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Diet composition and feeding habits of *Lithognathus mormyrus* (Sparidae) from the Gulf of Gabes (Central Mediterranean)

NADER BEN HADJ HAMIDA[1], OLFA BEN ABDALLAH-BEN HADJ HAMIDA[1], OTHMAN JARBOUI[1] AND HECHMI MISSAOUI[2]

[1]Institut National des Sciences et Technologies de la Mer (INSTM), P.O. BOX 1035 – 3018 Sfax, Tunisia, [2]Institut National Agronomique de Tunisie (INAT), 43 avenue Charles Nicolle 1082 – Tunis-Mahrajène, Tunisia

The diet and feeding habits of the striped seabream, Lithognathus mormyrus, *from the Gulf of Gabes were investigated by examining the stomach contents of 1221 specimens ranging from 9.7 cm to 24.1 cm total length (and 11.2 g to 158.1 g in weight). Specimens were collected from commercial catches between September 2005 and August 2007. Of the total number of examined stomachs, 1115 were empty (Index of vacuity = 91.3%). This percentage varied significantly over the year, attaining a maximum in winter (95.77%) and summer (95.79%) and, a minimum in autumn (82.25%). Eight higher taxonomic groups were identified (teleosts, crustaceans, molluscs, echinoderms, annelids, spongia and plantae). Crustaceans were the most important prey taxa, constituting 84.6% of the total IRI. Other taxa, such as teleosts, and molluscs were of secondary importance. Significant differences in the diet were observed in relation to season. The estimated trophic level was 3.63 ± 0.59 for the whole population of* L. mormyrus *of the Gulf of Gabes. Based on the composition of its diet, this species may be considered to be an omnivorous fish with a preference for animal material and showed a specialist feeding strategy.*

Keywords: feeding habits, *Lithognathus mormyrus*, Gulf of Gabes, Central Mediterranean

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INTRODUCTION

The Sparidae family consists of 106 species worldwide, with a peak of diversity in the North-east Atlantic and the Mediterranean, where 24 species have been described. The striped seabream (*Lithognathus mormyrus* Linnaeus, 1758) is a commercially valuable sparid that is caught frequently in the Gulf of Gabes (southern coast of Tunisia). This species is widespread in the Eastern Atlantic from the Bay of Biscay off France to the Cape of Good Hope in South Africa (Bauchot & Hureau, 1986). It is a very common species throughout the Mediterranean Sea, Black Sea and Azov Sea. It also occurs in the Red Sea and in the South Western Indian Ocean (Bauchot & Hureau, 1986). It inhabits littoral waters over various types of bottoms (rocky, sand or sandy-muddy bottoms) from the surf zone to a maximum depth of 150 m, entering some estuaries and coastal lagoons (Bauchot & Hureau, 1986; Pajuelo *et al.*, 2002; Ribeiro *et al.*, 2006). *Lithognathus mormyrus* and other seabreams (Sparidae) are important members of the continental shelf demersal fish community (Bradai, 2000) and consequently of the fisheries of the Gulf of Gabes. This species has a reasonably high commercial and recreational value, with commercial landings reaching 544 tonnes in 2011, representing about 11% of total landings of sparid species from the southern Tunisian coasts (DGPA, 2011). Along the coast of the Gulf of Gabes, striped seabream is caught by a multi-gear fishing in many fisheries, mainly with trammel nets and gill nets. These two types of fishing gears accounted for ~67 and 33%, respectively, of the total catch by weight of striped seabream in the region, representing ~86% of total catch of this species from the continental shelf of Tunisia (DGPA, 2011).

Studying feeding habits of marine fish, such as predator–prey relationships is useful in order to assess the role of marine fish in the ecosystem (Bachok *et al.*, 2004). Data on diet composition are also useful for developing trophic models as a tool of understanding the complexity of coastal ecosystems (Lopèz-Peralta & Arcila, 2002; Stergiou & Karpouzi, 2002). Diet analysis is also necessary for exploring the trophic overlap within and between species and determining the intensity of the inter- and intraspecific interactions in marine fish communities (Morte *et al.*, 2001).

The diet of *Lithognathus mormyrus* has been investigated in the Mediterranean Sea (Suau, 1970; Badalamenti *et al.*, 1992; Chessa *et al.*, 2005; Harchouche *et al.*, 2005; Kallianiotis *et al.*, 2005) and in the Adriatic Sea (Froglia, 1977; Fabi *et al.*, 2006; Šantić *et al.*, 2010). In Tunisian waters, data on feeding behaviour of the species are scarce and have only been investigated by Bradai *et al.* (1998b).

