DOI: 10.2478/cjf-2018-0017

CODEN RIBAEG ISSN 1330-061X (print), 1848-0586 (online)

DIET COMPOSITION AND TROPHIC LEVEL OF GREATER FORKBEARD *Phycis blennoides* (GADIFORM: PHYCIDAE) FROM THE ALGERIAN COAST

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ARTICLE INFO

Received: 13 June 2018
Received in revised form: 28 August 2018
Accepted: 30 August 2018
Online first: 6 November 2018

Keywords:
Feeding
Phycis blennoides
Cannibalism
Trophic level
Algerian coast

ABSTRACT

The diet of the greater forkbeard *Phycis blennoides* (Brünnich, 1768) of the Algerian coast was studied between December 2013 and June 2015, providing information on its ecology for a better understanding of the feeding strategy. A total of 956 individuals, whose total length (TL) varied between 9.7 and 54.5 cm and weight (W) between 2.80 and 1334.11 g, were examined. The index of relative importance (%IRI), combining the three main descriptors of the presence of different ingested prey (%F, %N, %W), was used to characterize the relative importance of different food taxa. Qualitative and quantitative variations in diet were studied according to sex, size and seasons. The average annual digestive vacuity index (%V) was 5.51. It did not vary between seasons (x^2_{cal} = 5.43, x^2_{th} = 7.82, α = 5%) and size (x^2_{cal} = 2.08, x^2_{th} = 5.99, α = 5%), but was different between male (%V = 4.94) and female (%V= 12.78). Qualitative analysis of stomach contents reveals a fairly diverse range of predation with 1342 preys counted for a total weight of 462.84 g, which corresponds to an average number (AN) and weight (AW) of 3.03 and 1.04 g, respectively. This species feeds on benthic preys, composed mainly of natantia crustaceans (%IRI = 44.84) and teleost fish (%IRI = 2.61) with intraspecific preys (%IRI = 6.15). This cannibalism was frequent in specimens with a TL that exceeds 20 cm; it was even more frequent in females as well as in winter. Significant differences in feeding habits of *P. blennoides* occurred according to sex, fish size and between seasons. The trophic level (TROPH) was high (3.66 < TROPH < 3.97), corresponding to carnivorous character.

How to Cite

Alioua, Z., Amira, S., Derbal, F., Rachedi, M., Bahbah, L., Bensari, B., Zerouali-Khodja, F. (2018): Diet composition and trophic level of greater forkbeard *Phycis blennoides* (Gadiform: Phycidae) from the Algerian coast. Croatian Journal of Fisheries, 76, 135-144. DOI: 10.2478/cjf-2018-0017.

INTRODUCTION

The greater forkbeard *Phycis blennoides* (Brünnich, 1768) frequents the Mediterranean Sea (Cohen et al., 1990) and Northeast Atlantic (Clarke, 2005). It is a nectobenthic (Sorbe, 1977; Stergiou and Karpouzi, 2002) and a dispersed fish (Clarke, 2005) whose size can reach 110 cm in total length (Cohen et al., 1990). This deep fish species frequents muddy bottoms, but also sandy bottoms, occasionally found at 10 m in depth (Cohen et al., 1990). It is generally sought over a large portion of the continental slope by means of trawling and longline by commercial fishers (Matarrese et al., 1998) between 200 and 1300 m (D'Onghia et al.,2004; Fernandez-Arcaya et al., 2013), and reached 1850 m (Rotllant et al., 2002). The maximum abundance of this species was stretched in the 200-400 m depth stratum (Massuti et al., 1996). Indeed, its commercial value is low (Sorbe, 1977; Morte et al., 2002), considered as "Least Concern" (Abdul-Malak et al., 2011) and "Data Deficient" (Garcia, 2015) in the IUCN red list of marine fish species in the Mediterranean.

Phycis blennoides is captured from artisanal fisheries by shrimp trawlers in the exploitable zones of the Algerian coast. It is mainly known for its organoleptic quality and its high commercial value (11-15 USD.Kg^{-1}) in the central region of Algeria. The presence of this species is very sporadic on the Algerian market, and the landed quantities are limited in space and time. These rare landings are possibly linked to the low frequency of occurrence in the natural environment, because of abiotic and biotic variations, or because of fishing gear accessibility or overexploitation. Only the reproductive biology was studied in western Algeria (Benghali et al., 2014a; 2014b). However, this paper aims to meet the need for information on *Phycis* genus in the south Mediterranean. In particular, we provide here the first complete study on the variation of the diet composition of *P. blennoides* in the Algerian coast for a better understanding of its trophic relations. In addition, the trophic level of *P. blennoides* and the cannibalism were studied.

