

ANNALES

Anali za istrske in mediteranske študije
Annali di Studi istriani e mediterranee
Annals for Istrian and Mediterranean Studies
Series Historia Naturalis, 33, 2023, 1





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Series Historia Naturalis, 33, 2023, 1

ISSN 1408-533X
e-ISSN 2591-1783

UDK 5

Letnik 33, leto 2023, številka 1

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Založništvo PADRE d.o.o.

Izdajatelj/Editori/Published by:

Zgodovinsko društvo za južno Primorsko - Koper / Società storica del Litorale - Capodistria®

Inštitut IRRIS za raziskave, razvoj in strategije družbe, kulture in okolja / Institute IRRIS for Research, Development and Strategies of Society, Culture and Environment / Istituto IRRIS di ricerca, sviluppo e strategie della società, cultura e ambiente®

**Sedež uredništva/Sede della redazione/
Address of Editorial Board:**Nacionalni inštitut za biologijo, Morska biološka postaja Piran / Istituto nazionale di biologia, Stazione di biologia marina di Pirano / National Institute of Biology, Marine Biology Station Piran
SI-6330 Piran / Pirano, Fornače/Fornace 41, tel.: +386 5 671 2900, fax +386 5 671 2901;
e-mail: annales@mbss.org, **internet:** www.zdjp.si

Redakcija te številke je bila zaključena 23. 06. 2023.

**Sofinancirajo/Supporto finanziario/
Financially supported by:**

Javna agencija za raziskovalno dejavnost Republike Slovenije (ARRS) in Mestna občina Koper

Annales - Series Historia Naturalis izhaja dvakrat letno.

Naklada/Tiratura/Circulation:

300 izvodov/copie/copies

Revija Annales, Series Historia Naturalis je vključena v naslednje podatkovne baze / La rivista Annales, series Historia Naturalis è inserita nei seguenti data base / Articles appearing in this journal are abstracted and indexed in: BIOSIS-Zoological Record (UK); Aquatic Sciences and Fisheries Abstracts (ASFA); Elsevier B.V.: SCOPUS (NL); Directory of Open Access Journals (DOAJ).

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received: 2022-03-22

DOI 10.19233/ASHN.2023.11

DIET AND FEEDING HABITS OF THE GREATER WEEVER *TRACHINUS DRACO* (TRACHINIDAE) FROM THE GULF OF TUNIS (CENTRAL MEDITERRANEAN SEA)

Mourad CHÉRIF

Institut National des Sciences et Technologies de la Mer, port de pêche, 2060 La Goulette, Tunisia

Rimel BENMESSAOUD

Institut National Agronomique de Tunis, 43 Avenue Charles Nicolle 1082, Tunis- Mahrajène, Tunisia

Sihem RAFRAFI-NOUIRA

Institut Supérieur de Pêche et d'Aquaculture de Bizerte, BP 15, 7080 Menzel Jemil, Tunisia

Christian CAPAPÉ

Laboratoire d'Ichtyologie, Université de Montpellier, 34095 Montpellier, France
e-mail: christian.capape@umontpellier.fr

ABSTRACT

The dietary patterns and the feeding habits of greater weever *Trachinus draco* (Linnaeus, 1758) are described based on an analysis of 280 stomach contents collected between May 2018 and March 2019 in the Gulf of Tunis. The vacuity index (%VI) was relatively low (23.92%). The proportion of empty stomachs varied significantly by season but not by sex. The most important preys were crustaceans (IRI = 54.55%), followed by teleosts (IRI = 32.93%), molluscs (IRI = 3.3%), and annelids (IRI = 0.05%), which were found occasionally. The specimen body size appeared to be the main factor influencing the diet composition of *T. draco*, as small specimens fed on crustaceans (IRI = 83.5%) and molluscs (IRI = 8.6%), and larger specimens consumed teleosts. The *T. draco* from the Gulf of Tunis is a carnivore species displaying a high trophic level ($3.7 < TROPH < 4.5$) and a positive allometry in the length-weight relationship. The species finds in the area sufficient resources to develop and reproduce.

