) (62%), nematode (23%) and other organisms (15%).

When considering all food items (Figure 2), crustacean was the most frequent food item in *Centropomus parallelus*. It was mainly composed of Copepod, Isopoda, Amphipoda, Ostracoda, shrimp and crab scraps.

The studied third order carnivorous fishes of Santa Cruz Channel can be seen in figure 3.

Table 1. Species of the Class Actinopterygii data of Itamaracá estuarine system, Pernambuco, Brazil.

Family	Specie	Individual fish specimens	Total size (cm) Min - Max	Weight (g) Min - Max	% of stomach fullness
Centropomidae	*Centropomus parallelus* Poey, 1860	229	12.0 - 66.0	20.0 - 2900.0	97
	Centropomus undecimalis (Bloch, 1792)	393	15.0 - 84.0	22.0 - 5600.0	94
Sphyraenidae	*Sphyraena barracuda* (Edwards, 1771)	88	5.1 - 35.0	0.7 - 208.8	97
Scombridae	*Scomberomorus brasiliensis* Collete, Russo & Zavala-Camin,1978	30	25.0 - 41.0	115.0 - 326.0	100

However, in *C. undecimalis, S. barracuda* and *S. brasiliensis* fishes were the most abundant mainly Gerreidae, Clupeidae, Gobiidae and Engraulidae in juvenile stage of life cycle. Mollusks were common item in the stomachs, but always with less than 9%, and both Gastropoda and Bivalvia were registered. Considering that tertiary consumers are commercially fished, their low numbers is a possibility and even a reality in the studied area.

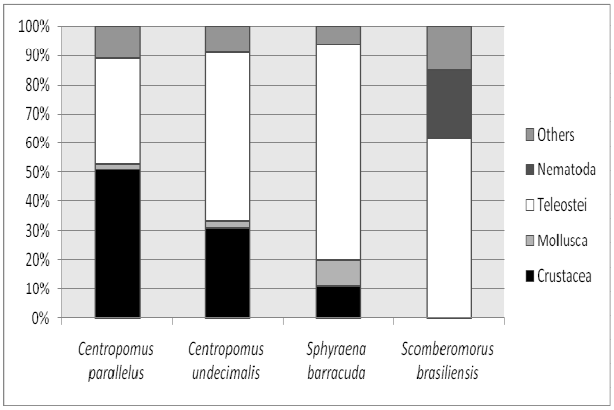

Figure 2. Main food items in the stomachal content of the Third order carnivorous at Santa Cruz Channel, Itamaracá, tropical Brazil.

DISCUSSION

The fish fauna of Itamaracá is extremely diversified, composed of 160 species, 109 genera and 60 families (Vasconcelos Filho, 2001; Vasconcelos Filho *et al*., 2004, 2008). Most species belong to Actynopterygii and only two species of the Class Chondrichthyes. These fishes have been categorized as resident, marine dependent and marine visitors (Vasconcelos Filho, 2001; Paranaguá *et al*., 1999). Fish composition, abundance, distribution, and condition are considered indicators of ecosystem health because fish integrate effects of environmental stress over space and time (Campos, 2000). The species composition of the community is influenced by seasons and tides, breeding and feeding behavior,

habitat diversity and available space, as well as other factors, such as pollution and water quality (Coutas & Hsieh, 1997).

