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OBSERVATIONS ON THE THINLIP CONGER *GNATHOPHIS MYSTAX* (OSTEICHTHYES: CONGRIDAE) FROM THE TUNISIAN COAST (CENTRAL MEDITERRANEAN)

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ABSTRACT

The paper reports on some aspects of morphology, morphometric measurements, meristic counts and colour of all Gnathophis mystax *found in northern Tunisian waters. Some measurements, such as pre-dorsal length, pre-anal length, pectoral length and pre-pectoral length are in correlation with size; however, the b < 3 values display negative allometry. The relationship between total length (TL) and the hepatosomatic index (HSI) is linked to size. Similar observations were recorded between TL and the gonadosomatic index (GSI), and between TL and condition (K). Of the 48 stomachs examined for contents, 29 were empty. A total of 19 items were found in the stomach contents, although partially digested.*

Key words: *Gnathophis mystax*, morphology, meristic counts, hepatosomatic index, gonadosomatic index, feeding habits

OSSERVAZIONI SUL GRONGO NASUTO *GNATHOPHIS MYSTAX* (OSTEICHTHYES: CONGRIDAE) LUNGO LA COSTA TUNISINA (MEDITERRANEO CENTRALE)

SINTESI

Gli autori riportano alcuni aspetti che si riferiscono a morfologia, misurazioni morfometriche, conte meristiche e colorazione di tutti gli individui di Gnathophis mystax *ritrovati nelle acque tunisine settentrionali. Alcune misurazioni, quali la lunghezza pre-dorsale, lunghezza pre-anale, lunghezza pettorale e la lunghezza pre-pettorale, sono correlate con le dimensioni degli individui. Tuttavia, i valori di b sono risultati minori a 3, indicando allometrie negative. Il rapporto tra la lunghezza totale (TL) e l'indice epatosomatico (HSI) è legato alle dimensioni. Osservazioni simili sono state registrate tra la TL e l'indice gonadosomatico (GSI), e tra la TL e la condizione (K). Dei 48 contenuti di stomaco esaminati, 29 erano vuoti. In totale, 19 pezzi sono stati trovati nei contenuti di stomaco, tuttavia già parzialmente digeriti.*

Parole chiave: *Gnathophis mystax*, morfologia, conte meristiche, indice epatosomatico, indice gonadosomatico, abitudini alimentari

INTRODUCTION

Thinlip conger *Gnathophis mystax* (Delaroche, 1809) is known to be commonly found off the eastern Atlantic coast extending from the south of Portugal to Morocco, southwardly the occurrence of the species remains doubtful and needs confirmation (Blache & Bauchot, 1972; Blache, 1977); it is replaced off the South African coast by southern Atlantic conger *Gnathophis capensis* (Kaup, 1856), following Smith (1990). In the Atlantic, the species is also reported off Madeira and the Canary Islands (Rucabado *et al*., 1978). *G. mystax* is well-known throughout the Mediterranean Sea and the Black Sea (Rucabado *et al*., 1978; Bauchot & Saldanha, 1986). The species has been reported as rather common off the northern Tunisian coast (Bradaï *et al*., 2004) and rare southwardly, where Bradaï (2000) recorded 2 specimens measuring 335 mm and 448 mm in total length, respectively.

G. mystax is a benthic species inhabiting muddy and sandy bottoms, dwelling at depths between 80 and 800 m (Bauchot & Saldanha, 1986). Little is known about the biology of *G. mystax*; Bauchot & Saldanha (1986) noted that spawning occurred in warm season, August to October in the Mediterranean Sea, with the egg averaging 2.5–3.0 mm in diameter, and probably referred to Blache (1977) when adding that leptocephali are characterized by long larval life, 12 months in tropical Atlantic. On the other hand, three papers focused on the diet and feeding habits of *G. mystax* specimens from the coast of Spain (Rucabado *et al*., 1978; Casadevall & Matallanas, 1990) and the Tyrrhenian Sea (Carpentieri *et al*., 2007).

The capture of specimens in northern Tunisian waters has allowed us to confirm the occurrence of the species in this area, as well as presenting herein some data about its morphometry, reproductive biology, diet and feeding habits. Such data constitute a first step to expanding the knowledge about the species in this area and to improving, if nothing else, its ecological role in it, as was the case with the Mediterranean moray eel *Muraena helena* Linnaeus, 1758 (Sallami *et al*., 2014).