Key words: *Trachinus draco*, northern Tunisia, diet composition, feeding behavior, trophic level

DIETA E ABITUDINI ALIMENTARI DI *TRACHINUS DRACO* (TRACHINIDAE) NEL GOLFO DI TUNISI (MEDITERRANEO CENTRALE)

SINTESI

L'articolo riporta i modelli e le abitudini alimentari della tracina draco *Trachinus draco* (Linnaeus, 1758) sulla base di un'analisi di 280 contenuti stomacali, raccolti tra maggio 2018 e marzo 2019 nel Golfo di Tunisi. L'indice di vacuità (%VI) era relativamente basso (23,92%). La percentuale di stomaci vuoti variava significativamente in base alla stagione ma non al sesso. Le prede più importanti erano crostacei (IRI = 54,55%), seguiti da teleostei (IRI = 32,93%), molluschi (IRI = 3,3%) e anellidi (IRI = 0,05%), trovati occasionalmente. Le dimensioni degli esemplari sembrano essere il fattore principale che influenza la composizione della dieta di *T. draco*, poiché gli esemplari piccoli si nutrivano di crostacei (IRI = 83,5%) e molluschi (IRI = 8,6%), mentre gli esemplari più grandi consumavano teleostei. Nel Golfo di Tunisi *T. draco* è una specie carnivora che presenta un livello trofico elevato ($3,7 < TROPH < 4,5$) e un'allometria positiva nel rapporto lunghezza-peso. La specie trova nell'area risorse sufficienti per svilupparsi e riprodursi.

Parole chiave: *Trachinus draco*, Tunisia settentrionale, composizione della dieta, comportamento alimentare, livello trofico

INTRODUCTION

Four trachinid species have been present to date in Tunisian marine waters: the lesser weever *Echiichthys vipera* (Cuvier, 1829); the spotted weever *Trachinus araneus* (Cuvier, 1829); the greater weever *T. draco* (Linnaeus, 1758); and the streaked weever *T. radiatus* (Cuvier, 1829) following (Hamed & Chakroun-Marzouk, 2016). Among these species, *T. draco* is the most frequently caught throughout the year by trawlers and artisanal fleets where it was previously often considered by-catch (Hamed & Chakroun-Marzouk, 2016). In fact, due to the drastic decline of fish resources, the high demand of fishery products enhanced the value of some fish species, including *T. draco*. Currently, this species is of high commercial value because it is frequently used for local consumption (Hamed *et al.*, 2017).

Despite the abundance of the greater weever in Tunisian waters, little is known about certain aspects of its biology, especially food and feeding. Therefore, the purpose of the present work is to provide information about the diet composition of the *T. draco* from the Gulf of Tunis, especially its feeding patterns according to season, size, and sex. Studying the food and feeding habits of the species remains a valuable method for investigating and delineating its impact in the wild.

MATERIAL AND METHODS

The greater weevers, *Trachinus draco* were sampled from different landing sites located in the Gulf of Tunis. The specimens were caught by different fishing gears, mainly gill nets, trammel nets, and bottom trawlers at depths between 30 and 150 m (Fig. 1). Samplings were carried out from May 2018 to March 2019. A total of 280 specimens were examined. Immediately after landing, all specimens were dissected and the preys removed, sorted, and identified to the lowest possible taxonomic level using keys and field guides (Riedl, 1963; Perrier, 1964, 1975; Fischer *et al.*, 1987).

The food composition and feeding habits of *T. draco* were analysed using the following indices suggested by Hureau (1970), Hyslop (1980), and Rosecchi and Nouaze (1987):

Vacuity Index, VI = (number of empty stomachs/total number of stomachs) × 100

Mean number of prey items per stomachs: Nm = total number of prey ingested / total number of full stomachs

Percentage of numerical abundance: %N = (number of prey item *i* / total number of preys) × 100

Percentage in weight: %W = (weight of prey *i* / total weight of all preys items) × 100

Percentage frequency of occurrence: %F = (number of stomachs containing prey item *i* / total number of full stomachs) × 100.