The objectives of this study were to: (1) quantify the diet composition, (2) examine potential diet differences by predator size, sex and season and (3) qualitatively assess feeding strategy. This study will strengthen our knowledge on the feeding biology of *L. mormyrus* in Tunisia and in the Mediterranean Sea.

Corresponding author:
N. Ben Hadj Hamida
Email: naderhadj@yahoo.fr

MATERIALS AND METHODS

In the Gulf of Gabes, from the parallel 35°N to the Tunisian–Libyan border (33°10N), *Lithognathus mormyrus* is caught by different types of artisanal fishing gears (mostly gill nets and trammel nets) and also by trawl. A total of 1221 specimens were collected throughout the year from 2005 to 2007. These specimens range in size from 9.7 to 24.1 cm total length (L_T; Figure 1) and from 11.2 to 158.1 g in total weight. In the laboratory the total length of each fish was measured to the nearest 0.1 cm and weighed to the nearest 0.1 g. Specimens were then dissected, the number of empty stomachs recorded and prey identified to the lowest possible taxonomic level using Riedel (1963) and Fischer *et al.* (1987a, b). In order to perform a qualitative and quantitative description of the diet, the following indices were used:

Percentage frequency of occurrence (%*F*): number of stomachs in which a food item was found, expressed as a percentage of the total number of full stomachs.
Percentage numerical abundance (%*N*): number of each prey item expressed as a percentage of the total number of food items in all stomachs.
Percentage gravimetric composition (%*W*): total weight of each prey item, expressed as a percentage of the total weight of stomach contents.
Index of relative importance (IRI) (Pinkas *et al.*, 1971) as modified by Hacunda (1981), to estimate the contribution of prey items in the fish diet:

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

The index was expressed in percentage as follows:

$$\%\mathrm{IRI} = \frac{\mathrm{IRI}}{\sum \mathrm{IRI}} \times 100.$$

In order to evaluate periods of feeding activity, the index of vacuity (I_V) was calculated as follows: number of empty stomachs divided by total number of stomachs multiplied by 100.

Prey species were sorted in decreasing order according to IRI. The cumulative %IRI was calculated from the main food categories and compared among different groups according to sex, size and season. To assess for possible changes in diet with respect to size, fish were divided into three size-classes: juvenile ($L_T \leq 13.0$ cm, N = 236), transitional or subadult ($13.0 < L_T \leq 16.0$ cm, N = 569) and adult ($L_T > 16.0$ cm, N = 416).

Statistical differences ($P < 0.05$) in the diet composition with respect to size, season and sex were assessed by a χ^2 test (Sokal & Rohlf, 1981) of the frequencies of a given prey. The variation of vacuity index was also tested by χ^2 test over a contingency table of the number of empty stomachs.

The effect of size and season on the mean number (Nm ST^{-1}) of prey items and mean weight per stomach (Wm ST^{-1}) were tested by analysis of variance (ANOVA). Tukey's test was employed to locate the source of significant differences (Zar, 1984).

Proportional food overlap between seasons was calculated using Schoener's (1971) dietary overlap index: $C_{xy} = 1 - 0.5 \sum |P_{xi} - P_{yi}|$, where P_{xi} and P_{yi} are the proportions of prey I (based on %IRI) found in the diet of groups *x* and *y*. This index ranges from 0 (no prey overlap) to 1 (all food items in equal proportions), and values ≥0.6 are usually considered to indicate significant overlap (Wallace, 1981).

The trophic level (TROPH) was estimated as follows (Pauly *et al.*, 2000):

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

where TROPH_j is the fractional trophic level of prey (*j*), DC_{ij} is the fraction of *j* in the diet of *i* and *G* is the total number of prey species. Trophic levels express the positions of organisms within the food webs that define a large part of aquatic ecosystems (Stergiou & Polunin, 2000). The determination of different prey trophic levels was based on Froese & Pauly (2000), Stergiou & Karpouzi (2002) and on Fishbase.

