received: 2019-08-22 DOI 10.19233/ASHN.2019.19

FOOD AND FEEDING HABITS OF *MUSTELUS MUSTELUS* (LINNAEUS, 1758) (CHONDRICHTHYES: TRIAKIDAE) ALONG THE WESTERN COAST OF LIBYA

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ABSTRACT

A total of 269 individuals of Mustelus mustelus *(Linnaeus, 1758) were provided through monthly collection by fishermen from the western coast of Libya (South Mediterranean) between November 2015 and November 2016. Each specimen was measured, weighed and dissected to investigate the food and feeding habits. Teleosts were the most important prey of* M. mustelus*, especially in individuals bigger than 90 cm TL. Crustaceans were the second most important and abundant prey for small individuals, whereas other prey groups were of minor importance and probably constituted just incidentally ingested food. Diet composition showed little seasonal variation: teleosts were the most important prey taxon in all seasons, except in autumn. The results indicate that* M. mustelus *can be considered as an opportunistic predator feeding on a wide range of prey items.*

Keywords: Smooth-hound, Diet, South Mediterranean, Libya

ABITUDINI ALIMENTARI DI *MUSTELUS MUSTELUS* (LINNAEUS, 1758) (CHONDRICHTHYES: TRIAKIDAE) LUNGO LA COSTA OCCIDENTALE DELLA LIBIA

SINTESI

Un totale di 269 individui di Mustelus mustelus *(Linnaeus, 1758) sono stati forniti attraverso la raccolta mensile dei pescatori della costa occidentale della Libia (Mediterraneo meridionale) tra novembre 2015 e novembre 2016. Ogni esemplare è stato misurato, pesato e dissezionato per indagare sul tipo di nutrimento e sulle abitudini alimentari. La preda più importante di* M. mustelus *sono risultati i teleostei, specialmente negli individui di dimensioni superiori a 90 cm di lunghezza totale. I crostacei sono risultati la seconda preda più importante e abbondante per i piccoli individui, mentre gli altri gruppi di prede sono di minore importanza e probabilmente costituiscono solo cibo ingerito casualmente. L'analisi della composizione della dieta ha evidenziato piccole variazioni stagionali, e i taxon di teleostei sono risultati le prede più importanti in tutte le stagioni, tranne in autunno. Secondo i risultati dello studio* M. mustelus *può essere considerato un predatore opportunista che si nutre di una vasta gamma di prede.*

Parole chiave: palombo, dieta, Mediterraneo meridionale, Libia

INTRODUCTION

In the Mediterranean, Chondrichthyes species presently have lower commercial value than Osteoichthyes and shellfishes; they only represent about 0.78 % of total landings (Cavanagh & Gibson, 2007; Di Francesco, 2010). But because of general fishing pressure, they have become vulnerable since they are often captured as bycatch by bottom trawl fleets (Ragnese *et al*., 2013). According to the statistics of the Fisheries and Agriculture Organization of the United Nations (FAO), the Chondrichthyes stock declined in the Mediterranean between 1970 and 1985, with landings increasing from 10,000 to 25,000 tonnes and then slowly decreasing back to 10,000 tonnes in 2000. Recently, Bradai *et al*., (2012) reported that landings declined to 7000 tonnes. The impact of fishing on Chondrichthyes stocks has become an issue of global concern. Thus, working groups and experts, such as the IUCN Sharks Specialist Group, have developed an international action plan for the conservation and management of shark exploitation, as well as lists of species in the Annexes of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) (Stevens *et al.,* 2000). Moreover, there are many efforts at regional level, such as the Elasmobranchs studying group as one of the specific scientific groups in GFCM, and at sub-regional level, such as the Elasmobranchs working group within the MedSudMed project, with Libya as one of the main parties.

M. mustelus, commonly called the smooth-hound, is often characterized as a slender shark with a long parabolic subangular snout, dorsolateral eyes, an angular mouth, pavement teeth with cusps usually obsolete or absent, and the second dorsal fin nearly as large as the first. The species has a grey-brown back and is white underneath (Compagno, 1984). It is widespread in the Eastern Atlantic Ocean from the British Isles to South Africa and common in the Mediterranean Sea (Compagno, 1984; Goosen & Smale, 1997). *M. mustelus* is more common than the other two species of the same genus (Serena *et al*., 2009). This demersal species inhabits water depths ranging from shallow to 350 m, but is most commonly found in shallow waters, in the depth range of 5 to 50 m, on sandy and clay bottoms (De Maddalena *et al*., 2001; Serena*,* 2005). The catches of this species registered a decline of 85% between 1994 and 2006, however, there have been no actions undertaken to protect or regulate the exploitation of the shark in its range areas (Serena *et al.,* 2009).