The main food items were identified using the index of relative importance (IRI) defined by Pinkas *et al.* (1971) and modified by Hacunda (1981): $IRI = \%F \times (\%N + \%P)$. This index is expressed as: $\%IRI = (IRI / \sum IRI) \times 100$. The IRI values were converted to percentages to facilitate comparisons between prey items (Cortés, 1999). All indices listed above contribute to a better understanding of the importance of specific prey items in the feeding behaviour of the investigated fish species.

The diet composition data were also used to establish the trophic level of the greater weever. The trophic level for any consumer species (*i*) is:

$$TROPH_i = 1 + \sum_{j=1}^G DC_{ij} * TROPH_j$$

where $TROPH_j$ is the fractional trophic level of prey (*j*), DC_{ij} represents the fraction of (*j*) in the diet of (*i*), and (*G*) is the total number of prey species (Pauly *et al.*, 1998; Pauly & Christensen, 2000; Pauly & Palomares, 2000; Stergiou & Karpouzi, 2002).

The $TROPH$ and standard errors (*SE*) of the *T. draco* specimens in the study area were calculated using

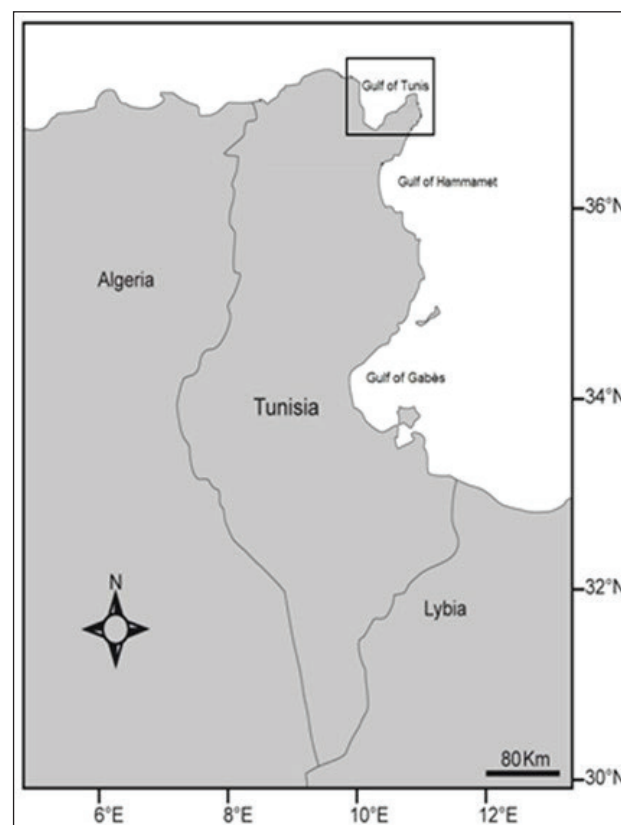


Fig. 1: Map of the Tunisian coast with a rectangle indicating the sampling area of *Trachinus draco*.

Sl. 1: Zemljevid tunizijske obale z označeno lokaliteto, kjer so ulovili primerke vrste *Trachinus draco*.

TrophLab (Pauly *et al.*, 2000). The relationship between *TROPH* and the midpoint of each length class considered here was quantified using the following equation:

$$TROPH_{Li} = TROPH_{L\infty} (1 - e^{-KL_i})$$

where $TROPH_{L\infty}$ is the asymptotic *TROPH* and (K) is the rate at which ($TROPH_{L\infty}$) is approached (Cortès, 1999).

Statistical analyses were carried out considering the main prey categories: crustaceans, teleosts, molluscs, and annelids. Indeed, a Chi-square test (Sokal & Rohlf, 1987) was performed to identify the main prey groups responsible for the differences among the factors of sex, season, and size class. The significance level adopted was 5%.