Relative importance of prey items, for interpretation of the feeding strategy, was constructed graphically using a variation of the Costello method (Costello, 1990) proposed by

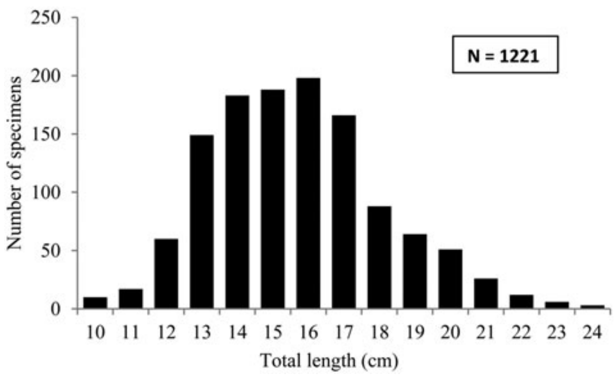

Fig. 1. Length-frequency distribution of *Lithognathus mormyrus* specimens caught in the Gulf of Gabes (N = 1221); juveniles ($L_T \leq 13.0$ cm, N = 236), transitional or subadults ($13.0 < L_T \leq 16.0$ cm, N = 569) and adults ($L_T > 16.0$ cm, N = 416).

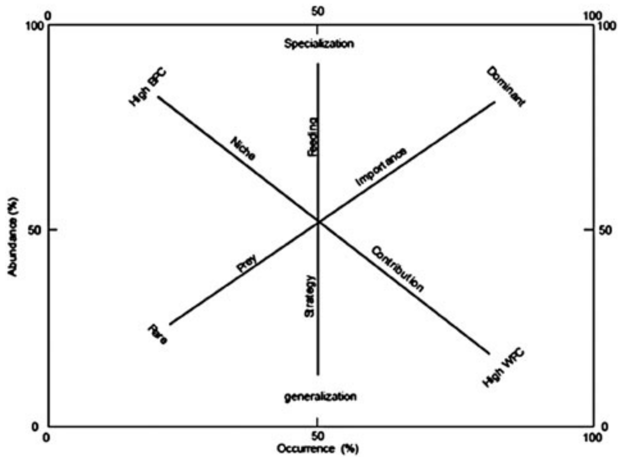

Fig. 2. Schematic representation of species feeding strategies proposed by Costello (1990) and modified by Amundsen *et al.* (1996). The first diagonal represents abundance increase along with prey importance. The vertical axis represents predator strategy going from generalist to specialist. The second diagonal axis represents resource use changing from BPC (between phenotype component, among individuals of population) to WPC (within phenotype component – tending towards the same resource use).

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Amundsen *et al.* (1996). This analysis is based on a graphical representation (Figure 2), making it possible to explore ingested food types, data in relation to feeding strategies, as well as intra- and inter-individual shifts in niche utilization.

RESULTS

Feeding intensity and trophic level

Of the 1221 stomachs examined, 1115 were empty (I_V = 91.3%). This percentage varied significantly by season (χ^2 = 45.95, $P < 0.05$), with a maximum of 95.79% during the summer and a minimum of 82.25% during the autumn (Table 1). The I_V analysis shows a low significant difference between the sexes ($\chi^2 = 4.63$, $P < 0.05$), whilst a high significant difference among size-classes ($\chi^2 = 40.99$, $P < 0.05$) (Table 2).

The calculation of trophic level gave an average of 3.63 ± 0.59 for the whole population of *L. mormyrus* in the Gulf of Gabes. According to the classification of Stergiou & Karpouzi (2002), the species is an omnivore with a preference for animal material (2.9 < TROPH < 3.7). This level was 3.66 for females and 3.58 for males, and increased from 3.59 for the smallest size class to 3.7 for the largest size.

The TROPH of this species varies significantly among season. According to Stergiou & Karpouzi (2002), the species seems to be omnivore with a preference for animal material during autumn (TROPH = 3.57 ± 0.57) and spring (TROPH = 3.6 ± 0.52), and carnivore with a preference for large decapods, cephalopods and fish (3.7 < TROPH < 4.5) during winter (TROPH = 3.79 ± 0.6) and summer (TROPH = 4.06 ± 0.7).

Diet composition

The stomach contents of the striped seabream consisted of eight major systematic groups: Red algae (Rhodophytes), sponges, echinoderms (Echinoids), crustaceans (Decapoda Macroura, Brachyura, Isopoda), annelids, molluscs (Cephalopoda and Gastropoda) and teleosts (Gobiidae, Engraulidae, Clupeidae) (Table 3). Crustaceans were the main prey, constituting 84.6% of the total IRI. Among these crustaceans, shrimps (particularly *Trachysalambria palaestinensis*) were the most important prey (%IRI = 56.1). Teleosts and molluscs were consumed as secondary prey (%IRI = 7.4 and 5.8 respectively). The other food items were of minor importance.