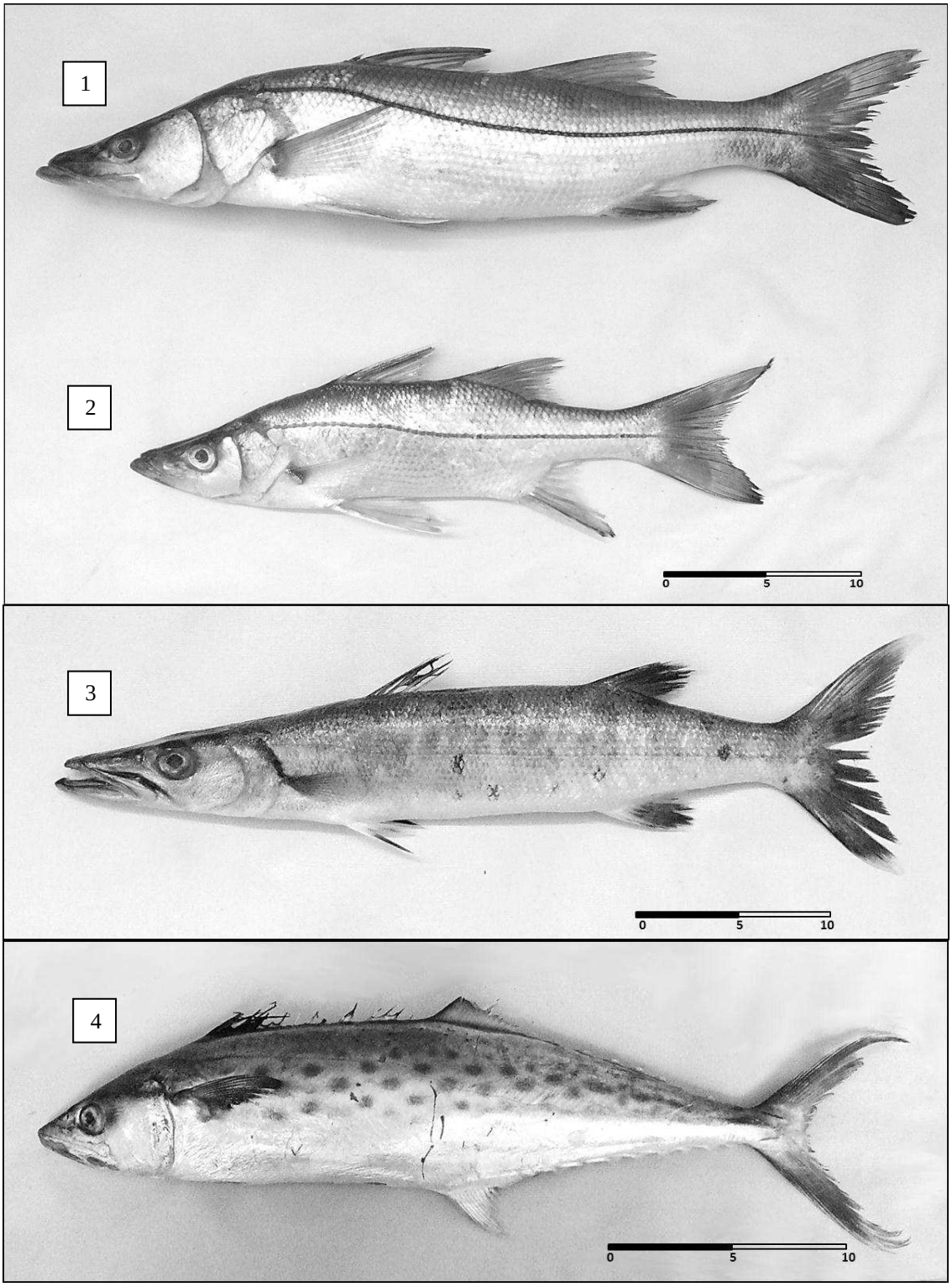

Figure 3: Third order canivorous fishes, *Centropomus undecimalis* (1), *Centropomus parallelus* (2), *Sphyraena barracuda* (3), *Scomberomorus brasiliensis* (4) from Santa Cruz Channel, Itamaracá, tropical Brazil.

The complexity of food sources found in fish stomachs reflects also changes in food preferences and sources as fish grow (ontogenetic changes) and the opportunistic nature of most fish species; as it was seen in our results, often the diet of a single species comprises more than 20 different food types. The whole trophic structure does not comprise specific trophic levels as fish eat food from a variety of sources (Yáñez-Arancibia, 1978; Yáñez-Arancibia & Pauly, 1986; Vaske Jr, 2001).