The length-weight relationship of total length (TL) versus total body weight was used as a complement for feeding studies following Froese *et al.* (2011). It was estimated from the allometric formula $W = a L^b$, where (W) is total body weight (g), (L) the total length (cm), and (a) and (b) are the coefficients of the functional regression between (W) and (L) (Ricker, 1973). In order to confirm whether the b values obtained in the linear regressions were significantly different from the isometric value ($b=3$), t -tests with appropriate degrees of freedom were used (Zar, 1999).

RESULTS

Vacuity index

A total of 280 specimens of *T. draco* were examined, 115 males and 165 females. They ranged from 11.3 to 28.6 cm in total length (TL), and 23.3 to 202.8 g in total body weight (Fig. 2). The vacuity index (VI) of *Trachinus draco* was 23.92% (Tab. 1). The VI of males (20.87%) and females (26.6%) were significantly different ($\chi^2 = 5.21$; $P < 0.05$; $df = 1$). The proportion of empty stomachs also significantly varied by season ($\chi^2 = 11.34$; $P < 0.05$; $df = 3$), with a

Tab. 1: Variations of the vacuity index (%VI) of *Trachinus draco* depending on the season and sex.

Tab. 1: Spremenljivost indeksa praznosti (%VI) za vrsto *Trachinus draco* glede na sezono in spol.

Seasons				Sex	
Summer	Autumn	Winter	Spring	Males	Females
21.31	16.67	15.91	33.03	20.87	26.06
$\chi^2 = 11.34$; $P < 0.05$; $df = 3$				$\chi^2 = 5.21$; $P < 0.05$; $df = 1$	

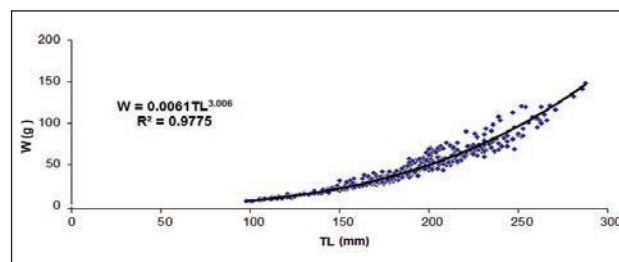


Fig. 2: Length-weight relationships of *Trachinus draco* from the Gulf of Tunis.

Sl. 2: Dolžinsko-masni odnos za vrsto *Trachinus draco* v Tuniskem zalivu.

maximum of 33.03% during the spring and 21.31% in summer, while the minimum was observed in winter (15.91%).

Diet composition

The diet of *T. draco* consisted of a large variety of invertebrates and teleosts from four different zoological groups (Tab. 2). Based on the index of relative importance (%IRI), crustaceans were the most frequently ingested prey (IRI = 54.55%), followed by teleosts (IRI = 32.93%). Conversely, molluscs (IRI = 3.3%) and annelids (IRI = 0.05%) were only occasionally found in stomach contents. The index of relative importance of unidentified species was less significant (IRI = 1.54%).

Seasonal variation in diet composition

The analysis of the diet composition of *T. draco* revealed significant variance in the IRI index depending on the season (Tab. 3). The mean IRI indicated crustaceans and teleosts as the main prey groups throughout the year, with crustaceans generally displaying a higher %IRI in summer and autumn (reaching 64.9% and 66.6%, respectively) and lower during winter and spring (51.8% and 54.8%, respectively). Teleosts were generally less abundant in summer (28.9%) and autumn (26.7%), their number gradually increasing from winter (34.2%) to spring (36.3%). Annelids were only found during winter (0.1%), while molluscs varied seasonally, between 2.2% in spring and 6.6% in winter. A Chi-square test revealed significant differences in diet between the season and prey categories ($\chi^2 = 14.51$; $P < 0.05$; $df = 3$) (Tab. 3).

