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Feeding habits of juvenile *Mustelus mustelus* (Carcharhiniformes, Triakidae) in the western Mediterranean.

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Abstract: The stomach content of 261 juvenile smoothhounds *Mustelus mustelus* (36-75 cm total length) from the Gulf of Valencia (Spain) were studied. Samples were obtained between 1988 and 1996. Brachyura were the most important prey in terms of frequency of occurrence and numerical composition, followed by Stomatopoda, teleosts and Natantia. No significant differences were found between male and female diets. A change in food composition according to the size of fish was observed.

Résumé : Les contenus stomacaux de 261 juvéniles d'émissole lisse *Mustelus mustelus* (36-75 cm de longueur totale) du Golfe de Valencia (Espagne) ont été étudiés. Les échantillons ont été récoltés entre 1988 et 1996. Les Brachyoures constituent les proies les plus nombreuses et les plus fréquentes, suivis par les Stomatopodes, les poissons et les Natantia. Aucune différence significative de régime alimentaire n'apparaît entre les mâles et les femelles alors qu'un changement dans l'alimentation en fonction de la taille a été mis en évidence.

Keywords : *Mustelus mustelus*, feeding, Elasmobranchii, Mediterranean.

Introduction

The smoothhound, *Mustelus mustelus* (L., 1758) is a common shark occurring in the Mediterranean and in the North-eastern Atlantic, from the Baltic Sea to the coast of Morocco, including waters of the southern coast of Iceland and those of Great Britain and Ireland (Branstetter, 1984; Moreno García, 1995). It is usually found on sandy or muddy bottoms at depths from 50 to 100 m (Quignard & Capapé, 1971; Lloris, 1990). The total lengths at first sexual maturity for males and females are respectively 96 cm and 108 cm (Capapé, 1974a, b). In the Mediterranean *M. mustelus* spawns in summer and the size at birth is around 28-32 cm (Capapé, 1974a, b, 1983).

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Despite its high commercial value, very little is known about the feeding ecology of the species. There are only few brief accounts describing the smoothhound diet which point out that crustaceans, fish and molluscs are the main staple diet (Wheeler, 1978; Branstetter, 1984; Moreno García, 1995).

The present work was conducted within the framework of a project for the study of trophic relationships in a demersal fish community in the Gulf of Valencia. Due to the paucity of information on the feeding ecology of the smoothhound, a pilot study was carried out on the stomach content of juveniles *M. mustelus*.

Materials and methods

A total of 261 smoothhounds were examined for their stomach content, and their sex was determined. Samples were obtained from diurnal commercial catches landed at the port of Valencia, Spain. Fish were caught between 1988 and 1996 from May to October at varying depths from 50 to 150 metres in the Gulf of Valencia (Western Mediterranean). Fish were measured to the nearest centimetre (Fig. 1), dissected, the stomachs were removed and preserved in 6% formalin. Upon opening their contents were then preserved in a 70% ethanol solution and stored for a later analysis. To assess for possible changes in diet with respect to the length, fish were divided into two size-classes (≤50 cm and ≥50.5 cm). In the laboratory, prey items were identified to the lowest possible taxonomic level. Hard parts such as beaks of cephalopods, chelae, telson or pereion fragments of crustaceans and fish otoliths were often significantly helpful in identifying prey items.

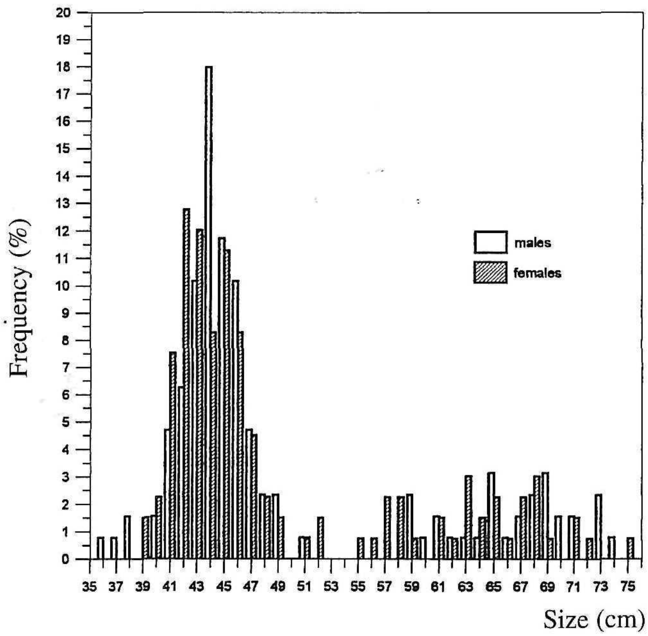

Figure 1. Length-frequency distribution of 261 juveniles of *Mustelus mustelus* caught in the Gulf of Valencia.
Figure 1. Distribution des fréquences de tailles de 261 juvéniles de *Mustelus mustelus* pêchés dans le Golfe de Valencia.