There were no dietary differences between sexes (χ^2 = 0.779, $P > 0.05$).

Diet composition in relation to fish size

Crustaceans were the most important prey in the diet of all size-classes (94.9, 88.8 and 75.2% IRI in juveniles, subadults and adults, respectively), but their importance is reduced when fish mature. For subadults, annelids (%IRI = 5.4) and molluscs (%IRI = 4.6) were relatively important; while teleosts (%IRI = 15.2) and molluscs (%IRI = 6.9) were frequent in the diet of larger fishes. Molluscs, teleosts and annelids are only part of the food spectrum of individuals greater than 13 cm total length. A χ^2 test revealed no significant differences in the diet among size-classes in any prey category ($\chi^2 = 11.352$, $P < 0.05$) (Figure 3A).

A nearly full dietary overlap was observed between juveniles, subadults and adults (0.99–1). The mean number of prey items (ANOVA, $F = 2.27$; $P > 0.05$) and the mean mass per stomach (ANOVA, $F = 1.68$; $P > 0.05$) were not significantly different between seasons (Figure 4).

Diet composition in relation to season

Analysis of the stomach contents of *L. mormyrus* in the Gulf of Gabes evidenced significant differences in the diet composition of this species among seasons ($\chi^2 = 112.716$, $P < 0.01$).

Crustaceans were present in the stomachs throughout the year, with a peak recorded in autumn (%IRI = 97). However, in winter, the ingested proportion of crustaceans decreases considerably (IRI% = 6) and constitutes a secondary food item. Teleosts, molluscs and annelids were not consumed by striped seabream during winter; the species seems to prefer other items (sponges, echinoderms and algae) with 94% of total IRI (Figure 3B).

During spring, striped seabream feeds mainly on molluscs (%IRI = 51.5%) and crustaceans (%IRI = 51.5%). Annelids are secondary item prey, while teleosts are ingested occasionally. The diet of *L. mormyrus* during summer was dominated by teleosts (%IRI = 81); crustaceans (%IRI = 14.1%) and annelids (%IRI = 4.4) are secondary prey.

The mean weight (Wm ST^{-1}) of prey items did not vary significantly throughout the year (ANOVA, $F = 2.18$, $P > 0.05$). The mean number (Nm ST^{-1}) of prey items showed a tendency to increase from winter (1 prey) to summer season (1.06 prey), but not significantly (ANOVA, $F = 0.74$, $P > 0.05$). Schoener's index (0.99) indicates high degree of diet overlap between all seasons (Table 4).

Feeding strategy

The feeding strategy plots (Figure 4) revealed that *L. mormyrus* ate predominantly crustaceans. We regarded this species as specializing in this food item during all seasons.

Table 1. Variation in the Index of Vacuity (I_V) of *Lithognathus mormyrus* by season.

Season	Non-empty stomachs	Empty stomachs	Total	Vacuity index	χ^2
Spring	28	283	311	91.00	0.04
Summer	17	387	404	95.80	10.20
Autumn	52	241	293	82.25	30.38
Winter	9	204	213	95.78	5.33
Total	106	1115	1221	91.20	45.95

Table 2. Variation in Index of Vacuity (I_V) of *Lithognathus mormyrus* by size classes.

Classes	Non empty stomachs	Empty stomachs	Total	Vacuity index	χ^2
TL ≤ 13 cm	4	232	236	98.31	14.53
13 < TL ≤ 16 cm	38	531	569	93.32	2.88
TL > 16 cm	64	352	416	84.62	23.58
Total	106	1115	1221	91.32	40.99

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Table 3. Diet composition of *Lithognathus mormyrus* in the Gulf of Gabes.