Feeding variation and trophic level according to fish size

To assess changes in diet with size (Tab. 3), three size classes were considered: $TL < 15$ cm, $15 < TL < 20$ cm, and $TL > 20$ cm. The diet of small specimens

Tab. 2: Diet composition of *Trachinus draco* (% Cn percentage in number; % Cw percentage in mass; % F frequency of occurrence; IRI index of relative importance; % IRI percentage index of relative importance of prey items).**Tab. 2: Sestava prehrane vrste *Trachinus draco* (% Cn - delež primerkov plena; % Cw - delež biomase plena; % F - frekvenca pojavljanja plena; IRI - indeks relativne pomembnosti plena; % IRI – delež indeksa relativne pomembnosti plena).**

Prey item/index			% Cn	% Cw	% F	IRI	%IRI
Mollusca	Gasteropoda	<i>Turitella</i> sp.	0.56	0.13	0.94	0.65	0.01
	Cephalopoda	<i>Illex</i> sp.	0.38	0.57	0.47	0.44	0.01
		<i>Sepia elegans</i>	1.31	1.33	0.94	2.49	0.03
		<i>Sepia officinalis</i>	0.94	1.09	0.47	0.95	0.01
		<i>Loligo vulgaris</i>	0.56	0.83	1.41	1.96	0.03
	Non-identified Cephalopoda		2.25	4.89	2.35	16.75	0.23
Total Mollusca			6.00	8.83	15.96	236.84	3.30
Teleostei	Carangidae	<i>Trachurus</i> sp.	0.56	1.01	1.41	2.21	0.03
	Congridae	<i>Conger conger</i>	0.56	1.37	0.94	1.81	0.03
	Caproidae	<i>Capros aper</i>	0.94	1.64	1.88	4.85	0.07
	Clupeidae	<i>Sardina pilchardus</i>	1.31	1.87	1.41	4.48	0.06
	Engraulidae	<i>Engraulis encrasicolus</i>	0.94	1.06	2.35	4.69	0.07
	Bothidae	<i>Arnoglossus laterna</i>	1.31	1.52	1.41	3.99	0.06
	Citharidae	<i>Citharus linguatula</i>	0.75	0.62	1.88	2.57	0.04
	Callionymidae	<i>Callionymus maculatus</i>	2.25	2.88	0.94	4.82	0.07
	Aulopodidae	<i>Aulopus filamentosus</i>	0.56	0.87	0.47	0.67	0.01
	Clinidae	<i>Clinitrachus argentatus</i>	0.94	1.07	1.41	2.82	0.04
	Gobiidae	<i>Gobius cobitis</i>	3.00	4.32	2.35	17.18	0.24
		<i>Gobius paganellus</i>	3.56	4.09	1.88	14.38	0.20
		<i>Zebrus zebrus</i>	2.44	2.49	1.88	9.25	0.13
		<i>Lesueurigobius friesii</i>	3.94	5.20	2.35	21.46	0.30
	Cepolidae	<i>Cepola rubescens</i>	2.25	2.12	1.88	8.20	0.11
		<i>Cepola macrophthalma</i>	2.81	4.36	1.88	13.47	0.19
	Ophichthidae	<i>Ophichthus rufus</i>	1.88	2.50	1.88	8.22	0.11
		<i>Echelus myrus</i>	1.69	1.60	1.41	4.63	0.06
	Non-identified Teleostei			6.19	6.78	3.29	42.62
Total Teleostei			37.90	47.36	27.70	2361.61	32.93
Crustacea	Mysida	<i>Gastrosaccus sanctus</i>	3.94	2.79	2.82	18.95	0.26
		<i>Siriella crassipes</i>	3.38	2.42	2.35	13.60	0.19
		<i>Siriella clausii</i>	4.50	3.34	3.76	29.45	0.41
		<i>Paramysis</i> sp.	3.94	2.86	2.82	19.17	0.27
		<i>Gastrosaccus normani</i>	3.56	3.17	3.76	25.28	0.35
		<i>Leptomysis mediterranea</i>	2.25	2.24	4.23	19.00	0.26
		<i>Gastrosaccus normani</i>	3.38	2.62	5.63	33.81	0.47
	Decapoda	<i>Phyllodoce</i> sp.	3.38	1.77	2.82	14.50	0.20
		<i>Liocarcinus</i> sp.	2.06	1.71	2.35	8.86	0.12
	Amphipoda	<i>Gammarus</i> sp.	1.50	1.52	1.41	4.26	0.06
		<i>Ampelisca</i> sp.	2.63	1.21	2.82	10.82	0.15
	Isopoda	<i>Anthura gracilis</i>	3.19	2.56	3.76	21.61	0.30
	Non-identified Crustacea			9.01	7.58	7.98	132.36
Total Crustacea			46.72	35.80	47.42	3912.72	54.55
Annelids	Polychaeta	<i>Nereis</i> sp.	1.31	1.41	1.41	3.84	0.05
Non-identified items			8.07	6.60	7.51	110.16	1.54