The contribution of each prey item to the diet was described by the percentage of frequency of occurrence (%F) and numerical composition (%Cn) (Hyslop, 1980). The percentage of empty stomachs (V) was also recorded.

Statistical differences (P<0.05) in basic diet composition as a function of sex and size were established by applying a Chi-square test (Sokhal & Rohlf, 1981). This was applied over the direct variables, grouping types of prey into eight categories and using contingency tables as applied by SPSS Pc software. These categories were: Brachyura, Natantia, Reptantia, Stomatopoda, other crustaceans (amphipods, mysids, isopods), Mollusca, teleosts and "others" (polychaetes, echinoids remains, algal remains). A Chi-square test was also applied to test significant differences in the number of empty stomachs.

Results

General feeding trends

Out of the 261 stomachs analysed, 253 were found to contain food. The percentage of empty stomachs was 3.06% (3.90% in males and 2.25% in females); but there was not significant differences between these values.

The stomach contents of the smoothhound consisted of at least 41 different prey species (Table 1), with a low average number of prey per stomach (mean 4.09). Crustaceans were the most numerous ingested preys, constituting 77.71% of the total. Among these, Brachyura were present in the greatest number and also occurred most frequently in the stomachs. In contrast, stomatopods (*Squilla mantis*) and Natantia were less abundant. Teleosts were less numerous than crustaceans (14.13%), while Mollusca, polychaetes, echinoderms and algal remains were only present in low numbers.

Diet variations as a function of smoothhound sex and size

The chi-square test revealed no significant differences in the composition of the prey ingested in relation to sex. Therefore, diet comparison between smoothhound sizes were made grouping sexes.

Large specimens of *Mustelus mustelus* had a higher average number of prey per stomach (6.42) than small fish (3.25). The dietary groups most occurring over each size range of *M. mustelus* are shown in Fig. 2. Brachyura dominated in number and occurrence in diet of all size classes (χ^2=1.79, df=1). Predation of Natantia (χ^2=0.007, df=1) and Reptantia (χ^2=2.76, df=1) did not vary significantly with size, but there was a tendency for Stomatopoda (χ^2=42.74, df=1, P<0.001) and teleosts (χ^2=60.07, df=1, P<0.001) consumption by large specimens. Although there were significant differences in frequency of "others" (χ^2=33.65, df=1, P<0.001), they were not important in the diet. No significant values were found for Mollusca (χ^2=3.59, df=1) and other crustaceans (χ^2=0.41, df=1).

Discussion

In the present study, frequency of occurrence and numerical composition were used to measure the relative importance of prey in the diet of smoothhound because a great number of preys were quite digested so that it was difficult to apply a gravimetric index. Many others studies on sharks diets have also used frequency of occurrence and

Table 1. Diet composition of 253 juveniles of *M. mustelus* containing food (n number of stomachs in which at least one prey occurs; p number of individuals of relevant prey; f% frequency of occurrence; Cn% numerical composition).

Tableau 1. Composition du régime alimentaire de *M. mustelus* d'après l'analyse de 253 juvéniles ayant ingéré des proies (n nombre d'estomacs contenant au moins une proie ; p nombre total d'individus d'une même proie ; f% indice de fréquence de la proie ; Cn% son pourcentage numérique).