Diet composition, which can identify the type of food preferred by each species of fish, is considered as an indicator of the availability of food in the region. In the present study, it showed that in the Gulf of Gabes (southern Tunisia, central Mediterranean Sea) *M. mustelus* feeds mainly on crustaceans, fish and cephalopods. Polychaetes, sipunculids and echinoderms are occasional preys, and there is no difference between the diets of males and females (Saidi *et al*., 2009). In a similar study conducted in Turkey in 2005, the diet of this species was heterogeneous and generalized, and it was found that crustaceans were consumed by most of the individuals (Filiz *et al*., 2009). Dietary studies for *M. mustelus* from the Adriatic Sea report that their diet mainly consists of crustaceans, teleosts and cephalopods (Jardas *et al.,* 2007a). The diet composition analysis from South Africa (Smale & Compagno, 1997) and Mauritania (Khallahi, 2004) showed similar conclusions. In addition, a study comparing the history of life and biology of two species of sympatric coastal shark, *M. mustelus* and *M. palumbes*, off southern Africa was described (Smale & Compagno, 1997). Morte *et al.* (1997) studied the feeding habits of juveniles (total length below 75 cm) in the Gulf of Valencia. Another study was conducted to describe the diet composition of the common smooth-hound in the northern Adriatic, linking its feeding habits to the structure of the gastrointestinal parasite community and providing new insight into the life cycles of the identified parasites (Gračan *et al.,* 2014).

Studies of population dynamics, such as age and growth, along with basic information on distribution, abundance, feeding and reproduction are essential for biologists to understand and predict the trend of population growth and the species' response to fishing pressure. There are no comprehensive studies that examine the biological aspects of Chondrichthyes in the Libyan coast. Therefore, the present study aims to provide new findings on the diet of *M. mustelus* along the western Libyan coast of the southern Mediterranean Sea.

MATERIAL AND METHODS

Samples of *M. mustelus* were collected monthly from fishermen on the western coast of Libya (Tripoli), between November 2015 and November 2016. The fish were transferred to the biodiversity laboratory of the Marine Biology Research Centre, where the samples were sorted and sexed, as well as measured for total length (TL) to the nearest centimetre and weighed for total weight (TW) to the nearest 10 g (Compagno, 1984). Each specimen was dissected with a ventral incision from the cloaca to the pectoral girdle in order to expose the body cavity. The stomach was removed, weighed and preserved in a 10% formaldehyde-seawater solution.

Stomach contents were examined as soon as possible after capture. Preys were identified to the lowest possible taxon. The excess liquid was drained off and the remaining mass of wet prey was determined to the nearest 0.1 g. The importance of prey was evaluated using the frequency of occurrence percentage (F %), percentage by number (% N) and percentage by wet mass (M %) (Pinkas *et al.,* 1971; Cortes, 1997; Morato *et al.,* 2003). The index of relative importance (IRI) fol-

lowing Pinkas *et al.* (1971) and modified by Hacunda (1981) was used: IRI = % F x (% N + % W). This index, which integrates the three previous percentages, allows a much more accurate interpretation of the diet by minimizing the skews caused by each of these percentages. The contribution of each prey in the diet was also estimated with the Index of Relative Importance (IRI) and its standardized value (% IRI) (Pinkas *et al.*, 1971; Cortés 1997). For assessing the diet in relation to shark size, the specimens were grouped in four size classes according to ontogenetic development: I = newborns, II = juveniles, III = subadults and IV = adults.

RESULTS

A total of 269 stomachs of *M. mustelus* were examined, 91 of them were empty (25.27 %). The diet of the specimens consisted of five major systematic groups: teleosts, crustaceans, cephalopods, nemerteans and polychaetes. Teleosts were the most important prey, constituting 50.29 % of the total IRI, followed by crustaceans (% IRI = 33.76) (Tab. 1). The relative importance of cephalopods, nemerteans and polychaetes was comparatively low.