Tab. 3: *Trachinus draco*. Variations in the index of relative importance (%IRI) of major prey groups depending on the season, fish size, and sex.**Tab. 3:** *Trachinus draco*. Spremenljivost indeksa relativne pomembnosti plena (%IRI) glavnih skupin plena v odvisnosti od sezone, velikosti ribe in spola.

Prey Groups	Seasons				Fish size TL (cm)			Sex	
	Winter	Spring	Summer	Autumn	TL<15	15<TL<20	TL>20	Males	Females
Mollusca	6.6	2.2	3.5	3.3	6.4	8.6	11.4	2.7	2.4
Teleosts	34.2	36.3	28.9	26.7	1.3	8.7	21.9	33.8	31.3
Crustaceans	51.8	54.8	64.9	66.6	83.5	76.2	60.6	58.4	61.6
Annelids	0.1	0	0	0	0.1	0	0	0	0.1
Unidentified	7.3	6.7	2.7	3.4	9.7	6.5	6.1	5.1	4.6
	$\chi^2 = 14.51$; $P > 0.05$; $df = 3$				$\chi^2 = 20.11$; $P > 0.05$; $df = 2$			$\chi^2 = 2.78$; $P < 0.05$; $df = 1$	

(TL < 15cm) mainly included crustaceans (IRI = 83.5%) and molluscs (IRI = 8.6%), while teleosts and annelids accounted for only 1.3% and 0.1% of consumed prey, respectively. In contrast, the diet composition of larger specimens of the greater weever shifted progressively towards small fishes (21.9%), and annelids disappeared completely from stomach contents. The Chi-square test indicated differences in diet composition among fish size classes ($\chi^2 = 20.11$; $P < 0.05$; $df = 2$).

Food items in relation to sex

The index of relative importance (IRI) showed that crustaceans and teleosts were the main prey items for both sexes all year round (Tab. 3). In contrast, molluscs were always a minor component of the diet of the species. The remaining prey items, i.e., the annelids, represented a low contribution to the diet and were only consumed by males (IRI = 0.1%). A Chi-square test revealed no significant differences between females and males in any of the prey categories ($\chi^2 = 2.78$; $P > 0.05$; $df = 1$).

The TROPH values for the greater weever in the study area were calculated using the quantitative routine of TrophLab (Pauly *et al.*, 2000). The relationship between TROPH and the midpoint of each length class revealed that *T. draco* is a carnivorous species that mainly consumes large crustaceans, cephalopods and fishes ($3.7 < \text{TROPH} < 4.5$) (Fig. 3).