MATERIALS AND METHODS

A total of 48 blacktail conger, *Gnathophis mystax*, were obtained between January 2010 and December 2011 at the fish markets of Zarzouna near Bizerte in northern Tunisia, and Kelibia, in the northern Cape Bon. All the specimens had been captured off the northern and north-eastern Tunisian coasts, including the Gulf of Tunis (Fig. 1). According to the information provided by experienced fishermen who are well-acquainted with the local fishing grounds, they were caught by commercial fishing vessels using trawl over sandy/muddy bottoms and longlines on rocky bottoms, at depths ranging from 50 to 200 m. All fresh specimens were measured

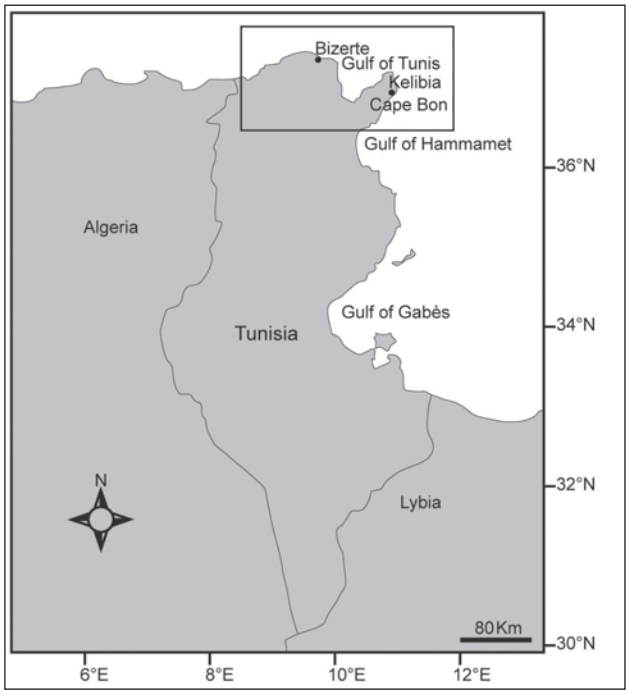

Fig. 1: Map of Tunisia showing the area of capture (rectangle) of** Gnathophis mystax**.
Sl. 1: Zemljevid Tunizije z označenim območjem ulova (pravokotnik) dolgonosega ugorja

in situ for total length (TL) to the nearest millimetre, and each specimen was weighed for total body weight (TBW) to the nearest gram. The specimens were then delivered to the laboratory, and the morphometric measurements recorded there in each specimen are plotted in Figure 2; relationships between total length and each measurement are expressed in logarithmic co-ordinates. We studied two meristic counts: vertebral number and number of pores in *linea lateralis*. In order to clearly expose the vertebral column, we kept the specimens in warm water prior to removing their flesh; following Bauchot & Saldanha (1986), we counted the numbers of abdominal vertebrae, caudal vertebrae and total vertebrae, and with special regard to *linea lateralis* we counted the pre-pectoral and pre-anal pores.

Once removed, the gonads, the liver, and the stomach contents were weighed to the nearest decigram. Additionally, the stomach contents were sorted out and identified to the lowest taxonomic level (or species level, where possible) using taxonomic keys and field guides (Perrier, 1964, 1975; Riedl, 1991; Louisy, 2002; Quéro *et al*., 2003). Prey items were counted and weighed to the nearest decigram, after surface water had been blotted off them with tissue paper. Whenever the prey recovered from the stomach was incomplete, its count was based on the number of different typical parts, such as beaks for cephalopods, claws and legs for various crus-

taceans, carapaces for decapod crabs, shell and foot for bivalves, operculum and shell for gastropods, and a whole vertebral column and otoliths for teleost species. Unidentified prey was preserved in 10% buffered formalin to be examined later by specialists.

The sample was evaluated for normality by means of the Shapiro-Wilk's test (W), with $P < 0.05$. The chi-square (χ^2) test was used to determine significance ($P < 0.05$). The relation between total length (TL) and total body weight (TBW) was used as a complement to feeding studies following Froese *et al.* (2011). Linear regression was expressed in decimal logarithmic coordinates and correlations were assessed by least-squares regression. Comparison of means was carried out by ANOVA. These two latter tests were performed via STAT VIEW 5.0 logistic model.

The analyses of food composition and feeding habits of *G. mystax* were studied by using indices suggested by Hureau (1970), Hyslop (1980) and Rosecchi & Nouaze (1985-86), such as:

- vacuity index, VI = (number of empty stomachs / total number of stomachs) × 100,
- mean number of preys per stomachs, MN = total number of prey ingested / total number of full stomachs,
- percentage of numerical abundance, %N = (number of prey items *i* / total number of preys) × 100,
- weight percentage, %W = (weight of prey *i* / total weight of all prey items) × 100,
- frequency of occurrence percentage, %F = (number of stomachs containing prey items *i* / total number of full stomachs) × 100.