MATERIAL AND METHODS

Sampling

Sampling of *P. blennoides* was carried out on 956 specimens ranging between 9.7 and 54.5 cm in total length (TL) and weighing (W) between 2.80 and 1334.11 g. Samples were collected monthly from commercial fisheries between December 2013 and June 2015 along the Algerian coast (Fig. 1). According to fishermen of the Algerian ports, *P. blennoides* was captured by longlines and mostly by bottom-trawl between 100-1300 m.

In the laboratory, total length (cm) and total weight (g) were measured for each specimen. The sex was determined according to Rotllant et al. (2002) criteria. The stomach of each individual was sectioned, weighed and kept in a 10% formaldehyde solution. The different ingested preys were sorted, identified according to the key of identifications (Alvarez and Crustáceos, 1968; Falciai and Minervini, 1992), counted and weighed. Prey identification was carried out to species level depending on the condition of the prey.

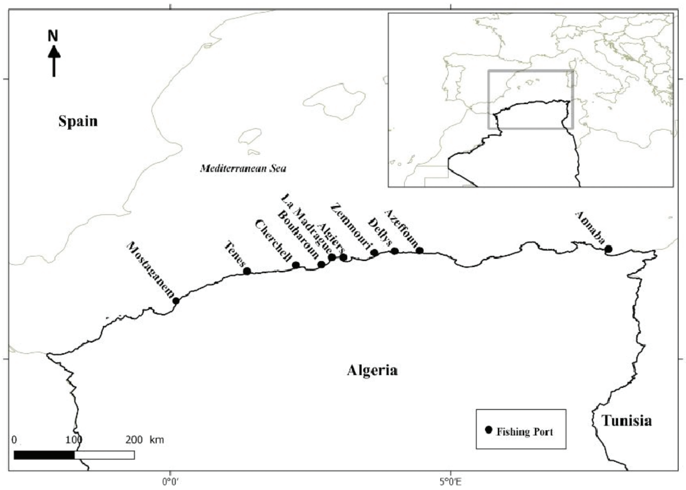

Fig 1. Study area with *Phycis blennoides* fishing ports along the Algerian coast

Diet analysis

The food indices used to assess diet composition (in number and mass) are the following:

The vacuity index: $\%V = \frac{Nv}{N' + Nv} \times 100$

Nv: number of empty stomachs;

N': number of full stomachs.

Significant changes in the stomach vacuity depending on sex (male, female), season (autumn, winter, spring, summer) and size (small, medium, large) were evaluated using the Chi-square test (χ^2_{cal}: calculated value, χ^2_{th}: theoretical value, risk α : 5%). These size categories were selected according to the length at first maturity of Rotllant et al. (2002) around 20 cm. Juveniles represent the small (s) category (< 20 cm), matures were divided into medium (m) and large (l) categories. According to our observations, the most common size in Algerian market and fisheries was between 20 and 30 cm, and large individuals with non-everted stomachs were rare (> 30 cm).

Frequency of prey occurrence: $\%F = \frac{Ni}{N'} \times 100$

Ni: number of stomachs with a category i of food;

N': number of full stomachs.

Percentage by number of a prey: $\%N = \frac{ni}{n} \times 100$

ni: number of individuals of the species i in the stomachs;

n: total number of preys identified in the same stomachs.

Percent biomass of a prey: $\%W = \frac{Wi}{Wt} \times 100$

Wi: total weight of item i in the stomachs of a predator;

Wt: total mass of prey identified in the whole of the stomachs of predators.

Index of Relative Importance: $\mathrm{IRI} = \%\mathrm{F} \times (\%\mathrm{N} + \%\mathrm{W})$ (Pinkas et al., 1971).

Percentage Index of Relative Importance: $\%\mathrm{IRI} = \left(\frac{\mathrm{IRI}}{\sum \mathrm{IRI}}\right) \times 100$ (Cortes, 1998; Liao et al., 2001).

