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Preliminary observations on the feeding habits of the Mediterranean needlefish *Tylosurus acus imperialis* (Teleostei: Belonidae)

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ABSTRACT

Objective: To present the first information on the feeding habits of the Mediterranean needlefish *Tylosurus acus imperialis* (*T. a. imperialis*) of Tunisia and to examine the diet variation in relation to the fish size, maturity and sex.
Methods: Gut contents of 92 specimens of *T. a. imperialis*, collected mainly from May 2004 to July 2006 off the Gulf of Gabès, Southeastern Tunisian coast, were analyzed.
Results: The results showed that 55.4% of them had empty guts and 44.6% contained food in their guts. The emptiness index did not vary significantly according to size classes or sexes of *T. a. imperialis*. Basic food consisted of teleosts (Mugilidae, Gobidae and Belonidae) (62.6%) followed by crustaceans (37.3%), mostly decapods *Sycionia carinata* (5.4%). A decrease in the feeding rate at the peak of the spawning season was observed for both sexes. A diet variation among juvenile and adult specimens of *T. a. imperialis* was found.
Conclusions: This study enhances our knowledge on the biology of the Mediterranean needlefish *T. a. imperialis*. This fish is an active predator and an opportunistic feeder but the feeding rate declines at the peak of the spawning season.

1. Introduction

The Mediterranean needlefish *Tylosurus acus imperialis* (*T. a. imperialis*) is an epipelagic, marine species mainly restricted to the Mediterranean Sea[1]. This belonid species has migratory patterns. It inhabits offshore waters, but it also frequents coastal waters[2,3]. This species appears seasonally during its spawning period between May and July in the Tunisian coast[4].

The biological knowledge of the Mediterranean needlefish *T. a. imperialis* is scarce and concerns only the reproductive season[2,5,6]. Recently, we have reported the first information on the biology relating to the reproduction, age and growth of *T. a. imperialis* off the Tunisian coast[4]. Since then, the sexual maturity and the morphometric characteristics of *T. a. imperialis* from the North Aegean Sea have been reported[7,8]; whereas there are no data concerning its diet.

The dietary consumption estimates of the Mediterranean needlefish are necessary to understand their role in trophic webs in a given space and time. The diet is influenced by multiple factors, such as prey availability, mobility, abundance, environmental factors, and the developmental stage and sex of the predator, which have been identified as determinants of the ecological importance of each species in the trophic web in which they participate[9,10].

The aim of this study is to analyze the stomach contents and to give an insight into *T. a. imperialis* feeding habits by describing its prey and observing its dietary changes related to size, maturity and sex.

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2. Materials and methods

A total of 92 specimens of *T. a. imperialis* were caught mainly from May 2004 to July 2006 by local fishermen using gill nets off the Gulf of Gabès, Southeastern Tunisian coast (Figure 1). Fish were identified according to Bauchot and Collette and Parin[2,11].

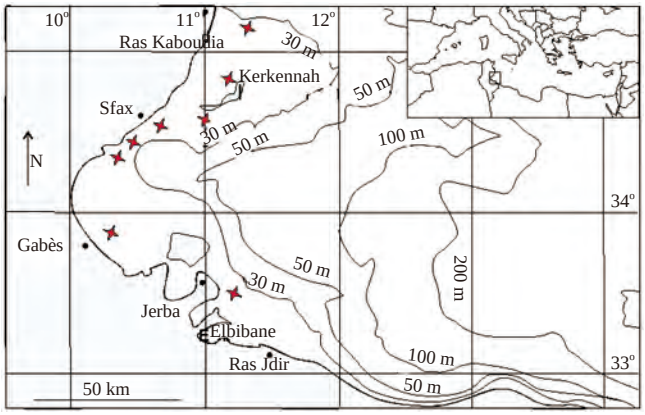

Figure 1. Sampling localities of the Mediterranean needlefish *T. a. imperialis* off the Gulf of Gabès, Southeastern Tunisian coast.

For each specimen, the total length (Lt) was recorded to the nearest 0.01 cm. The total body and eviscerated body were weighted to an accuracy of 0.01 g. Sex and maturity were determined macroscopically for each specimen.

Stomachs were removed, opened and their contents were weighted to the nearest 0.01 g and preserved in 7% buffered neutral formaldehyde.

Food items were sorted under a binocular microscope into taxonomic groups at species level whenever possible, the number was recorded and the weight (nearest 0.01 g) was registered after the removal of the surface water by blotting on absorbent paper.

The emptiness index (Ei) was calculated to obtain quantitative information on the number of stomachs that were adequate and representative of the diet. To characterize the diet, the percentage frequency of occurrence (F%), the percentage by number (N%) and the percentage by weight (W%) were calculated. The main food categories were defined according to the index of relative importance (IRI) proposed by Pinkas *et al.*[12] and modified by Hacunda as follow[13]:

$$IRI = (N\% + W\%) \times F\%$$

Based on the suggestion by Cortés, IRI was calculated and expressed as a percentage (% IRI)[14].