Prey category	*n*	*p*	*F(%)*	*Cn(%)*
Polychaeta	30	39	11.858	3.652
Sipunculida	2	2	0.791	0.187
Echinoderma				
Ophiuroidea	2	3	0.791	0.281
Mollusca				
Bivalvia	1	1	0.395	0.094
Nucula nucleus	1	1	0.395	0.094
Nucula sp	1	1	0.395	0.094
Tellina planata	1	1	0.395	0.094
Chlamys opercularis	1	1	0.395	0.094
Donax sp.	1	1	0.395	0.094
Mactridae	1	1	0.395	0.094
Spisula subtruncata	2	2	0.791	0.187
Gasteropoda	1	1	0.395	0.094
Cerithiidae	1	1	0.395	0.094
Turritella communis	1	1	0.395	0.094
Scaphopoda				
Dentalium sp.	1	1	0.395	0.094
Cephalopoda	1	1	0.395	0.094
Sepia officinalis	2	2	0.791	0.187
Alloteuthis mediterranea	2	2	0.791	0.187
Loligo vulgaris	4	4	1.581	0.375
Crustacea				
Mysidacea				
Lophogastridae				
Lophogaster typicus	1	1	0.395	0.094
Isopoda	4	5	1.581	0.468
Amphipoda	1	2	0.395	0.187
Stomatopoda				
Squilla mantis	112	142	44.269	13.296
Parasquilla ferussaci	1	1	0.395	0.094
Platysquilla eusebia	9	9	3.557	0.843
Decapoda				
Natantia	31	36	12.253	3.371
Penaeus kerathurus	2	2	0.791	0.187
Sicyonia carinata	12	15	4.743	1.404
Caridea	3	3	1.186	0.281
Alpheus glaber	10	14	3.953	1.311
Processa parva	1	1	0.395	0.094
Processa sp.	4	4	1.581	0.375
Crangonidae	1	1	0.395	0.094
Pontocaris cathaphracta	6	13	2.372	1.217
Pontocaris sp.	2	2	0.791	0.187
Reptantia				
Scyllarus sp.	2	2	0.791	0.187
Upogebia typica	1	3	0.395	0.281
Upogebia sp.	11	11	4.348	1.03
Anomura	10	13	3.953	1.217
Paguridea	19	23	7.510	2.154
Pagurus prideauxi	1	2	0.395	0.187
Diogenes pugilator	3	3	1.186	0.281
Brachyura	26	33	10.28	3.09
Ethusa mascarone	2	3	0.791	0.281
Dorippe lanata	14	20	5.534	1.873
Calappa granulata	3	4	1.186	0.375
Ilia nucleus	1	1	0.395	0.094
Atelecyclus rotundatus	18	23	7.115	2.154
Atelecyclus sp.	1	2	0.395	0.187
Liocarcinus corrugator	1	1	0.435	0.109
Liocarcinus sp.	199	411	78.656	38.483
Portunus hastatus	2	2	0.791	0.187
Goneplax rhomboides	5	8	1.976	0.749
Brachynotus sexdentatus	1	1	0.395	0.094
Parthenope massena	3	3	1.186	0.281
Parthenope sp.	2	2	0.791	0.187
Majidae	1	3	0.395	0.281
Corystes cassivelaunus	1	1	0.395	0.094
Maja verrucosa	1	1	0.395	0.094
Macropodia sp.	3	3	1.186	0.281
Teleostei	82	98	32.411	9.176
Clupeiformes				
Sardina pilchardus	8	12	3.162	1.124
Sardinella aurita	2	3	0.791	0.281
Engraulis encrasicholus	2	5	0.791	0.468
Anguilliformes	12	16	4.743	1.498
Dalophis imberbis	1	1	0.395	0.094
Apterichthus caecus	2	3	0.791	0.281
Congridae	2	2	0.791	0.187
Conger conger	1	1	0.395	0.094
Sparidae	3	3	1.186	0.281
Pagellus erythrinus	1	1	0.395	0.094
Scombridae				
Scomber scombrus	1	1	0.395	0.094
Mugilidae	2	2	0.791	0.187
Mugil cephalus	2	2	0.791	0.187
Bothidae				
Arnoglossus sp.	1	1	0.395	0.094
Algal remains	16	16	6.324	1.498
Posidonia sp.	5	5	1.976	0.468

numerical composition (Hanchet, 1991; Stillwell & Kohler, 1993; Saldanha *et al.*, 1995, Ellis *et al.*, 1996). However, the main criticism of these methods is that they give little information on the relative amount or biomass of the various items in the stomachs (Hyslop, 1980). Provided that these limitations are recognised, stomach contents analysis can supply useful information regarding the types of prey consumed, dietary breadth and the relative importance of different prey categories in the diet, thereby providing indications on the niche occupied by the predator species (Zaret & Rand, 1971; Eliassen & Jobling, 1985).

