DIET OF THE ANGULAR ROUGH SHARK OXYNOTUS CENTRINA (CHONDRICHTHYES: OXYNOTIDAE) OFF THE LANGUEDOCIAN COAST (SOUTHERN FRANCE, NORTH-WESTERN MEDITERRANEAN

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OXYNOTIDAE
OXYNOTUS CENTRINA
DIET
COAST OF LANGUEDOC
FRANCE
MEDITERRANEAN SEA

ABSTRACT. – The diet of the angular rough shark *Oxynotus centrina* (Linnaeus, 1758) was studied from specimens collected off the Languedocian coast (southern France). Of the 102 examined stomach contents, 57 were empty; the vacuity index of males did not significantly differ from that of females. The food items were analyzed as percentage frequency of occurrence, percentage of numerical abundance, percentage mass composition, index of relative importance (IRI), expressed as a percentage (% IRI) to quantify the diet. The diet of *O. centrina* consisted of one major systematic group, Polychaeta (% IRI = 60.01), three accessory groups, Sipunculidae (% IRI = 18.56), Crustacea (% IRI = 13.95) and Teleostei (% IRI = 7.43), one occasional group, Echinodermata (% IRI = 18.44) and a particular polychaete, *Platynereis dumerilii* (% IRI = 13.33). *O. centrina* is a suction feeder specialized in wormlike preys.

INTRODUCTION

The angular rough shark *Oxynotus centrina* (Linnaeus, 1758) is reported in the eastern Atlantic from the British Isles (Wheeler 1969) to southern Portugal (Albuquerque 1954-1956), and south of the Strait of Gibraltar to Senegal (Maurin & Bonnet 1971, Capapé *et al*. 1999), additionally, its occurrence off South Africa needs further confirmation (Springer 1990). *O. centrina* is known throughout the Mediterranean, but landings are rather rare (Quéro 1984, Capapé *et al*. 2000). Description of embryos was given by Lo Bianco (1909) from the Bay of Naples and Megalofonou & Damalas (2004) from the Aegean Sea. Some traits of the reproductive biology were reported by Capapé *et al*. (1999, 2000, 2001) from specimens collected off the Languedocian coast (southern France), northern Tunisia (central Mediterranean) and Senegal (eastern tropical Atlantic).

On the other hand, scarce information is available on diet composition and feeding habits of the angular rough shark. For instance, Wetherbee & Cortés (2004) did not cite *O. centrina* among a large number of elasmobranch species. Capapé (1975) found unidentified small crustaceans in stomach contents of specimens caught off Tunisia. Compagno (1984) and Barrull & Mate (1996) noted that *O. centrina* feeds on polychaetes, while Macpherson (1989) reported that it eats myctophids and cephalopods. Barrull & Mate (2001) recorded predation on shark egg cases of the small spotted catshark *Scyliorhinus canicula* (Linnaeus 1758) by the angular rough shark. Saïdi (2002) found a newborn *Raja* sp. ingested by a female caught in the Gulf of Gabès (southern Tunisia). The knowledge of the feeding habits and diet composition is both helpful and useful to assess the main ecological requirements of the species in the area. So, investigations conducted off the Languedocian coast during a twenty year period allow us to collect angular rough sharks and to describe in this paper the diet patterns of *Oxynotus centrina*.

MATERIAL AND METHODS

A total of 102 specimens, 55 males and 47 females, was examined. The observed specimens were collected off the Languedocian coast, 84 by demersal gill-nets, 18 by demersal trawls, at depths between 50 and 200 m, on sandy and muddy bottoms, between 1988 and 2007 (Fig. 1). The total length (TL) of all the specimens was measured to the nearest millimetre; they were weighed to the nearest gram. As soon as the angular rough sharks were collected, they were dissected and the stomach contents were removed, sorted and identified to the lowest taxon (species level when possible) using key and field guides (Riedl 1963, Perrier 1964, 1975, Fischer *et al*. 1981, 1987). The prey items were counted and weighed to the nearest decigram after removal of surface water by blotting on tissue paper. To analyze the diet composition of *O. centrina*, we used some indices following Berg (1979), Hyslop (1980) and Tirasin & Jörgensen (1999): vacuity index (VI) = number of empty stomachs divided by the total number of stomachs; percentage frequency of occurrence (% F) = the number of stomachs, in which a food item was found expressed as a percentage of the total number of stomachs; percentage numerical abundance (% Cn) = number of each prey type, expressed as a percentage of the total number of all food types in all stomachs; percentage ponderal composition (% Cw)