The main food items were identified using the index of relative importance (IRI) of Pinkas *et al.* (1971), as modified by Hacunda (1981):

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

This index was expressed as:

$$\%\mathrm{IRI} = \frac{\mathrm{IRI}}{\Sigma \mathrm{IRI}} \times 100$$

All the indices listed above contributed to a better understanding of the importance of individual prey items in the feeding habits of the fish species under study.

The trophic level for any consumer species *i* is:

$$\mathrm{TROPH} = 1 + \sum_{j-1}^{\mathrm{G}} \mathrm{DC}_{ij} \times \mathrm{TROPH}_j$$

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).

The TROPH and standard errors (SE) of *G. mystax* in the study area were calculated using TrophLab (Pauly *et al.*, 2000), a stand-alone Microsoft Access routine for estimating trophic levels, downloadable from FishBase (Froese & Pauly, 2014). Statistical differences ($P < 0.05$) in the basic diet composition as a function of size and season were established by applying a χ^2 test (Sokal & Rohlf, 1987).

Hepatosomatic index (HSI), gonadosomatic index (GSI) and condition factor (K) were calculated as:

$$\mathrm{HSI} = \frac{\mathrm{LM}}{\mathrm{TBW}} \times 100$$

$$\mathrm{GSI} = \frac{\mathrm{GM}}{\mathrm{TBW}} \times 100$$

$$\mathrm{K} = \frac{\mathrm{TBW}}{\mathrm{TL}^3} \times 100$$

with TL = total length, LM = liver mass, GM = gonad mass, and TBW = total body weight. Variations in HSI and GSI related to size were considered in all categories of specimens. Tests for significance ($P < 0.05$) were performed by using ANOVA and a χ^2 test, with special regard to variations in HSI and GSI related to size.

RESULTS

Sample description

The distribution of the sampled *Gnathophis mystax* is presented in Figure 2 (Shapiro-Wilk test, W= 0.98; $P < 0.001$); that allows us to state that the studied sample came from a normally distributed population. Of the 48 specimens collected, 31 were females and significantly outnumbered the males ($\chi^2 = 19$, df = 1, $P < 0.05$). The smallest specimen measured 170 mm in total length and weighed 8.3 g, whereas the largest specimen measured 363 mm and weighed 61.4 g.

Morphological measurements and meristic counts

The specimens of *G. mystax* were identified as follows: snake-like body, scaleless, rounded in anterior half, rather compressed behind anus, snout prominent, pointed and slender, eye large and oval, interorbital space narrow, mouth moderately large, labial flange narrow on upper lip, broader on lower lip, anterior nostril opening in a flexible tube at snout near to premaxillary teeth, posterior nostril a horizontal slit with a slightly crenulate edge, opening before and near eye. Colour brownish, rather darker dorsally, belly lighter, posterior edges of dorsal and anal fins blackish, distal end of caudal fin black.

Three *G. mystax* are preserved in the Ichthyological Collection of the Faculté des Sciences of Tunis and the

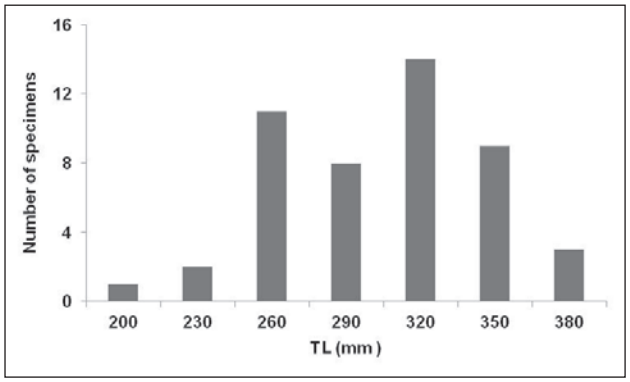

Fig. 2: Size distribution of studied specimens of *G. mystax*.
Sl. 2: Velikostna porazdelitev obravnavanih osebkov

Faculté des Sciences of Bizerte and registered under the following catalogue numbers: FSB-Gna-mys 01, FST-Gna-mys 02 and FST-Gna-mys 03, respectively; some measurements (Fig. 3) were carried out on these three specimens and summarized in Table 1.