The prey classification of the food spectrum is performed by Pinkas et al. (1971). Foods are then ranked by descending order according to the value of the index percentage obtained (Rosecchi and Nouaze, 1987; Liao et al., 2001). The Spearman coefficient (ρ) (Fritz, 1974) is applied to index percentages (%IRI) to compare the trophic compositions (sex, size, season) in order to test if foods are ingested in the same proportions. The concordance is verified by applying the following formula: $\rho = 1 - \frac{6\sum \mathrm{I}\, d^2}{n^3 - n}$ d: arithmetic difference between ranks assigned to the same item by the two judges or on two variables; n: total number of items to be classified. Preys were ranked in descending order of the IRI index to obtain two matching series. The number rank must be the same in both samples, so that if one of the categories of taxa does not appear in any of the samples, it is still assigned a rank. If the percentage of relative importance index is identical within the taxonomic series, we assign each item to a common rank, which will be the average of ranks that preys would have been if there was no tie. Statistical significance is known through the distribution of Student's t-test at n-2 degrees of freedom (Dagnelie, 1975).

The diversity index of Shannon-Weaver H' (Shannon and Weaver, 1964) allows identifying the diversity of prey in the power supply: $\mathrm{H}' = -\sum \mathrm{P}_i \times \log_2(\mathrm{P}_i)$, P_i: proportion of IRI (IRI_i / ΣIRI) represented by every prey species *i*.

Trophic level

The trophic level (TROPH) was estimated as follows (Pauly et al., 2000): TROPH = 1 + DC_{ij} x TROPH_j where TROPH_j is the fractional trophic level of prey (j), DCij is the fraction of j in the diet of i and G is the total number of prey species. TROPHs were calculated for each dataset based on the full array of prey items in the diet (Stergiou and Karpouzi, 2002). The position of organisms within the food webs (TROPHs) and their standard error (S.E.) were estimated from the gravimetric abundances of prey (%W) using the quantitative approach of TrophLab. The square root of O.I. is the S.E. of the TROPH (Christensen and Pauly, 1992a; 1992b).

RESULTS

In the total of 956 individuals of *P. blennoides*, 720 had full stomachs, 42 were empty corresponding to a low average vacuity (%V = 5.51) and 194 were everted. This phenomenon was observed in all size range (Fig. 2).

These stomachs were excluded from trophic index calculations (%F, %N, %W, IRI, %IRI) because their contents were expulsed. Then, the regurgitation of 20.29% stomachs was caused by the dilatation of the swim bladder. Out of a total of 720 full stomachs, 278 were much degraded and the qualitative analysis was possible on only 442 full stomachs given to the state of advanced digestion. A total of 1342 prey were identified with an overall weight of 462.84 g. This corresponds to an average number and weight of prey per stomach of 3.03 and 1.04 g, respectively. In total, 24 species were identified (Table 1). 16 carcinological species, 3 teleost fish species, a cartilaginous fish, 2 cephalopods and one species of Polychaeta and plant were numbered.

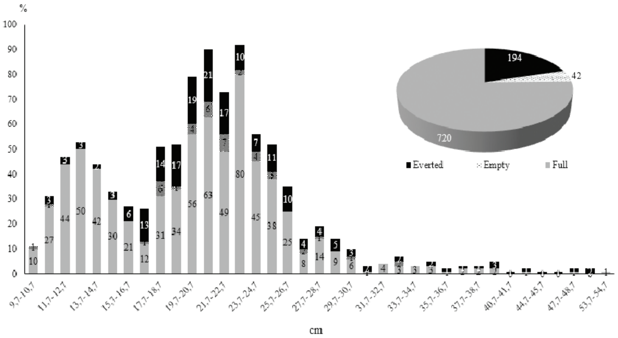

Fig 2. Length frequency distribution of *Phycis blennoides* specimens from the Algerian coast (total length in cm)

The trophic level of the total population was 3.94 units (S.E. = 0.67, O.I. = 0.82) (Table 2). The trophic level values indicate that this species could be considered carnivorous, regardless of the sex, size and seasons with a preference for decapods and fishes (3.66 < TROPH < 3.97; 0.79 < O.I. < 0.83) (Table 2).