Fishes differ greatly in the character of the food they consume; however, they show a basic dependence on phytoplankton and detritus through both the pelagic and benthic pathways. The pelagic pathway begins with phytoplankton, and goes to copepods, decapods, and mysids, to small fishes like anchovy and herring, then to large predators like Centropomidae. The benthic pathway begins with detritus and other organic matter, which is consumed by benthic copepods and polychaetes as well as filter feeding organisms; and then these are eaten by small dwelling fish, which are eaten by large predators like Centropomidae, Scombridae and Sphyraenidae. These pathways are closely linked because many species eat both pelagic and benthic organisms, and the top carnivore is often the same fish in both pathways (Silbert *et al*., 1978). Because many fish feed from both benthic and pelagic pathways, they are the main organisms that link the benthic and pelagic energy flow (Chassot *et al*., 2008). In our present study it was observed that *Centropomus parellelus* mainly food was Crustacea followed by fishes, while *C. undecimalis* feed preferentially of fish followed by Crustacea, a fact also observed by Silva & Vasconcelos Filho (1972), Vasconcelos Filho *et al*. (1980), Vasconcelos Filho & Galiza (1980), being possible the co-existence of both species at the same time, thus avoiding interspecific competition mainly when juveniles. This could be an adaptive accommodation between competitors.

Studies carried out by Rabelo et al. (2009) at the estuary of Caravelas (Bahia) showed that Teleostei (69.6%) and Brachyurans (86.7%) were the most frequent items in *C. undecimalis* and *C. parallelus* stomachs, respectively. Also, they observed that Brachyurans were the most frequent in number item

(37.5% for *C. undecimalis* and 81.6% for *C. parallelus*) and in term of weight, Teleostei represented 77.9% of total stomach content for *C. undecimalis* and Brachyurans represented 87.3% for *C. parallelus*; and it was estimated the index of relative importance toTeleostei (57.1%) and Brachyurans (94.7%) proving to be the most important items for *C. undecimalis* and *C. parallelus*, respectively. The similarity percentage was estimated with a 26.2% value. The study showed that the analyzed species share roughly the same preys, but their relative importance is different, so that similarity between diets is low.

Among the studied species Centropomidae have small acicular teeth present in the maxila, vomer and palatine (Figueiredo & Menezes, 1980). However, Sphaerenidae are voracious predators with mouth wide and strong canines and Scombridae are predators with triangular teeth (Menezes & Figueiredo, 1985; Figueiredo & Menezes, 2000).

With respect to the studies on *S. barracuda* it was evidenced that these fish include the more abundant teleosteos commons in the stomachal analyses, reaching up to 74% among the feeding items, followed by crustaceans (11%) and clams (9%) (Vasconcelos Filho (2001). For *S. brasiliensis* the fishes were dominant in the stomachal content samples reaching 62% followed by Nematoda (23%), fact already registered by Vasconcelos Filho *et al.* (1984).

In this area studies about food items from primary consumers fishes were carried out by Vasconcelos Filho *et al*. (2009) that classified the species in planktophagous: *Opisthonema oglinum*; herbivorous: *Hyporhamphus unifasciatus*, *Hemirhamphus brasiliensis*; detritivorous: *Mugil curema*, *Mugil liza* and *Gobionellus oceanicus*; and, omnivorous: *Chaetodipterus faber*, *Eugerres brasilianus* and *Diapterus auratus*. The high plankton and meiobenthos abundance showed the high support capacity of Santa Cruz Channel allowing the establishment of first order consumers, an important link in the trophic web.

Studies about 14 species of second order carnivorous fishes feeding habit were also carried out at Itamaracá estuarine system (Barros *et al*., 2010; Vasconcelos Filho *et al*. 2010), and the results showed that the most abundant species were *Sphoeroides testudineus, Citharichthys spilopterus, Symphurus*

plagusia and *Achirus lineatus.* The total of 1349 studied stomachs showed that Crustacea were the more frequent group occurring in nearly 92% of the analyzed samples. Many species fed both in benthos and pelagic ecosystem, being an important link between these ecosystems. For example Barros *et al*. (2010) showed that that carnivorous fish *Sphoeroides testudineus* from Santa Cruz Channel presented 170 mollusks shells in their gut, being 76% of Gastropoda and 24% of Bivalvia. The results showed that the Santa Cruz Channel is a system that concentrates high level of energy with a high support fish capacity. Despite the multiple impacts in the studied area the fish's stomach content showed that that the environment is still preserved and able to support fishes populations.

The results reveal that the Santa Cruz Channel is an ecosystem where occurs an energy storage capable of supporting tertiary fishes populations. Despite human impacts, species composition suggests a healthy habitat and this is still an ecosystem capable of supporting different throphic fishes populations.

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