Additionally, the relationships between total length (TL) and some measurements such as pre-dorsal length (Pre Dors length), pre-anal length (Pre Anal length), pectoral length (Pect length) and pre-pectoral length (Pre

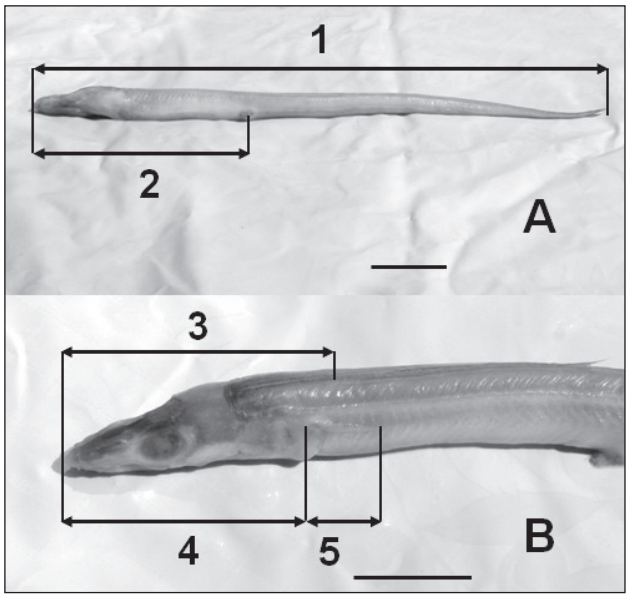

Fig. 3: Measurements recorded in *G. mystax*: ***(A) 1 - total length, 2 - Pre-anal length; (B) 3 - Pre-dorsal length, 4 - Pre-pectoral length, 5 - Pectoral length.***
Sl. 3: Meritve, opravljene na primerkih dolgonosih ugorjev: (A) 1 - celotna dolžina, 2 - dolžina do zadnjične plavuti; (B) 3 - razdalja do hrbtne plavuti, 4 - razdalja do prsne plavuti, 5 - razdalja do trebušne plavuti.

Tab. 1: Morphometric measurements, meristic counts and weights carried out in three specimens of *Gnathophis mystax* ***caught off the northern Tunisian coast.***
Tab. 1: Morfometrične meritve, meristika in masa pri treh primerkih dolgonosega ugorja, ujetih v severnotunizijskih vodah

Specimen	FST-Gna-mys 01		FST-Gna-mys 02		FST-Gna-mys 03	
Measurements	mm	%TL	mm	%TL	mm	%TL
Total length (TL)	248	100	309	100	370	100
Pre anal length	92	37.23	117	37.86	140	37.83
Pre dorsal length	46	18.00	56	18.14	68	18.37
Pre pectoral length	39	16.73	48	15.60	63	17.02
Pectoral length	12	4.36	15	4.85	20	5.13
Counts						
Abdominal vertebrae	43		43		43	
Caudal vertebrae	89		91		91	
Total vertebrae	132		134		134	
Pre pectoral pores	5		5		6	
Pre anal pores	32		32		32	
Weights (g)						
Total body weight	16.8		31.3		70.7	
Eviscerated body weight	15.2		27.5		65.2	
Liver weight	0.2		0.4		1.3	
Gonad weight	0.2		0.3		1.1	