Taxa	Species	F%	N%	W%	IRI	IRI%
Crustacea	*Metapenaeus monoceros*	3.77	3.51	12.68	61.09	0.82
	Trachysalambria palaestinensis	20.75	21.05	30.87	1077.57	14.46
	Sicyonia carinata	0.94	0.88	2.01	2.72	0.04
	Non-identified shrimp	17.92	16.67	8.61	453.04	6.08
	Total shrimp	43.40	42.11	54.16	4177.71	56.06
	Non-identified crab	5.66	5.26	2.04	41.32	0.55
	Isopoda	0.94	0.88	0.07	0.89	0.01
	Non-identified crustacean	5.66	5.26	3.44	49.27	0.66
	Total Crustacea	55.66	53.5	59.7	6301.8	84.56
Teleostei	*Mullus barbatus*	0.94	0.88	0.63	1.42	0.02
	Gobius sp.	0.94	0.88	3.85	4.46	0.06
	Engraulis encrasicolus	5.66	5.26	5.03	58.25	0.78
	Sardina pilchardus	2.83	2.63	7.53	28.75	0.39
	Non-identified Teleostei	5.66	5.26	2.27	42.67	0.57
	Total Teleostei	16.04	14.91	19.31	548.83	7.36
Mollusca	*Sepia officinalis*	3.77	3.51	3.48	26.38	0.35
	Non-identified Cephalopoda	1.89	1.75	0.32	3.92	0.05
	Total Cephalopoda	5.66	5.26	3.81	51.33	0.69
	Nassarius reticulatus	0.94	0.88	0.03	0.85	0.01
	Non-identified Gastropoda	1.89	1.75	3.44	9.80	0.13
	Non-identified bivalve	6.60	6.14	3.22	61.79	0.83
	Non-identified mollusc	0.94	0.88	1.56	2.30	0.03
	Total Mollusca	16.04	14.91	12.05	432.40	5.80
Polychaeta		7.55	7.02	6.45	101.61	1.36
Echinodermata	*Paracentrotus lividus*	5.66	5.26	1.24	36.79	0.49
	Non-identified echinoderm	1.89	1.75	0.32	3.92	0.05
	Total Echinodermata	7.55	7.02	1.56	64.73	0.87
Algae	*Ceramium* sp.	0.94	0.88	0.03	0.85	0.01
Spongia		0.94	0.88	0.11	0.93	0.01
Non-identified item		0.94	0.88	0.79	1.57	0.02
Total		105.7	100	100	7452.76	100

F, frequency of occurrence; *N*, numerical composition; *W*, biomass composition; IRI, Index of Relative Importance.

These plots also position prey types which indicate some individual specialization in some periods, e.g. molluscs, in spring; teleosts in summer, annelids in autumn and echinoderms in winter. The variability in resource breadth between individuals was high (high variation between phenotypes).

DISCUSSION

Dietary studies of *Lithognathus mormyrus* in the Gulf of Gabes, show a high proportion of empty stomachs. This is consistent with results of Bradai *et al.* (1998b) who estimated annual I_V to be 94.1% in the same area. Fabi *et al.* (2006) and Harchouche *et al.* (2005) reported a high I_V for *L. mormyrus* in the northern Adriatic ($I_V = 68.5\%$) and in the Bay of Algiers and Annaba ($I_V = 62.8\%$ for juveniles and 64.3% for adults), respectively, while Šantić *et al.* (2010) found a very low I_V value (17.7%) for striped seabream from eastern central Adriatic Sea. However, the proportion of empty stomachs is often variable in commercial Sparid catches.

The high $\%I_V$ may also be related to the fact that captures occurred at night, which is when the fish are most active as they are generally feeding. The individuals caught were hauled on board the following morning, so some of them may have remained in the net for several hours, and their capture may have occurred after the digestion of prey. As a result, many specimens had an empty stomach at the time they were collected.

In view of the lack of evidence of stomach reversion at capture, the high percentage of empty stomachs observed in the present study may reflect short periods of feeding followed by periods of rapid digestion. Feeding intensity is negatively related to the percentage of empty stomachs (Bowman & Bowman, 1980). In our study, vacuity index ($\%I_V$) values were increased in April–June which coincided with a gonad maturation period of *L. mormyrus* in the Gulf of Gabes (Bradai, 2000). Feeding intensity decreased during the winter and summer months, as can be deduced from the high number of empty stomachs (>90%). Different factors may cause a decrease in feeding activity in fish (Nikolsky, 1976). This can be explained either by the unavailability of the prey or by the temperature-dependent physiological process. According to Wassef & Eisawy (1985), temperature has a strong effect on the feeding activity of the seabream. In fact, Tyler (1971) reported that many demersal fishes show a decrease in the feeding rate as temperature drops. Surface temperatures of sea water measured in the Gulf of Gabes from July to October 2010 varied from 15.3 to 28.6 °C (Hajji, 2012).