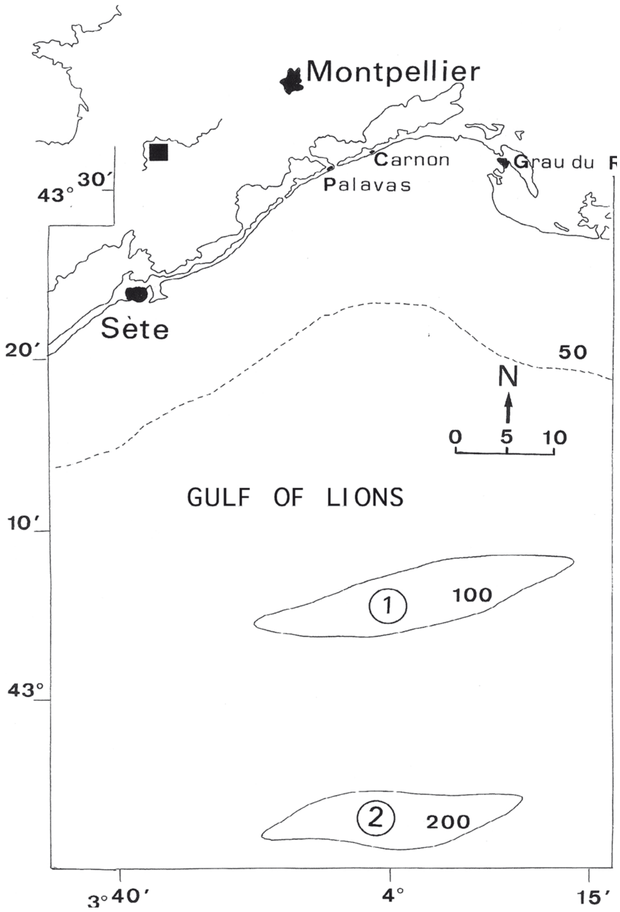

Fig. 1. – Map of France pointing out the coast of Languedoc and the capture sites of the angular rough shark *Oxynotus centrina* in the 'pits' from off Sète where *S. canicula* and the blackmouth catshark *Galeus melastomus* are the dominant elasmobranch species (redrawn from Capapé *et al.* 2000).

= wet weight of each prey type, expressed as a percentage of the total weights of stomach contents in a sample. Additionally, we used the index of relative abundance, IRI (Pinkas *et al.* 1971, Cortès 1997) as IRI = % F x (% Cn = % Cw), expressed as a percentage to quantify the diet as % IRI = (IRI / ∑ IRI) x 100.

Tests for significance were performed using the chi-square test. Correlations were assessed by least-squares regression. In the relationship total mass, TM (g) *versus* total length TL (mm) comparisons of curves were carried out by ANCOVA.

RESULTS

Males ranged from 210 to 640 mm TL and weighed from 66 to 2780 g, while females ranged from 210 to 780 mm TL and weighed from 71 to 6130 g. Females reached both larger size and larger mass than males (Fig. 2). The relationships total mass (TM) *versus* total length (TL) showed significant differences between males and females (F = 91.59: p < 0.01; df = 1). The relationships were for males: TM (g) = 6.52 TL (mm) - 1713.28; n = 55; r = 0.95 and, for females: TM (g) = 15.17 TL (mm) - 5766.73; n = 47; r = 0.94 (Fig. 2). Of the 102 sampled angular rough sharks, the 8 smallest free-swimming specimens, 7 males and one female, exhibited an unhealed umbilical scar on the ventral surface and an internal yolk sac. They ranged between 210 and 240 mm TL, and weighed between 66 and 73 g.; and probably, they were neonates.