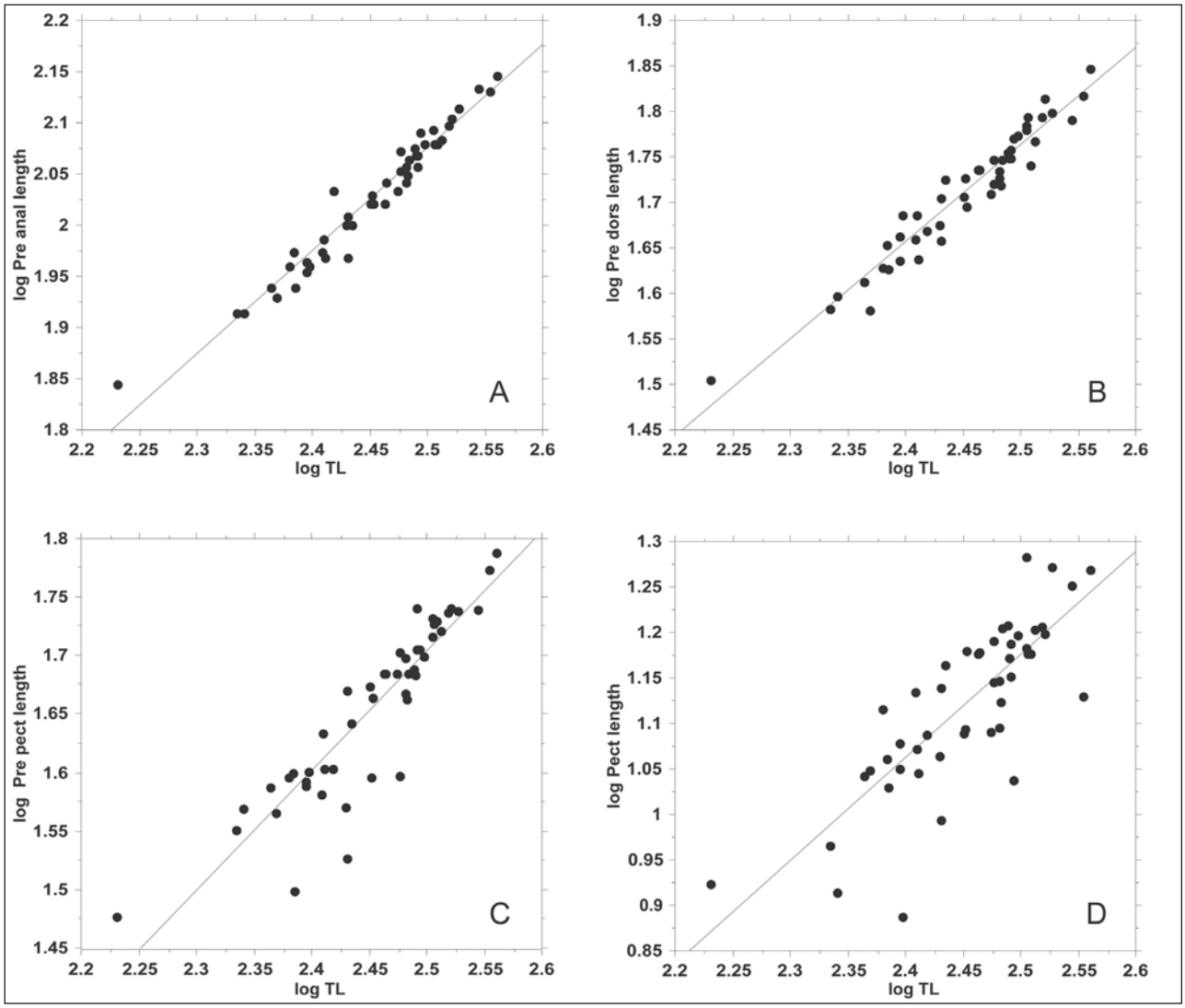

Fig. 4: Relationship expressed in logarithmic co-ordinates: total length (TL)** vs. **(A) Pre-anal length, (B) Pre-dorsal length, (C) Pre-pectoral length, (D) Pectoral length, for the studied sample of** G. mystax**.
Sl. 4: Premosorazmerni odnosi med logaritemsko izraženimi parametri, in sicer celotna dolžina (TL) proti (A) razdalji do zadnjične plavuti, (B) razdalji do hrbtne plavuti, (C) razdalji do prsne plavuti in (D) dolžini prsne plavuti pri vzorcu dolgonosih ugorjev.

Pect length) are plotted in Figure 4, as follows:

(A) log Pre Anal length = 1.01 × log TL - 0.436 (r = 0.97, $P < 0.001$)

(B) log Pre Dors length = 1.07 × log TL - 0.90 (r = 0.97, $P < 0.001$)

(C) log Pre Pect length = 1.024 × log TL - 0.856 (r = 0.90, $P < 0.01$)

(D) log Pect length = 1.14 × log TL - 1.66 (r = 0.81, $P < 0.001$)

Vertebral counts were carried out in 39 specimens: the number of abdominal vertebrae ranged between 38 and 44, with 43 as the modal value and a mean of 41.90 ± 1.41; they were outnumbered by caudal vertebrae, which ranged between 88 and 98, with 90 as the modal value and a mean of 90.55 ± 12.20. The total number of vertebrae ranged between 130 and 142, with 133 and 134 as the modal values and a mean of 131.02 ± 16.5. The results are similar to those recorded in the Mediterranean (Tab. 2). Pores were counted in 48 specimens; 5 pre-pectoral pores were recorded in 32 specimens, and 6 in 16 specimens, and were outnumbered by pre-anal pores, which ranged between 30 and 33, with 33 as the modal value and a mean of 32.10 ± 1.13.