However, the relatively greater feeding intensity of the species coincided with the autumn season, which may reflect the fact that the fish requires more energy to palliate the deficit due to the spawning event. Otherwise, I_V of *L. mormyrus* of the Gulf of Gabes varies according to size. I_V values decrease with fish age. In fact, juvenile fishes require much more energy for growth.

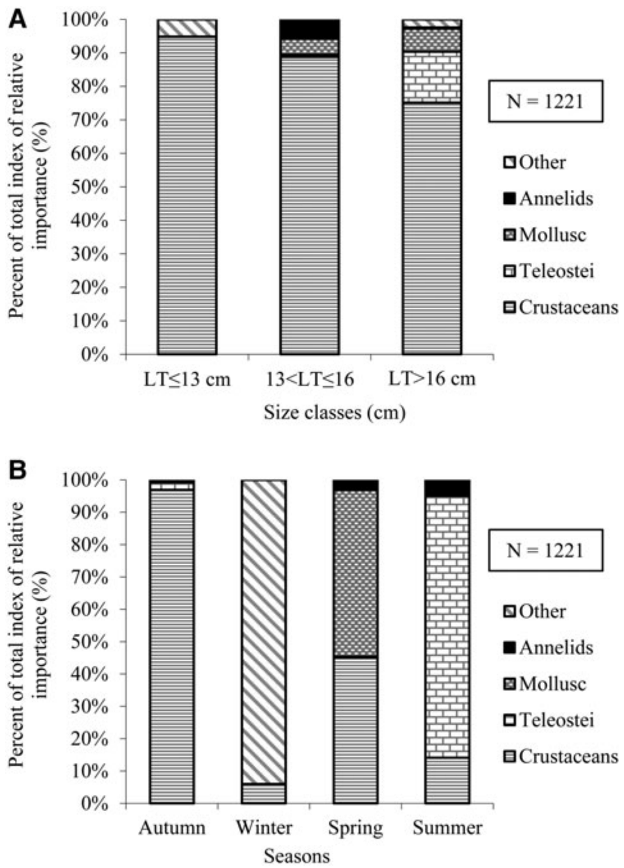

Fig. 3. Diet composition of *Lithognathus mormyrus* among sex (A), size classes (B) and season (C) based on percentage index of relative importance (IRI) values of major prey groups in the Gulf of Gabes.

Table 4. Seasonal proportional food overlap coefficients (Schoener's index) of the diet of *Lithognathus mormyrus*.

Seasons	Winter	Spring	Summer	Autumn
Winter	–			
Spring	0.999	–		
Summer	0.999	1.000	–	
Autumn	0.999	1.000	0.999	–

The present study revealed that the diet of *L. mormyrus* was diverse, and consisted mainly of crustaceans (%*F* = 55.66), teleosts (%*F* = 16.04) and molluscs (%*F* = 16.04), although the occurrence of annelids and echinoderms were also relatively important (%*F* = 7.55 each). Other prey groups, i.e. sponges and Red algae, were less important in the diet of striped seabream. In the Gulf of Gabes, Bradai *et al.* (1998b) found that crustaceans were preferential prey, while annelids and molluscs represented secondary food; remaining prey such as teleosts and tunicates were of minor importance and represented an accessory food.

Striped seabream is a carnivorous bottom feeder; juveniles presumably feed on copepods, small polychaetes and amphipods (Froglia, 1977; Jardas, 1985), whereas adults are more generalist feeders (Suau, 1970; Froglia, 1977; Badalamenti *et al.*, 1992).

According to Fabi *et al.* (2006), striped seabream appeared to be opportunistic, capable of adapting to environmental variations and exploiting the available food resources, although with different strategies. *Lithognathus mormyrus* focused mainly on decapods and molluscs, turning to other prey only when the preferred ones were scarce.