$$\text{TROPH}_{Li} = 3.94 * (1 - e^{-0.31 * Li})$$

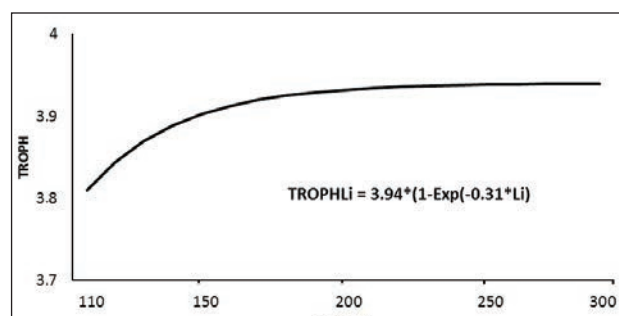
Length-weight relationship

The values of the exponent b for the combined sexes were significantly higher than 3 ($b = 3.006$;

$R^2 = 0.97$), indicating a positive allometry for the greater weever from the Gulf of Tunis (t-test = 5.17; $P < 0.05$).

DISCUSSION

The feeding behaviour of the greater weever has been studied in the Danish coast (Bagge, 2004) and various areas of the Mediterranean Sea (Vivo & Sanz 1989; Morte *et al.*, 1999; Karachle & Stergiou, 2010; Karachle & Stergiou, 2011; Šantić *et al.*, 2016), but not the central Mediterranean Sea. Our study showed that the *T. draco* from Tunisian waters feeds on a wide range of prey, largely crustaceans and small teleost species and, to a lesser extent, molluscs and annelids. These observations corroborate *pro parte* Morte *et al.*, (1999) and Šantić *et al.*, (2016), who reported decapods as an important prey group, and fishes as secondary prey items.

**Fig. 3:** Relationship between trophic level (TROPH) and total length (TL).**Sl. 3:** Odnos med trofičnim nivojem (TROPH) in totalno dolžino (TL).

However, the diet variation and prey composition may be related to the occurrence and availability of different benthic assemblages in different areas (Ferrari & Chieregato, 1981).

Of the 280 *T. draco* stomachs examined, 67 were found empty (VI = 23.9%). The percentage of empty stomachs in specimens of this species from the Gulf of Tunis was relatively low compared to those recorded in previous studies. Morte *et al.* (1999) reported a VI of 42.12% in the Gulf of Valencia (Spain). The percentage of empty stomachs observed in the Danish coast was also very high, close to 100% during certain months (Bagge, 2004). Several studies have noted variations in the vacuity index, which is probably due to the availability of preys for the predators (Andaloro, 1982; Giarrata, 1985). Additionally, variations in temperature have been shown to influence feeding intensity (Jukić & Županović, 1965; Tyler, 1971; Zore-Armanda *et al.*, 1991).

Ontogenetic changes in food composition are well known among fishes (Karachle & Stergiou, 2010; Rafrafi-Nouira *et al.*, 2016). The present study confirms the relationship between prey items and body size for *T. draco* in Tunisian waters, with consumption of crustaceans decreasing and consumption of cephalopods and teleosts increasing with the fish's body size. Similar patterns were reported by Morte *et al.* (1999) from the Gulf of Valencia and by Šantić *et al.* (2016) in the Adriatic Sea. The seasonal changes in the diet of *T. draco* observed herein are also in agreement with the data reported by Morte *et al.* (1999) and Šantić *et al.* (2016) for the Adriatic Sea. The food spectrum was also influenced by prey availability, which likely varied with the seasons, as well as by the adaptability of predators and ability to locate prey (Zander, 1996). In the present study, no significant difference was observed in prey composition between males and females of *T. draco*. Since neither Morte *et al.* (1999) nor Šantić *et al.* (2016) examined sex differences in dietary patterns, a comparison between the studied areas in this respect is not possible.

Stergiou & Karpouzi (2002) and Karachle & Stergiou (2017) classified fishes in five distinct functional trophic groups. Following their classifications, *T. draco* could be considered a carnivorous species with a preference for large decapods, cephalopods, and teleosts ($TROPHL_{\infty} = 3.94$, $S.E = 0.22$). This is

the first paper to study the trophic level for *T. draco*.