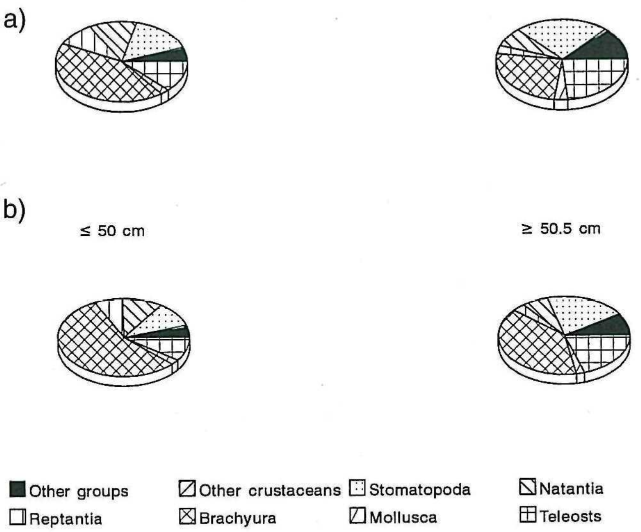

Figure 2. Changes in the main prey categories of *Mustelus mustelus* according to the length-class (cm). a) Frequency of occurrence; b) numerical composition.

Figure 2. Variations des principales catégories de proies dans le régime alimentaire de *Mustelus mustelus*, en fonction de la taille de ce dernier. a) indice de fréquence de proie ; b) pourcentage numérique.

In this study a few number of stomachs were found without food and this agrees with observations by Capapé & Quignard (1977), Euzen (1987) and Ellis *et al.* (1996) who usually found a low percentage of elasmobranchs with empty stomachs in comparison with teleost fish. This suggests that *M. mustelus* eats frequently and/or that gastric evacuation is slow relative to feeding frequency. Capapé & Quignard (1977) pointed out that *M. punctulatus* Risso 1826 is a voracious species which feeds abundantly all the year round.

Few detailed reports about feeding habits have been carried out on the genus *Mustelus* and even fewer on the species *M. mustelus*. On the British coasts, Ford (1921) examined 48 specimens of *Mustelus* spp. and reported that the diet was based on crustaceans, teleosts and polychaetes. Capapé & Quignard (1977) reported that juveniles of *M. punctulatus* from the Tunis coast fed on decapods (*Liocarcinus* sp., *Dorippe lanata* and *Alpheus* sp.), stomatopods (*Squilla mantis*), cephalopods (*Sepia* sp.) and teleosts (*Citharus macrolepidotus*). In the Mediterranean and Atlantic, both Capapé (1975) and Ellis *et al.* (1996) concluded that the diet of *M. asterias* Cloquet, 1821 is essentially based on cephalopods, teleosts and crustaceans. Rountree & Able (1996), in studing the diet of juvenile *M. canis* Mitchill, 1815 in the estuary of southern New Jersey (Atlantic Ocean), reported a food spectrum dominated by natantids (*Crangon septemspinosa* and *Palaemonetes vulgaris*) and polychaetes. Our study points out that *M. mustelus* feeds primarily on crabs, with *Liocarcinus* sp. as the main prey items. Nevertheless, Stomatopoda may be more significant than Brachyura, in terms of mass or energy, because individuals of Stomatopoda are larger than any Brachyura that appears in these stomach contents. Teleosts, polychaetes and Mollusca are also consumed.

In *M. mustelus* the teeth are broad and flattened, almost heart-shaped with faint ridges down the long axis. This specific type of dental morphology is thought to be adapted for the trituration of shells of molluscs and cuticle of crustaceans (Wheeler & Jones, 1989). The presence of numerous triturated preys in our samples supports these views.

No differences were found in the diet of males and females of *M. mustelus*, this may indicate that there was no special food requirement and that the foraging habits were similar in both sexes due to the fact that all the specimens were juvenile. Similar results have been presented for juveniles of *M. punctulatus* (Capapé & Quignard, 1977).

Food intake varied with smoothhound size, as already observed in others sharks (Capapé & Quignard, 1977; Macpherson, 1980; Carrassón *et al.*, 1992; Ellis *et al.*, 1996). We just found the largest preys in stomachs that belong to the largest specimens.

The preference of *M. mustelus* for *Squilla mantis* and *Liocarcinus* sp. clearly suggests that they may be important predators for these species. However, information on the abundance of *M. mustelus, S. mantis* and *Liocarcinus* sp. in the Gulf of Valencia is presently not sufficient to determine whether this interaction has significant effects on the population dynamics of these preys.

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