The natantia decapods are preferred prey (%IRI = 44.84), specially represented by shrimp *Parapenaeus longirostris* (%IRI = 22.92) and *Alpheus glaber* %IRI = 18.84), followed by parasite nematodes (%IRI = 15.34). The reptantia decapods are also consumed in large quantities (%IRI = 13.03), especially *Calocaris macandreae* (%IRI = 12.08). Teleost fishes are also preferential preys (%IRI = 10.91). *P. blennoides* seems to show cannibalistic behaviour since the fish prey is essentially represented by *P. blennoides* (%IRI = 6.15). This species accidentally expanded its food spectrum to other

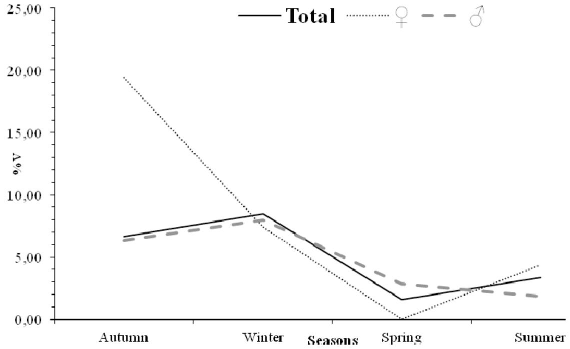

Fig 3. Seasonal variations in vacuity index (%V) of *Phycis blennoides* from the Algerian coast

Table 1. Qualitative and quantitative diet composition of *Phycis blennoides* in the Algerian coast. %F: Percentage by occurrence, %N: percentage of number, %W: percentage of mass, IRI: Importance relative index, %IRI: percentage of IRI, Pi: proportion of IRI (IRIi / Σ IRI), H': Shannon index