Biological observations

The relationship between total length and the hepatosomatic index (HSI) is plotted in Figure 5, and it appears

Tab. 2: Number of vertebrae counted in** G. mystax **caught off the northern Tunisian coast, compared to those recorded in the Mediterranean.
Tab. 2: Število preštetih vretenc v raziskanem vzorcu s severnotunizijske obale v primerjavi s podatki iz Sredozemlja

Number of vertebrae			Area	Authors
Abdominal	Caudal	Total		
43-47	-	134-141	Mediterranean Sea	Bauchot & Saldanha (1986)
43-47	91-94	134-141	Mediterranean Sea	Aboussouan (1994)
38-44	88-98	134-141	Tunisian coast	This study

that HSI values increase with size. The highest values were recorded in the largest specimens and were significantly different (t-test = 13.41, df = 47, $P < 0.01$), similar observations were recorded between TL and the gonadosomatic index, GSI (Fig. 6), and between TL and condition, K (Fig. 7), with t-test = 7.37, df = 47, $P < 0.05$ for the former, and t-test = 67.71, df = 47, $P < 0.05$ for the latter.

Additionally, the relationship between TL and total body weight (TBW) was:

$\log TBW = 3.09 \times \log TL - 5.88$ ($r = 0.96$, $n = 48$) (Fig. 8).

Diet

Of the 48 stomach examined for contents, 29 were empty, and the assessed vacuity index (VI) was relatively high, reaching 60.41 %. 19 items in all were found in the stomach contents. They were already partially digested, therefore the species-level identification was difficult; nevertheless, remains of crustaceans and osteichthyans were observed (Tab. 3).

Crustaceans were the preferential prey with %IRI = 98.85, osteichthyans were secondary with %IRI = 1.14. Additionally, crustaceans constituted the most important prey items in term of abundance (%N = 89.47), frequency of occurrence (%F = 89.47) and biomass (%W = 92.64). The TROPH value calculated for *G. mystax* was 3.51 ± 0.6.

DISCUSSION

The morphology, morphometric measurements, meristic counts and colour of all available *Gnathophis mystax* found in northern Tunisian waters were in total agreement with Albuquerque (1954-1956), Saldanha (1967), Bauchot & Saldanha (1986), Aboussouan (1994), Louisy (2002) and Quéro *et al.* (2003). Such records confirm the occurrence of the species in the study area. Also, some measurements, such as pre-dorsal length, pre-anal length, pectoral length and pre-pectoral length, are correlated with size; b values, however, were < 3, displaying negative allometries. Since the species lives burrowed into muddy bottoms, it is less prone to long-distance migrations, its snake-like morphology allows it to move covered by mucous around its habitat, and the use of fins is not fundamental.

G. mystax inhabits deep marine areas (Bauchot & Saldanha, 1986; Casadevall & Matallanas, 1990), as are those close to the shore of the northern Tunisian coast (Castany, 1955; Ben Mustapha, 1966). The Gulf of Gabès in the south, on the other hand, is a very shallow basin with an underwater depth of less than 50 m extending as far as 110 km off the coast, and the 200 m isobath runs at a distance of 250-400 km away from the coast (Seurat, 1934; Ben Othman, 1971). Such ecological parameters could explain why *G. mystax* is more frequently caught off the northern Tunisian coast (Bradai *et al.*, 2004). Additionally, according to the information given by Tunisian fishermen, the species is discarded at sea due to its low commercial value and thus rarely found in local fishery landing sites or fish markets, as confirmed by the sample studied in the present paper, which only comprised 48 specimens. For the time being, the species is not considered as threatened and, following Papaconstantinou et al. (2011), is probably still present in all the areas where it has been previously recorded, including Tunisian waters.

Tab. 3: Diet composition for total sample of** G. mystax **caught off the northern Tunisian coast. Legend: %N - percentage by number, %W - percentage by weight, %F - percentage by occurrence, %IRI - index of relative importance.
Tab. 3: Sestava prehrane dolgonosih ugorjev, ujetih ob severnotunizijski obali. Legenda: %N - delež števila primerkov plena, %W - delež mase, %F - frekvenca pojavljanja, %IRI - indeks relativne pomembnosti plena.