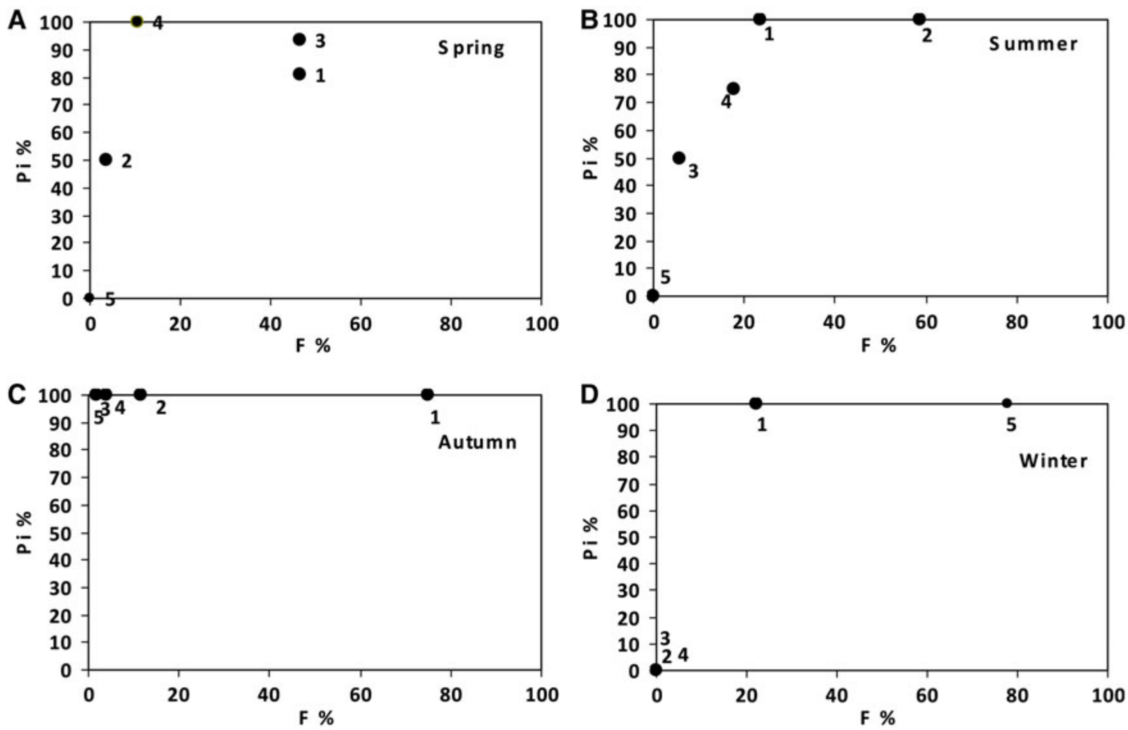

Fig. 4. Feeding strategy plots for *Lithognathus mormyrus* in (A) Spring, (B) Summer, (C) Autumn and (D) Winter. Prey types are numbered as follows: 1. Crustaceans; 2. Teleosts; 3. Molluscs; 5. Annelids; 5. Echinoderms.

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In the Italian and Hellenic waters, bivalves with polychaetes constituted the main prey items in the diet of this fish (Badalamenti *et al.*, 1992; Kallianiotis *et al.*, 2005).

Šantić *et al.* (2010) reported that *L. mormyrus* is an active seeking bottom feeder whose diet in the Adriatic Sea, as well as in Italian and Hellenic waters, consists of diverse benthic groups, with wide range of size and morphology. In the eastern central Adriatic Sea bivalves were the most important prey in all seasons as well as in large specimens, whereas copepods and amphipods constituted the main prey in stomach of smaller individuals. The present data are a step ahead to improve knowledge on the feeding ecology of striped sea bream.

Variation in the prey importance could be related to the presence/availability of different benthic assemblages among regions. In fact, Bradai (2010) noted that benthic invertebrates (Crustaceans and Molluscs) and fishes constitute the main components of benthic fauna of the Gulf of Gabes.

High seasonal variation in the diet of striped seabream was noticed within the study area. Values of Schoener's index (>0.9) indicated high significant dietary overlap between all seasons.

The striped seabream diet in autumn was dominated by crustaceans, whereas in spring there was an increase in the consumption of the molluscs. The diet of the striped seabream, during summer, consists mainly of teleosts. During winter, sponges, echinoderms and algae were the most important prey of the species.

In Hellenic waters (Thracian Sea), considerable seasonal variation was observed in the diet of striped seabream (Kallianiotis *et al.*, 2005). Bivalves dominated in spring, amphipods in winter, while polychaetes were more frequently preyed upon in other seasons. On the other hand, Šantić *et al.* (2010) found low seasonal variation in the diet of this species in the Adriatic Sea. Bivalves dominated the diet composition throughout the year, particularly in winter. Increased decapods consumption was observed during summer. These changes may be correlated to the seasonal variation in food availability (Kallianiotis *et al.*, 2005).