Prey items	%F	%N	%W	IRI	%IRI	Pi	H'
AMPHIPODA	0.23	0.08	0	0.02	0	0	0
ISOPODA (Total)	0.91	0.3	0.06	0.08	0	0	0
Gnathidae	0.23	0.08	0	0.02	0	0	0
Paranzia sp.	0.23	0.08	0.01	0.02	0	0	0
Rocinela dumerili	0.23	0.08	0.05	0.03	0	0	0
Isopoda und.	0.23	0.08	0	0.02	0	0	0
MYSIDA (Total)	1.36	0.67	0.01	0.7	0.02	0	0
Mysidae und.	1.13	0.6	0	0.68	0.02	0	0
Boreomysis megalops	0.23	0.08	0	0.02	0	0	0
DECAPODA (TOTAL)	123.6	62.07	51.71	1938.94	68.1	0.68	-1.98
Reptantia (Total)	28.31	12.85	17.53	371.03	13.03	0.13	-0.44
Munida curvimana	0.23	0.08	0.57	0.15	0.01	0	0
Anomura und.	1.13	0.37	0.34	0.4	0.01	0	0
Goneplax rhamboïdes	2.04	0.75	0.65	2.83	0.1	0	-0.01
Liocarcinus depurator	0.23	0.22	1.05	0.29	0.01	0	0
Monodaeus couchii	0.23	0.08	2.27	0.53	0.02	0	0
Xantho incises	0.23	0.15	0.11	0.06	0	0	0
Xantho pilipes	0.23	0.08	0	0.02	0	0	0
Xantho sp.	0.23	0.08	0.1	0.04	0	0	0
Brachyoura und.	5.66	1.94	2.08	22.73	0.8	0.01	-0.06
Calocaris macandreae	17.87	9.02	10.23	343.93	12.08	0.12	-0.37
Reptantia und.	0.23	0.08	0.13	0.05	0	0	0
Natantia (Total)	66.54	36.78	27.07	1276.54	44.84	0.45	-1.12
Crangonidae	0.23	0.08	0	0.02	0	0	0
Pasiphaea sivado	3.17	1.71	0.31	6.41	0.23	0	-0.02
Pleisionika heterocarpus	0.23	0.08	0.23	0.07	0	0	0
Pleisionika narval	0.23	0.08	0.05	0.03	0	0	0
Sergestidae	0.23	0.08	0.02	0.02	0	0	0
Sergestes sp.	0.23	0.08	0.25	0.07	0	0	0
Alpheus glaber	21.95	8.5	15.94	536.26	18.84	0.19	-0.45
Parapenaeus longirostris	26.92	17.44	6.8	652.56	22.92	0.23	-0.49
Aristeus antennatus	1.58	0.52	1.16	2.67	0.09	0	-0.01
Natantia und.	11.77	8.21	2.31	78.43	2.76	0.03	-0.16
Crustacean und.	28.73	12.44	7.11	291.37	10.23	0.1	-0.42
TELEOSTEI (Total)	22.62	11.18	32.86	310.47	10.91	0.11	-0.51
Gadiculus argenteus	0.68	0.45	0.65	0.74	0.03	0	0
Phycis blennoides	8.6	3.95	16.41	175.03	6.15	0.06	-0.25
Merluccius merluccius	0.23	0.08	0.2	0.06	0	0	0
Gadidae und.	4.75	3.43	9.28	60.37	2.12	0.02	-0.12
Solea solea	0.23	0.08	0.42	0.11	0	0	0
Teleostei und.	8.15	3.2	5.9	74.16	2.61	0.03	-0.14
CHONDRICHTHYES (Total)	0.23	0.08	7.87	1.8	0.06	0	-0.01
Etmopterus spinax	0.23	0.08	7.87	1.8	0.06	0	-0.01
MOLLUSCA (Total)	1.81	1.27	2.1	1.19	0.04	0	-0.01
Illex coindetti	0.23	0.08	0.72	0.18	0.01	0	0
Loligo vulgaris	0.23	0.08	1.35	0.32	0.01	0	0
Gastropoda und.	0.68	0.82	0	0.56	0.02	0	0
Cephalopoda und.	0.45	0.22	0.04	0.12	0	0	0
Bivalvia und.	0.23	0.08	0	0.02	0	0	0
ANNELIDA (Total)	3.85	1.42	0.22	5.06	0.18	0	-0.02
Lysidice ninette	3.39	1.27	0.21	5.03	0.18	0	-0.02
Polychaeta und.	0.23	0.08	0	0.02	0	0	0
Annelida und.	0.23	0.08	0	0.02	0	0	0
NEMATHELMINTHE (Total)	27.38	15.8	0.15	436.6	15.34	0.15	-0.42
Nematoda	27.38	15.8	0.15	436.6	15.34	0.15	-0.42
VEGETAL (Total)	0.45	0.15	0.06	0.05	0	0	0
Posidonia oceanica	0.23	0.08	0.06	0.03	0	0	0
Vegetal remain	0.23	0.08	0	0.02	0	0	0
UNDETERMINED(Total)	5.66	1.94	1.4	16.33	0.57	0.01	-0.04
Parasits und	0.45	0.22	0	0.1	0	0	0
Undetermined preys	5.2	1.71	1.4	16.23	0.57	0.01	-0.04
REMAIN (Total)	15.61	5.14	3.56	135.78	4.77	0.05	-0.21

Table 2. Trophic level, standard error and omnivory index in *Phycis blennoides* of the Algerian coast. TROPHs: Trophic level, S.E: Standard error, O.I: Omnivory Index, TP: Total population

	Male	Female	<20	20-30	>30	Autumn	Winter	Spring	Summer	TP
TROPHs	3.97	3.92	3.66	3.92	3.95	3.88	3.86	3.89	3.91	3.94
S.E.	0.69	0.68	0.62	0.67	0.69	0.67	0.63	0.67	0.67	0.67
O.I.	0.83	0.82	0.79	0.82	0.83	0.82	0.79	0.82	0.82	0.82

preys such as annelids, Chondrichthyes, molluscs, isopods, amphipods and plants (%IRI < 1).

The vacuity is significantly higher (χ^2_{cal} = 9.66, χ^2_{th} = 3.84; α = 5%) in females (V = 12.78%) than in males (V = 4.94%) (Fig. 3, Table 3).