Prey items	%N	%W	%F	%IRI
Crustaceans	89.47	92.64	89.47	98.85
Osteichthyans	10.52	7.35	10.52	1.14

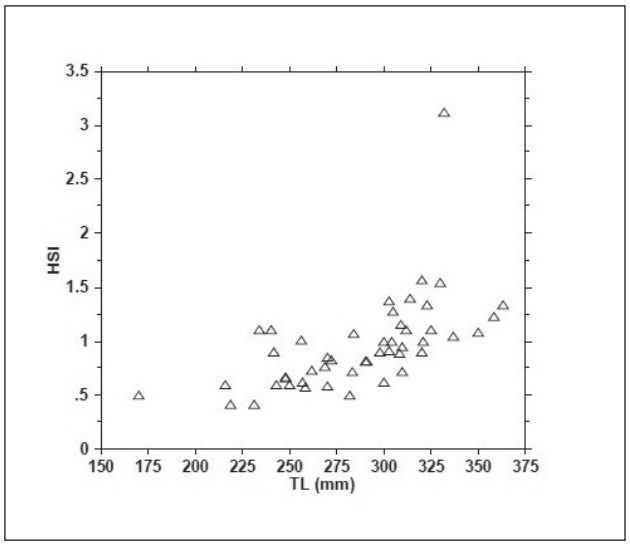

Fig. 5: Total length (TL)** vs. **hepatosomatic index (HSI) for the studied sample of** G. mystax**.
Sl. 5: Odnos med celotno dolžino (TL) in hepatosomatičnim indeksom (HSI) pri vzorcu dolgonosih ugorjev

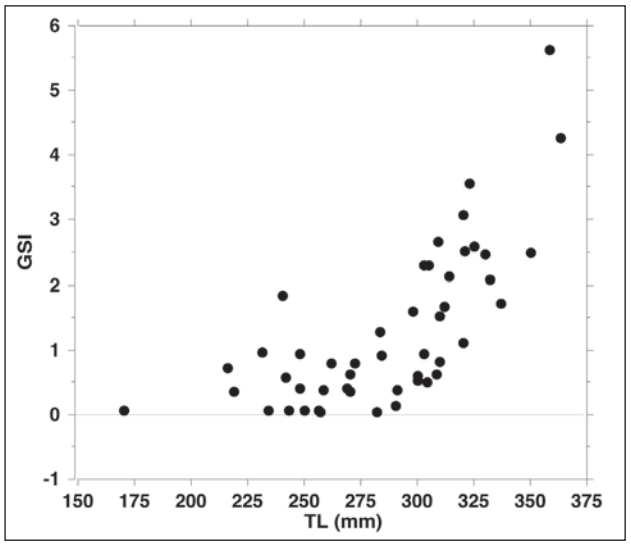

Fig. 6: Total length (TL)** vs. **gonadosomatic index (GSI) for the studied sample of** G. mystax**.
Sl. 6: Odnos med celotno dolžino (TL) in gonadosomatičnim indeksom (HSI) pri vzorcu dolgonosih ugorjev

The values of HSI, GSI and K of G. mystax increased with size; the well-correlated growths suggest that the species had sufficient food available in its life area to develop (Froese *et al.*, 2011). Additionally, a larger liver may allow both males and females to maximize gonadal production, as shown by the concomitant increase of GSI values in larger specimens. The high values of K and the positive allometry calculated from the total length vs. to-

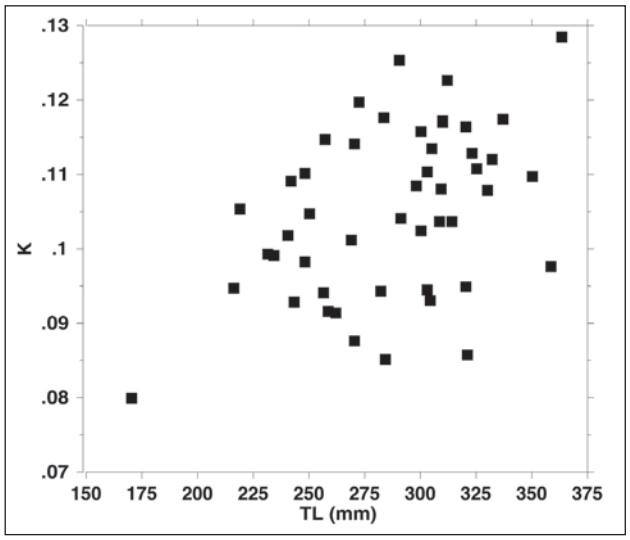

Fig. 7: Total length (TL)** vs. **condition factor (K) for the studied sample of** G. mystax**.
Sl. 7: Odnos med celotno dolžino (TL) in indeksom kondicije (K) pri dolgonosih ugorjih