Diet changes according to ontogenetic development

The diets were calculated and expressed as (% IRI in Fig. 1 according to the ontogenetic development of *M. mustelus* specimens from the southern Mediterranean.

Newborns

In the size class of newborns, crustaceans were the most important prey group (% IRI = 68.82), followed by teleosts (% IRI = 31.17).

Tab. 1: Major prey groups in the diet of** M. mustelus **from the western coast of Libya, by percentage number (% N), percentage weight (% W), frequency of occurrence (% F) and index of relative importance (% IRI).
Tab. 1: Najpomembnejše skupine plena v prehrani navadnega morskega psa ob zahodni libijski obali. Legenda: delež števila plena (% N), delež mase plena (% W), frekvenca pojavljanja plena (% F) in indeks relativne pomembnosti plena (% IRI).

Prey group	F %	N %	W %	% IRI
Crustacea	57.62	42.74	14.83	33.76
Teleostei	59.47	30.82	52.26	50.29
Cephalopoda	13.50	5.44	16.46	3.00
Nemertea	34.94	19.94	16.29	12.88
Polychaeta	4.00	1.03	0.14	0.04

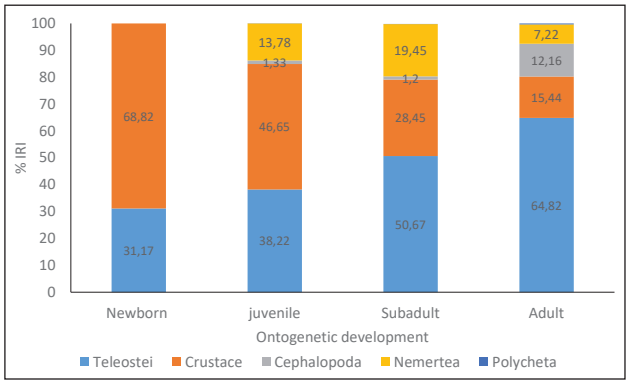

Fig. 1: Ontogenetic differences in the diet of** M. mustelus **from the western Libyan coast, expressed as % IRI.
Sl. 1: Ontogenetske razlike v prehrani navadnega morskega psa ob zahodni libijski obali, izražene kot delež indeksa relativne pomembnosti plena.

Juveniles

Crustaceans were the most frequent prey (% IRI = 46.65), followed by teleosts (% IRI = 38.22). Nemerteans (% IRI = 13.78) were the third most important group, while cephalopods and polychaetes represented minor components of the diet.

Subadults

Teleosts were the dominant prey consumed (% IRI = 50.67), followed by crustaceans (% IRI = 28.45) and nemerteans (% IRI =19.45). Cephalopods (% IRI = 1.2) and polychaetes (% IRI = 0.04) were minor components in the diet.

Adults

Teleosts were the most important prey category (% IRI = 64.82), followed by crustaceans (% IRI =15.44) and cephalopods (% IRI = 12.16), while nemerteans represented a minor component (% IRI = 7.22).

Seasonal changes in diet

The diets of *M. mustelus* in the south Mediterranean were also calculated and expressed as % IRI according to seasonal changes (Fig. 2): in spring, teleosts were the dominant group (% IRI = 64.72), followed by crustaceans (% IRI = 15.66) and cephalopods (% IRI =15.17). In summer, teleosts were the most frequently captured prey category (% IRI = 53.75), followed by crustaceans (% IRI = 35.51), while nemerteans and cephalopods were only minor components in the diet. In autumn, crustaceans constituted the bulk of the diet (% IRI = 45.16), followed by teleosts (% IRI = 33.49) and nemerteans (% IRI = 17.88). In winter, the relative importance of teleosts was