The abundance of *T. draco* in northern Tunisian waters and the positive allometry observed in the length-weight relationship indicates that the species has found here sufficient resources to thrive. This suggests a wealth of other fish in the area that may have a favourable impact on the local economy. It is worth noting that *T. draco* is now actively targeted by fishermen and no longer considered a by-catch species (Hamed *et al.*, 2017).

However, *T. draco* is a venomous and thereby dangerous fish, which can cause injury to humans (Mebs, 2006). The species has venomous spines on the first dorsal fin and one on the opercular bone, which are effective against predation by other species, but can pose a risk to humans. The species' presence in the area is therefore a potential public health problem (Capapé *et al.*, 1976). Information provided by fishermen indicates that they have sustained injuries while handling the species. Furthermore, tourism, which plays an important role in the Tunisian economy, especially health tourism on the sandy beaches along the coast (El Bekri, 2013), could also be impacted by the presence of *T. draco*. Bathers and recreational fishermen, who are particularly abundant in spring and summer, are at risk for injury by this and/or other venomous species (Capapé *et al.*, 1975, 1976).

The dietary patterns and the feeding habits of *T. draco* allow us to understand the biodiversity of the study area, and the trophic level clearly indicates the role of the species as a top predator regulating local biotopes. It appears that a viable population of *T. draco* is successfully established in the area where the species is appreciated by local consumers, and therefore plays an interesting economic role despite the fact that it can cause serious injuries and envenomation. This study could serve as a reference point for designing appropriate measures to regulate the capture of the species and thus safeguard its presence in the area (La Mesa *et al.*, 2007; Kitsos *et al.*, 2008).

ACKNOWLEDGEMENTS

The authors wish to thank and acknowledge the assistance of professional fishermen in collecting material for this study.

PREHRANJEVALNE NAVADE MORSKEGA ZMAJA *TRACHINUS DRACO* (TRACHINIDAE) IZ TUNIŠKEGA ZALIVA (OSREDNJE SREDOZEMSKO MORJE)

Mourad CHÉRIF

Institut National des Sciences et Technologies de la Mer, port de pêche, 2060 La Goulette, Tunisia

Rimel BENMESSAOUD

Institut National Agronomique de Tunis, 43 Avenue Charles Nicolle 1082, Tunis- Mahrajène, Tunisia

Sihem RAFRAFI-NOUIRA

Institut Supérieur de Pêche et d'Aquaculture de Bizerte, BP 15, 7080 Menzel Jemil, Tunisia

Christian CAPAPÉ

Laboratoire d'Ichtyologie, Université de Montpellier, 34095 Montpellier, France

e-mail: christian.capape@umontpellier.fr

POVZETEK

Avtorji opisujejo prehranjevalne vzorce morskega zmaja *Trachinus draco* (Linnaeus, 1758), pridobljene na podlagi preiskave iz želodcev 280 primerkov, ujetih med majem 2018 in marcem 2019 v Tuniškem zalivu. Indeks praznosti (%VI) je bil relativno nizek (23,92%). Delež praznih želodcev se je glede na sezono spreminjal, ne pa tudi glede na spol. Najpomembnejše vrste plena so bili raki (IRI = 54,55%), sledile so jim kostnice (IRI = 32,93%), mehkužci (IRI = 3,3%) in kolobarniki (IRI = 0,05%), ki so bili najdeni občasno. Kaže, da je telesna velikost ključni dejavnik, ki vpliva na prehrano vrste *T. draco*, saj so manjši primerki plenili rake (IRI = 83,5%) in mehkužce (IRI = 8,6%), večji pa kostnice. Morski zmaj iz Tuniškega zaliva je mesojeda vrsta z visokim trofičnim nivojem ($3.7 < TROPH < 4.5$) in pozitivno alometrijo glede na masno-dolžinski odnos. Na obravnavanem območju ima zadovoljive razmere za rast in razmnoževanje.

Ključne besede: *Trachinus draco*, severna Tunizija, sestava prehrane, prehranjevalno vedenje, trofični nivo

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