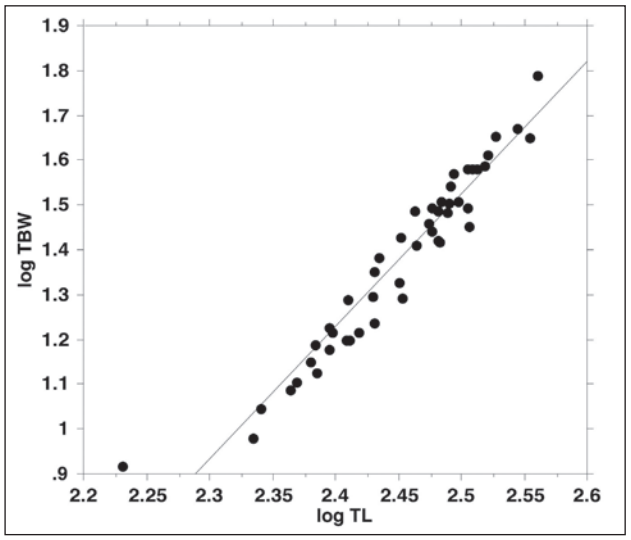

Fig. 8: Relationship between total length (TL) and total body weight (TBW) expressed in logarithmic co-ordinates for the studied sample of** G. mystax**.
Sl. 8: Odnos med celotno dolžino (TL) in celokupno maso (TBW) (izražen v logaritemskih vrednostih) pri dolgonosih ugorjih

tal body weight relationship could confirm such pattern.

Conversely, VI displayed a high value in total accordance with Casadevall & Matallanas (1990), which could be accounted for by the manner of sampling, by the type of biological environment, by the fact that the preys were unavailable in both bottom and in the water column, and fishing methods cannot be ruled out either. All the specimens sampled off the northern Tunisian coast were caught by trawling and generally spent quite some time in the nets before being landed; the prey they had consumed had thus been completely digested and their stomachs were found empty when analysed. This hypothesis was corroborated by the unidentifiable remains of digested prey items found inside the stomachs. Two zoological groups were recorded in the stomach contents, crustaceans and osteichthyans, confirming observations of previous studies carried out in other marine areas. However, Rucabado *et al*. (1978), Casadevall & Matallanas (1990) and Carpentieri *et al*. (2007) discovered other preys, such as annelids, bivalves, cephalopods and echinoderms, probably because their sample was larger than ours; furthermore, ontogenic changes are probably related to the biological environment and therefore prey availability.

The TROPH value of the sampled *G. mystax* was 3.51 ±0.6, close to that estimated by Stergiou & Karpouzi (2002), which ranged between 3.42 and 3.62. It follows that *G. mystax* is a carnivorous species playing a major role in the regulation of marine ecosystems; it is a top predator just like the elasmobranch species and many marine mammals with a TROPH ranging between 3.10 and 4.74 (Cortés, 1999) and 3.20 and 4.50 (Pauly *et al*., 1998), respectively. *G. mystax* exploits similar resources as other high-level marine consumers of the area, but since it dwells at greater depths, the pressure of competition for food is probably avoided, especially since its closely related species of conger eel (*Conger conger)*, which forages the same prey items, inhabits shallow coastal waters with a rocky bottom and a depth ranging from 0 to 100 m (Bauchot & Saldanha, 1986).

OPAZOVANJA DOLGONOSEGA UGORJA *GNATHOPHIS MYSTAX* (OSTEICHTHYES: CONGRIDAE) OB TUNIZIJSKI OBALI (OSREDNJE SREDOZEMLJE)

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POVZETEK

*Avtorji poročajo o nekaterih morfoloških vidikih, morfometričnih in merističnih meritvah ter barvnem vzorcu razpoložljivih primerkov dolgonosega ugorja (*Gnathophis mystax*) v severnotunizijskih vodah. Nekatere meritve, kot npr. razdalja do hrbtne plavuti, razdalja do zadnjične plavuti, razdalja do prsne plavuti in razdalja do trebušne plavuti, so povezane z velikostjo, vendar kaže vrednost b < 3 na negativno alometrično rast. Avtorji so ugotovili premosorazmerno korelacijo med hepatosomatičnim indeksom (HIS) in celotno dolžino telesa. Podobno povezanost so ugotovili med gonadosomatičnim indeksom (GSI) in dolžino telesa ter kondicijskim indeksom (K). Pregledali so tudi 48 želodcev, od katerih je bilo 29 praznih. V želodcih so našli 19 različnih skupin plena, ki pa je bil že delno prebavljen.*

Ključne besede: *Gnathophis mystax*, morfologija, meristika, hepatosomatični indeks, gonadosomatični indeks, prehrana

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