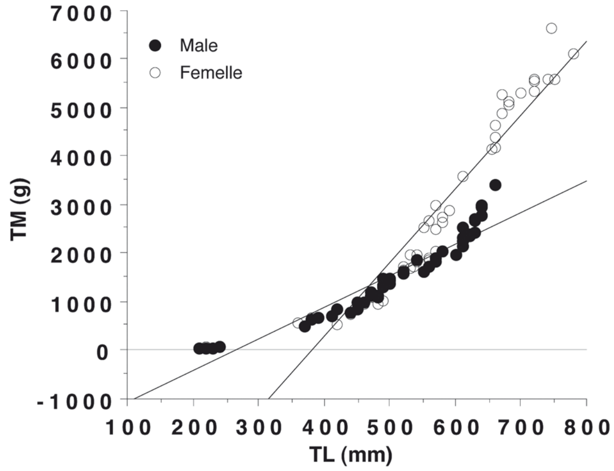

Fig. 2. – Total Mass (TM) *versus* Total Length (TL) for male and for female *Oxynotus centrina*.

Identifiable food or remains of food were found in 57 of the 102 angular rough shark stomachs examined. However, no regurgitation of stomach contents was observed. The vacuity index (VI) of the total sample was 55.88. No significant difference was recorded between VI of males, 36.36, and that of females, 46.81 (χ^2 = 2.9; p = 0.01). Additionally, of the 8 sampled neonates, a single specimen contained remains of unidentified food in the stomach, while that of the 7 other specimens was empty.

The diet composition of the angular rough shark is summarized in Table 1: it consisted of one major systematic group, Polychaeta (% IRI = 60.01), three accessory groups, Sipunculidae (% IRI = 18.56), Crustacea (% IRI = 13.95) and Teleostei (% IRI = 7.43), one occasional group: Echinodermata, a single specimen of *Amphiura* sp. (% IRI = 0.05) was ingested. The most frequently identified prey species was a sipunculid, *Sipunculus nudus* (% IRI = 18.44) and a polychaete, *Platynereis dumerilii* (% IRI = 13.33). However, the occurrence of a crab, *Goneplax rhomboides* (% IRI = 9.15) in stomach contents cannot be neglected. Additionally, there was no significant difference in diet of male and female angular rough sharks related to size, although females attained a larger size and were heavier than males (Fig. 2).

DISCUSSION

The diet composition of the Languedocian angular rough sharks is partially in agreement with Compagno

Table I. – Diet composition of the 102 angular rough sharks collected off the Languedocian coast (% F: frequency of occurrence; % Cn: percentage numerical composition; % Cw: percentage ponderal composition; IRI: index of relative importance).

Food items	(% F)	(% Cn)	(% Cw)	IRI	% IRI
Polychaeta					
Aphrodita aculeata	3.92	3.81	5.42	36.18	1.45
Eunice sp.	3.92	3.81	1.23	8.63	0.35
Laetmonice hystrix	8.82	8.57	3.64	108.91	4.36
Platynereis dumerilii	14.71	14.29	3.23	257.72	13.33
Unidentified	21.56	20.95	39.43	1086.19	43.52
Total	50.01	51.43	52.95	1497.63	60.01
Sipunculida					
Aspidosiphon mulleri	0.98	0.95	0.42	1.34	0.05
Phycocosma granulatum	0.98	0.95	0.78	1.70	0.07
Sipunculus nudus	17.65	17.14	8.93	460.14	18.44
Total	19.91	19.04	10.13	463.18	18.56
Crustacea					
Goneplax rhomboides	12.74	13.33	4.59	228.30	9.15
Unidentified	5.88	5.71	14.68	119.89	4.80
Total	18.62	19.04	19.27	348.19	13.95
Echinodermata					
Amphiura sp.	0.98	0.95	0.19	1.30	0.05
Teleostei					
Cepola macrophtalma	2.94	2.86	2.56	15.93	0.64
Unidentified	6.86	6.67	18.04	169.51	6.79
Total	9.80	9.53	20.60	185.44	7.43

(1984) and Barrul & Mate (1996), who considered polychaetes as main prey of *O. centrina*, but also with Capapé's findings (1975) in stomach contents from Tunisian specimens and Macpherson (1989) who reported that the species feeds also on crustaceans. In contrast, cephalopods (see Macpherson 1989), egg cases of oviparous elasmobranch species (see Barrul & Mate 1996) or *Raja* sp. (see Saïdi 2002) were not found. Additionally, occurrence of teleost remains in stomach contents of *O. centrina* was reported for the first time (see Table I). Lack of food in guts of the 8 smallest free-swimming specimens clearly showed that neonates first used the yolk of the internal vesicle as the main source of nutriment.