Both sexes have dietary preferences for *C. macandreae* and *A. glaber* with different proportions of number and weight. Fish prey are better represented in females ($\%IRI_{♀}$ = 29.28) than males ($\%IRI_{♂}$ = 17.33) with a cannibalistic behaviour in both sexes but higher in females ($\%IRI_{♂}$ = 9.53, $\%IRI_{♀}$ = 19.45). Qualitatively, the Shannon-Weaver index indicates in both sexes a similarity in diversity of prey ingested (H' = 3.31) (Table 3). Quantitatively, males ingest twice as many voluminous prey as females ($An_{♂}$ = 15.28, $Aw_{♂}$ = 8.05 g; $An_{♀}$ = 6.44, $Aw_{♀}$ = 4.45 g) (Table 3). The Spearman correlation coefficient confirms the heterogeneity of the diet between the two sexes (ρ = 0.164, t_{obs}: 1.263, α < 0.05). No significant variation (χ^2_{cal} = 2.08, χ^2_{th} = 5.99, α = 5%) of the vacuity index was observed between the three size categories (V_s = 3.06%, V_m = 7.39%, V_l = 6.9%) (Table 3). Small individuals (TL < 20 cm) feed mainly on natantia (%IRI = 73.45%), especially shrimp *P. longirostris* where parasitic nematodes are regularly present (% IRI = 15.54). However, teleost fishes are ingested mainly by medium (%IRI = 24.09) and large (%IRI = 12.78) specimens, and less often by small individuals (%IRI = 1.6). Qualitatively, the Shannon-Weaver index indicates a higher specific diversity in medium-sized individuals (H'_m = 3.41), compared to that of small (H'_s = 2.23) and large specimens (H'_l = 3.26). If the average number of preys decrease with increasing in size (A_n = 20.8, 16.15, 4.00), the volume of these preys increase considerably with an average weight of 4.05, 6.80 and 6.91 g, respectively, for small, medium and large sizes. Statistical comparison of the diet, based on the three categories of size, shows that it is heterogeneous for the three pairings: small-medium (ρ = 0.178, t_{obs} = 1.313), medium-large

Table 3. Sexual, ontogenetic and seasonal variations of diet in *Phycis blennoides* of the Algerian coast. %V: Vacuity coefficient, Tr: Taxon richness, AN: Average prey numbers, AW: Average prey weight (g), Nfs: Number of full stomach, H': Shannon Index, Abs: missing preys, 0.00: preys without weight, ρ: Spearman, ρ_{cal}: calculated value, ρ_{th} : theoretical value

Prey items	Male	Female	<20 cm	20-30 cm	>30 cm	Autumn	Winter	Spring	Summer
AMPHIPODA	Abs	Abs	0.00	Abs	Abs	0	0	0	0.00
ISOPODA	0.00	Abs	0.01	0.00	Abs	0.02	0.02	0	0.00
MYSIDA	0.00	0.15	0.02	0.03	Abs	0	0.26	0.09	0.00
REPTANTIA	23.89	20.93	2.52	22.91	37.72	7.20	43.78	16.08	4.95
NATANTIA	28.33	20.08	73.45	22.25	19.13	23.21	15.52	36.96	64.72
CRUSTACEA und.	14.91	9.74	3.70	14.56	16.58	34.16	6.21	15.86	3.33
TELEOSTEI	17.33	29.28	1.60	24.09	12.78	23.92	18.04	4.74	6.54
CHONDRICHTHYES	0.27	Abs	0.00	0.00	3.33	0	0	2.92	0.00
MOLLUSCA	0.07	0.43	0.01	0.11	0.15	0.63	0.24	0.05	0.00
ANNELIDA	0.01	0.16	0.26	0.09	Abs	0.01	0.31	0.05	0.23
NEMATHELMINTHE	10.56	13.10	15.54	9.97	2.62	4.56	9.71	8.61	17.29
VEGETAL	0.00	0.06	Abs	0.00	0.16	0	0.03	0.05	0.00
%V	4.94	12.8	3.06	7.39	6.9	6.64	8.46	1.61	3.33
Tr	11	9	11	11	8	8	10	10	10
An	15.3	6.44	20.8	16.2	4	9.42	7.33	6.67	23.06
Aw	8.05	4.45	4.05	6.8	6.91	4.56	4.17	3.95	6.48
Nfs	173	46	236	180	26	109	78	42	213
H'	3.31	3.31	2.23	3.41	3.26	2.94	2.57	3.49	2.53
Variations	Male-female		Small-medium	Small-large	Medium-large	Autumn-winter	Winter-spring	Spring-summer	Autumn-summer
Spearman (ρ_{cal}) (ρ_{th}=0.587)	0.164		0.178	0.416	0.252	0.208	0.208	0.252	0.184