No significant variation in the diet of *L. mormyrus* among size was observed within the study area. Froglia (1977) reported that smaller specimens of *L. mormyrus* from western Adriatic coasts consume more copepods, cumaceans and juveniles of polychaetes, often switching to echinoderms, decapods, bivalves and teleosts as they increase in length. In the Thracian Sea, Kallianiotis *et al.* (2005) indicated that while maturing *L. mormyrus* becomes a more generalist feeder. The food consumption and the dietary overlap revealed significant changes in the diet of striped seabream with its growth in the eastern central Adriatic sea (Šantić *et al.*, 2010), where smaller specimens (<16 cm) mainly feed on amphipods and copepods; as the fish grows up, bivalves and decapods increase in importance.

According to the classification of fishes in functional groups based on their TROPH (Stergiou & Karpouzi, 2002), *L. mormyrus* was found to be considered as an omnivorous species with a preference for animal material. In addition, we compared its TROPH in other areas of its distribution based on published diet composition data (Table 5).

In our study based on the Amundsen's method, the striped seabream has a specialist feeding strategy. Crustaceans were the main diet of *L. mormyrus*, during all seasons. A dietary analysis is key to the assessment of feeding strategy (Amundsen *et al.*, 1996) and the breadth of a predator's diet (i.e. niche width; Schoener, 1971), which ultimately identify the functional role of a predator in an ecosystem.

Data on feeding of striped seabream from other areas indicate that the diet of the species includes a wide range of prey. Many of the authors (Rosecchi, 1987; Rosecchi & Nouaze, 1987; Kara *et al.*, 1997; Caragitsou & Papaconstantinou, 1998; Pita *et al.*, 2002; Pallaoro *et al.*, 2003) have observed generally analogous feeding habits in other species of Sparidae. Similar indications were also made by authors working on sparid species off the coasts of Tunisia (Ghorbel & Bouaïn, 1991; Bradai *et al.*, 1998a, Bradai, 2000; Chemmam-Abdelkader, 2004; Hadj Taieb *et al.*, 2013; Chaouch *et al.*, 2014).

In conclusion, *L. mormyrus* is an active seeking bottom feeder whose diet in the Gulf of Gabes, as well as in the Adriatic Sea and in Italian and Hellenic waters, consists of diverse benthic groups, with a wide range of size and morphology. It is mainly a specialist feeding strategy species with a preference for animal prey. In the Tunisian south-eastern waters, crustaceans were the most important prey of all size classes, particularly in autumn and spring, whereas molluscs and teleosts constituted the main prey in the stomach contents during spring and summer.

Feeding mechanisms that lead to specialization or generalization in the diet are not yet properly defined. This question is broad and has so far barely been addressed. Furthermore, morphological and physiological specialization can also influence fish feeding behaviour and must be considered. Further research will be focused on feeding ecology of *L. mormyrus* in order to better understand inter- and intra-specific interactions in the study area and elucidate the impact of climate changes on these interactions.

Table 5. Feeding habits of *Lithognathus mormyrus* in different areas. Length range (in total length) of specimens (in cm); TROPH: trophic level; SE: standard error of TROPH.

References	Areas	Length range	Main prey	TROPH	SE
Bradai *et al.* (1998b)	Gulf of Gabes	10.6–27.1	Crustaceans and annelids	3.53	0.55
Kallianiotis *et al.* (2005)	Thracian Sea	15.6–31	Polychaetes, molluscs bivalves, crustaceans	3.17	0.36
Fabi *et al.* (2006) (autumn)	Artificial Reef in Northern Adriatic	14–31	Crustaceans, molluscs bivalves, polychaetes, gastropods	3.34	0.47
Fabi *et al.* (2006) (summer)		15–34	Crustaceans, molluscs bivalves, gastropods, polychaetes, cnidarians	3.31	0.47
Šantić *et al.* (2010)	Eastern central Adriatic	12.8–31.7	Molluscs, bivalves, crustaceans, echinoderms, teleosts, polychaetes	3.31	0.43
Present study	Gulf of Gabes	9.7–24.1	Crustaceans (shrimps), teleosts, molluscs	3.63	0.59

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Correspondence should be addressed to:
N. Ben Hadj Hamida
Institut National des Sciences et Technologies de la Mer (INSTM), P.O. BOX 1035 – 3018 Sfax, Tunisia
email: naderhadj@yahoo.fr