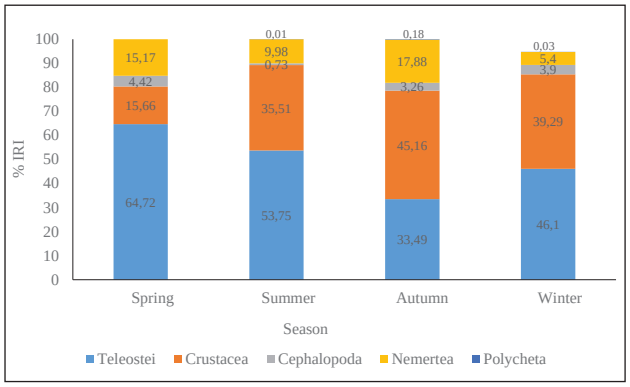

Fig. 2: Seasonal changes in the diet of* M. mustelus *from the western Libyan coast expressed as % IRI.
Sl. 2: Sezonske razlike v prehrani navadnega morskega psa ob zahodni libijski obali, izražene kot delež indeksa relativne pomembnosti plena.

high (% IRI = 46.1), followed by crustaceans (% IRI = 39.29), while nemerteans, cephalopods and polychaetes were minor components of the diet.

DISCUSSION

To understand the biological interactions of organisms in their ecosystem it is necessary to know the relationships and differences related to their diets and food consumption (Lopez *et al.,* 2009, 2012). Therefore, qualitative and quantitative analyses of feeding habits are very helpful in determining the level and abundance of prey eaten by each species in their habitats (Movillo & Bahamonde, 1971; Lopez *et al.,* 2012). Moreover, quantitative studies using the same approach can estimate the predation and, consequently, reflect the important factors and dependencies in predator diets (Wootton, 1990; Abrams, 2000; Lopez *et al.,* 2012). In this study, the results indicated that *M. mustelus* feeds on benthic and demersal preys, thus determining the feeding behaviour of this species as demersal. There were no gender-specific differences or requirements in the diet of *M. mustelus*, which suggests that the foraging habits are similar in both sexes or that they encounter the same prey items in their environments. In addition, the study provided broad support that this species could be an opportunistic predator, feeding on a variety of prey items (Cappe, 1975; Morte *et al.,* 1997; Smale & Compagno, 1997; Costantini *et al.,* 2000; Khallahi, 2004; Jardas *et al.,* 2007a; Saidi *et al.,* 2009). Its predatory habits indicate that *M. mustelus* feeds mainly on crabs, mantis shrimp, shrimp living on sandy and soft sedimentary bottom, pelagic and benthopelagic teleosts, cephalopods, nemerteans, and polychaetes (Jardas, 1996; Tortonese, 1956; Bini, 1967; Branstetter, 1986; King & Clark, 1984; Kamura & Hashimoto, 2004; Jardas *et al.,* 2007b; Saidi *et al.,* 2009; Filiz, 2009). There were, however, regional differences among prey species. The study showed that the diet consisted of five major systematic groups: crustaceans, teleosts, cephalopods, polychaetes and nemerteans. The identified preys belonged to 5 families of crustaceans, 5 families of teleosts and 2 families of cephalopods, in addition to a few unidentified species. Teleosts were the most important prey group of *M. mustelus* on the western coast of Libya, constituting (% IRI = 50.29) of the total IRI, Additionally, they were the dominant prey by mass (W % = 52.26) and had the highest frequency (F % = 59.47). This is probably due to the abundance and diversity of fishes along this coastline (Tab. 1). Crustaceans were the second most frequent prey (% IRI = 33.76), all of them belonging to the order of decapods (shrimp, crabs, and Mantis shrimps, as well as members of the Penaeidae, Majidae, Portunida, Carapidae and Squillidae, and some unidentified species).

The most consumed teleost species were mainly demersal, but there were also many pelagic species present (e.g., scombrids, clupeids). Thus, it can be determined that the smooth-hound is the major predator of benthic teleosts as well as of some species of the same genus, particularly *M. palumbes, M. henlei, M. canis,* and *M. antarcticus* (Capapé, 1975; Compagno, 1984; Simpfendorfer *et al.,* 2001). Most of the cephalopods were quantitatively important, for instance, members of the Sepiidae and Octopodidae (octopods were dominant by mass, and crustaceans were numerically important). This finding is in accordance with a study carried out by Saidi *et al.* (2009). While nemerteans represented 12.88 % of total IRI, cephalopods (octopods and sepia) stood at 3 % and polychaetes at 0.04 % of total IRI as minor components of the diet. In contrast, Smale and Compagno (1997), Costantini *et al.* (2000), Khallahi (2004), Jardas *et al.* (2007a), Saidi *et al.* (2009), Filiz (2009) recorded that this species feeds primarily on decapod crustaceans and to a lesser extent on teleosts.