To detect the possible changes in diet in relation to the size, specimens of *T. a. imperialis* were divided into two size classes according to size at maturity: juveniles (< 79 cm) and adults (⩾ 79 cm)[4].

A *Chi*-square test (χ^2) was applied to test significant differences in the number of empty stomachs (Ei) in relation to sex and size. The significance of the variation in the mean number of prey per stomach was tested by ANOVA (F). This was applied by the software package SPSS. All statistical inferences were based on the 0.05 significance level.

3. Results

Collected needlefish specimens used for diet analysis, ranged from 34.20 to 110.50 cm [mean ± SD: (80.18 ± 9.90) cm] in total length and from 53.94 to 2 231.50 g [mean ± SD: (666.42 ± 280.55) g] in total weight.

Among those 92 needlefish stomachs examined, 55.4% were empty and 44.6% contained food in their guts. The Ei did not vary significantly according to size classes (χ^2 = 2.001, P = 0.157) and also sexes (χ^2 = 0.202, P = 0.652) (Table 1). No significant difference in the Ei was observed between males and females in May (χ^2 = 56.35, P = 0.73). Whereas, significant variations of this proportion were found in June and July (χ^2 = 7.126, P = 0.007; χ^2 = 5.238, P = 0.022, respectively). A decrease in the Ei occurred in June for both sexes (Figure 2).

Table 1
Variations of emptiness indexes with sex and size for *T. a. imperialis*.

Indexes	Total	Females	Males	Lt < 79 cm	Lt ⩾ 79 cm
Es	51	25	26	21	30
Fs	41	14	27	15	26
Ei	55.43	64.10	49.05	58.33	53.57

Es: Empty stomach; Fs: Full stomach.

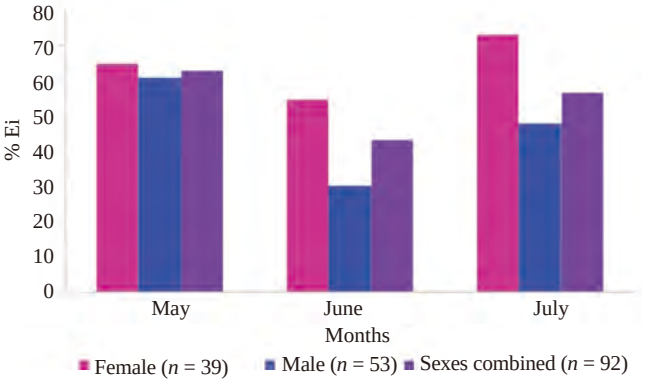

Figure 2. Monthly variations of the emptiness index (% Ei) for males, females and combined sexes of the Mediterranean needlefish *T. a. imperialis* off the Gulf of Gabès, Southeastern Tunisian coast.

The number of prey items identified in the stomachs of the examined specimens of *T. a. imperialis* was 680 weighing a total of 532.73 g, with an average of 12 items and 9.51 g per stomach. The analysis of gut contents indicated that needlefish *T. a. imperialis* is carnivorous preferring to feed on teleosts (% IRI = 62.58) followed by crustaceans (% IRI = 37.32), especially decapods *Sycionia carinata* (*S. carinata*) (% IRI = 5.42) (Table 2). Teleost fish made up 85% of the total weight of stomach contents, while crustaceans were the most dominant ingested

prey with 90% by number (Table 2). Teleosts at the juvenile stage identified from the guts of *T. a. imperialis* were ranked in order of significance as follows: Mugilidae, Gobidae and Belonidae.

Table 2
Overall diet composition of *T. a. imperialis* off the Gulf of Gabès, Tunisian coast.

Prey		Number	F%	N%	W%	IRI
Annelid unidentified		9	15.899	1.309	0.002	20.855
Crustacea		614	68.894	90.342	14.699	7236.649
	Copepoda					
	Microstella norvegica	463	10.599	68.083	0.001	721.638
	Decapoda					
	Sicyoniidae					
	S. carinata	71	42.396	10.474	14.330	1051.633
	Isopoda	38	37.097	5.674	0.155	216.233
	Cymothoidae					
	Anilocra physodes	9	15.899	1.310	0.002	20.855
	Gnathiidae					
	Gnathia maxillaris	3	5.300	0.436	0.000	2.314
	Idoteidae					
	Idotea metallica	3	5.300	0.436	0.003	2.328
	Sphaeromatidae					
	Cymodoce sp.	24	10.600	3.491	0.150	38.593
Teleostei		101	95.392	14.839	85.457	9567.370
	Belonidae	6	5.300	0.873	0.209	5.736
	Gobidae	3	5.300	0.436	1.649	11.052
	Mugilidae	9	10.599	1.310	39.005	427.291
	Liza saliens	6	5.300	0.873	26.930	147.336
	Unidentified	77	74.194	11.347	44.588	4150.037

There was a variation in the average number of prey per stomach in relation to the fish length in *T. a. imperialis* ($F_{0.169}$ = 0.031, $P < 0.05$). The IRI of the most frequently ingested preys in the stomach of *T. a. imperialis* with regard to size classes were given in Figure 3. Most of prey taxa ingested by the juvenile specimens were also ingested by adult ones with different proportions. In both size classes, teleosts were the most important preys but more frequent in larger specimens (χ^2 = 64.13, $P < 0.01$). Crustaceans were more frequent in the smaller specimens (χ^2 = 40.31, $P < 0.01$). Among crustaceans, decapods were the most important in the diet of the larger specimens (χ^2 = 31.78, $P < 0.01$), whereas copepods were present only in smaller specimens (χ^2 = 31.50, $P < 0.01$) (Figure 3).