Polychaetes are generally consumed by batoids and are rarely found in stomach contents of sharks; in contrast, *O. centrina* remains to our knowledge the only shark species that ingests so abundantly wormlike preys (Wilga & Lauder 2004, Motta 2004, Wetherbee & Cortés 2004) Talent (1976) reported that polychaete worms occurred in some stomach contents of leopard sharks *Triakis semifasciata* Girard, 1854, from Monterey Bay (California), with volume and number of items eaten being small but frequency of occurrence noteworthy, especially in specimens from 600 to 1200 mm, more rarely in larger specimens. Additionally, Talent (1976) noted that leopard sharks are primarily opportunistic feeders, in contrast, angular rough sharks are specialist feeders and should be considered as the best instance of annelidophagy among elasmobranch species. Two morphological characters could explain this phenomenon. Firstly, following Wilga & Lauder (2004), *O. centrina* should be included among the sharks of body type 3, with lack of anal, large epicaudal lobe and slightly higher pectoral fin insertion, living in deep areas. Additionally, the angular rough shark presents a high body, strongly compressed, triangular in cross-section. Secundly, *O. centrina* has a very small mouth with thick lips exhibiting complex series of cross-folds, the teeth are small, arranged in 9 series. *O. centrina* is a rather sluggish shark, living on muddy bottoms, and it is not an active feeder such as other shark species; its feeding habits are relatively close to those of both squatinid and batoid species (see Motta 2004). *O. centrina* probably uses suction to capture wormlike prey along with sediments and ejects the latter from the mouth, the spiracle and the gill slits, the role of lip cross-folds cannot be neglected during the prey selection. Similar feeding mechanism was previously described by Tanaka (1973) in the nurse shark *Ginglymostoma cirratum* (Bonnaterre, 1788) kept in captivity. So, *O. centrina* avoids a maximum competition pressure with other sympatric shark species, skates and rays being not qualitatively and quantitatively abundant in the area, especially deep bottoms (Capapé *et al.* 2006, 2007). The occurrence of *Cepola macrophtalma*, anguilliform fish (sensu Motta 2004) in several stomach contents of *O. centrina* could also be explained by similar food processing. It could be also the result of a competition for food. Predation cannot be totally excluded from feeding habits of the angular rough shark as shown by the presence of crustacean species such as the angular crab *Goneplax rhomboides* (Linnaeus, 1758) found several times in guts. In contrast, findings of egg cases reported by Barrull & Mate (2001) in *O. centrina* remains questionable about how often this category of predation occurs. However, off the Languedocian coast, the angular rough shark inhabits same areas together with the small spotted catshark *Scyliorhinus canicula* (Linnaeus, 1758) and the blackmouth catshark *Galeus melastomus* Bonaparte, 1810 (see Fig. 1), no egg cases of both latter species were found in *O. centrina* gut sampled. There does not appear competition for food between the three species in the area. By contrast, if the capture of a juvenile *Raja* sp. remained accidental according to Saïdi (2002), this finding may be also the result of a competition for food between elasmobranch species that use suction feeding (see Motta 2004). Additionally, it cannot be totally excluded that yolk could be a source of nutriments not only for neonates, but occasionally for larger free-swimming specimens.

However, consumption of wormlike prey such as polychaetes and sipunculids could be considered as both important and good nutritional source for the development of angular rough sharks in the area as shown by Fig. 2. Referring to Wetherbee & Cortés (2004), such prey probably have a rapid gastric evacuation that could explain the vacuity of several guts. The *O. centrina* specialization in worm like prey is the result of different factors: habitat in deep areas, body form, length and shape of mouth, suction feeding and, somewhat less, by reproductive processes (see Capapé *et al*. 1999, 2000).

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