Size-related changes in the diet were considered; the data obtained showed that the diet composition of *M. mustelus* changes considerably with its growth (Morte *et al.,* 1997; Smale & Compagno, 1997; Jardas *et al.,* 2007a; Saidi *et al.,* 2009), and there is a slight increase in prey diversity with the increase of shark size. These changes may be related to altered environmental conditions or to the changing energy requirements of the animal.

The new-born and juvenile sharks under study fed mainly on crustaceans (% IRI = 68.82 and % IRI = 46.65, respectively), which are considered the most important prey group in these size classes. When the sharks increase in length (70 ≤ TL <90 cm), they switch to teleosts and cephalopods. The share of crustaceans diminishes in importance, while the rates of teleosts, cephalopods (*Octopus vulgaris* and *Sepia officinalis*), nemerteans and polychaetes increase. The studied adult sharks mainly fed on teleosts (% IRI = 64.82), followed by cephalopods (% IRI = 12.16), while the relative importance of crustaceans

decreased with the increase of shark size, to a minimal level of % IRI = 15.44 in large specimens. However, the wide dietary diversity in larger specimens may reflect the ability of large individuals to use a wider range of habitat resources, also on the trophic level, due to their increased morphological adaptation. The high presence of teleosts in the stomachs of *M. mustelus* can be explained by the fact that the species is a relatively active and fast predator, agile in swimming and manoeuvring, moving from the bottom to the centre of the water column. The second factor to be perhaps considered is the mechanical damage incurred by bony fish during fishing operations involving trawling and use of other fishing tools. However, these species become vulnerable to larger predatory fishes in the surrounding medium, including *M. mustelus*. Cartilaginous fishes play an important role in protecting and cleaning the marine environment.

Little seasonal variation in the diet of smooth-hound was noticed within the study area. Values of the index of relative importance suggested that teleosts dominate the diet composition in all seasons, except autumn. The highest percentage was measured in spring, (64.72 of the total % IRI), followed by summer (% IRI = 53.75). Increased teleost consumption during these months coincides with the spawning period in many fishes, which may be present in high densities. In autumn, crustaceans constituted the bulk of the diet (% IRI = 45.16) as the most frequent prey (F % = 85.9), followed by teleost (% IRI = 33.49) and nemerteans (% IRI = 17.88). Cephalopods and polychaetes were present in stomach contents during all seasons but in smaller quantities.

CONCLUSIONS

As this study has shown, the diet composition of *M. mustelus* inhabiting the western Libyan coast displays little seasonal variation: teleosts are the most important prey taxon in all seasons, except in autumn. The results indicate that *M. mustelus* can be considered as an opportunistic predator feeding on a wide range of prey items.

ACKNOWLEDGEMENTS

The authors express their thanks to the marine biology research center to support this work. We also would like to thank the fishermen and fishermen's union who have helped us in this work.

PREHRANJEVALNE NAVADE NAVADNEGA MORSKEGA PSA, *MUSTELUS MUSTELUS* (LINNAEUS, 1758) (CHONDRICHTHYES: TRIAKIDAE), VZDOLŽ ZAHODNE OBALE LIBIJE

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POVZETEK

Med novembrom 2015 in 2016 so ribiči tekom mesečnega izlova ujeli 269 primerkov vrste Mustelus mustelus *(Linnaeus, 1758) ob zahodni obali Libije (južno Sredozemsko morje). Vsak primerek so avtorji izmerili, stehtali in secirali, da bi ugotovili prehranjevalne navade. Najbolj pomembna skupina plena so bile ribe kostnice, še posebej pri primerkih navadnih morskih psov, ki so merili več kot 90 cm v dolžino telesa. Raki so bili druga najpomembnejša skupina plena, še posebej pri manjših primerkih morskih psov, medtem ko so bile druge skupine plena manj pomembne in jih avtorji smatrajo kot slučajno ulovljen plen. Sestava prehrane kaže majhno sezonsko variabilnost: kostnice so bile najpomembnejši plen v vseh letnih časih, razen jeseni. Rezultati kažejo, da je* M. mustelus *oportunističen plenilec, ki se prehranjuje s širokim izborom plena.*

Ključne besede: navadni morski pes, prehrana, južno Sredozemsko morje, Libija

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