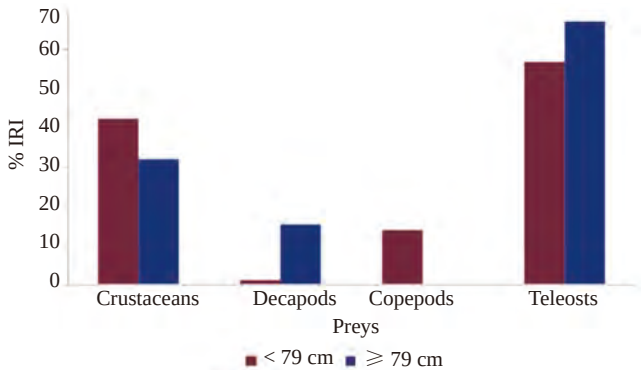

Figure 3. *T. a. imperialis* length-class diet changes of IRI percentage (% IRI) of main prey categories.

4. Discussion

Our findings represented the first contribution to the knowledge of the feeding behavior of the Mediterranean needlefish *T. a. imperialis* of Tunisia. The analysis of gut contents showed that this needlefish is a carnivorous fish preferring to feed on teleost fish and crustaceans, especially decapods *S. carinata*.

The carnivorous behavior has also been reported among needlefish *Tylosurus acus* (*T. acus*). Previous studies have shown that teleosts and crustaceans are major components in the diet of *T. acus*. The Atlantic needlefish *T. acus* feeds on small fish, crustaceans and insects[15-17]. Barbour reported that the *Anchoa choerostoma*, Bermuda anchovies, and the reef silverside *Allanetta harringtonesis* (actually valid name: *Hypoatherina harringtonensis*) are particularly the most important preys of *T. acus*[18]. Randall found that full stomachs (7 in 13 individuals examined) contained mostly carangid and belonid fishes (96.3%), crabs (1.4%), insects (1.4%) and stomatopods crustaceans (0.9%) in the Virgin Islands[17]. Clupeid and Engraulid fishes are the main prey items of *T. acus* diet off the Brazilian coast[19]. Similarly, Collette stated that belonid fishes are generally carnivorous feeding primarily on small fishes that they catch sideways in their beaks[1].

Our findings showed that the Mediterranean needlefish *T. a. imperialis* feed on small specimens of its own kind (skeleton and spines green colored characteristic of Belonidae) and could be considered as cannibalistic. In the needlefish *T. a. imperialis*, Randall found belonid fish in its diet[17]. Moreover, cannibalism was also reported in garfish *Belone belone*[20-23].

In the diet composition of the Mediterranean needlefish *T. a. imperialis*, we found food items from the pelagic field such as Mugilid and belonid fishes, zooplankton copepods and others from the benthic field fishes such as gobid fish and crustaceans decapods. It seems, therefore, that this fish is an active predator and an opportunistic feeder which performs vertical migrations to feed using a well-developed swim bladder. Similarly, in *T. acus* diet, the prey reef silverside was known to congregate in large schools that usually consist of similar-sized fishes that descend to greater depths to avoid the colder temperatures at the water's surface[18].

The presence of crustaceans isopods such as *Anilocra physodes* and *Gnathia maxillaris* in the diet of *T. a. imperialis* could be related to its piscivourous consumed preys. Indeed, these bloodsuckers parasites of fishes weaken and render them vulnerable to their predators.

In our study, we found no significant differences in the Ei between small and large individuals, as far as, in the catch structure lengths, the majority of the collected specimens were

in the size range of 70 cm and 80 cm. Similarly, the absence of significant differences in the Ei between males and females can be explained by the significant equal proportion of males and females in the sample examined of *T. a. imperialis* collected mainly in their spawning period between May and July off the Tunisian coast. Nevertheless, the difference in the Ei among months can be explained by the fluctuation of the sex ratio. Indeed, spawning migration of *T. a. imperialis* starts by a rush of males, females are present at the end of the migration only[4]. The decrease in the Ei in June for both sexes can be related to the maximum of reproduction effort. The spawning period of *T. a. imperialis* of Tunisia was between May and July with a peak in June which consequently corresponds to the lowest feeding rate. It can be concluded that fish need more energy input in the spawning season to meet the requirements of reproduction.

Data generated from this study on the Mediterranean needlefish diet proposed *T. a. imperialis* as an active predator and an opportunistic feeder with a decline feeding rate during the peak of spawning season.

Conflict of interest statement

We declare that we have no conflict of interest.

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