(ρ = 0.252, t_{obs} = 1.536) and small-large (ρ = 0.416, t_{obs} = 1.855, $\alpha < 0.05$), which means that the diet of small fish is different from those of medium and large-sized fish. No significant differences in the vacuity of *P. blennoides* were observed (x^2_{cal} = 5.43, x^2_{th} = 7.82, α = 5%) among the four seasons (Figure 3), however, this species feeds without disruption. The lowest vacuity is recorded in spring (%V = 1.61) and the highest in winter (%V = 8.46) (Table 3). Reptantia dominate in winter (%IRI = 43.78) followed by spring (%IRI = 16.08), whereas natantia dominate in autumn (%IRI = 23.21) and summer (%IRI = 64.72). The ingestion of teleost fishes is considerable in cold weather, especially in autumn (%IRI = 23.92) and winter (%IRI =18.04), with a continuous cannibalism in all seasons. However, the highest value of conspecific individuals is recorded in winter (%IRI = 17.48). In addition, one cartilaginous fish was found in spring, ranked as accidental prey (%IRI = 2.92). The small crustaceans of peracarida (mysids, amphipods, isopods), molluscs, annelids and vegetal are accidentally ingested in very small quantities, whatever the sampling season (%IRI < 1). The presence of nematode worm (nemathelminths parasites) in the diet is more pronounced in summer (%IRI = 17.29) than in other relatively cooler periods ($\%IRI_{Spring}$ =8.61, $\%IRI_{Autumn}$ = 4.56, $\%IRI_{Winter}$ = 9.71). According to the Shannon-Weaver index, the spring period is more diversified (H '= 3.49) than the other seasons (H'_{Autumn} = 2.94, H'_{Winter} = 2.57, H'_{Summer} = 2.53). It is in summer that *P. blennoides* consumes mainly large prey (An = 23.06, Aw = 6.48 g) with a food preference for natantia crustaceans (% IRI = 64.72). The mean proportions in number and weight of other carcinological prey and teleost fish vary substantially between seasons (Table 3). The Spearman correlation coefficient confirms the heterogeneity of the diet between the four seasons (autumn-winter/winter-spring: ρ = 0.208, t_{obs} = 1.411, spring-summer: ρ = 0.252, t_{obs} = 1.536, autumn-summer: ρ = 0.184, t_{obs} = 1.333, $\alpha < 0.05$).

DISCUSSION

The diet of *P. blennoides* in the Algerian coast consists mainly of crustaceans (in particular natantia) and teleost fishes. The proportion of reptantia crustaceans and other taxonomic groups (nemathelminthe, annelids, chondrichthyes, molluscs, isopods, amphipods, vegetal) in the diet of this predator is very accessory. This specialization on carcinological and ichthyological prey is observed in other Mediterranean populations (Macpherson, 1978; Morte et al., 2002). Moreover, this species was described as carnivorous and euryphagous (Sorbe, 1977). The main target preys are natantia (*P. longirostris* and *A. glaber*) and reptantia decapods (*C. macandreae*). *A. glaber* and *C. macandreae* preys are mainly described in this species but with very different numerical and biomass quantities according to the study zones (Sorbe, 1977; Macpherson, 1978; Sartor, 1995; Morte et al., 2002). Mysids are negligible prey along the Algerian coast but are considered essential in the population of the Gulf of Valencia, notably the species *Anchialina agilis* and *Lophogaster typicus* (Morte et al., 2002). Otherwise, all the studies on the diet of *P. blennoides* (Sorbe, 1977; Macpherson, 1978; Sartor, 1995; Morte et al., 2002) show that the specific richness of crustaceans is between 75% and 95% of the total species identified in the stomach contents. The seasonal ontogenical and sexual variability in the *P. blennoides* diet reflects changes in prey availability and therefore an opportunistic feeding scenario. However, the data obtained in this study show that the dietary of the greater forkbeard differs qualitatively and quantitatively compared to those of other gadiforms, such as *Phycis phycis* (Morato et al., 1999), *Gadus morhua* (Magnussen, 2011; Krumsick and Rose, 2012), *Merluccius merluccius* (Sartor, 1995; Carpentieri et al., 2005; Stagioni et al., 2011; Philips, 2012; Abdellaoui et al., 2014) and *Merlangius merlangus* (Ross et al., 2016). Overall, fluctuations of vacuity values might depend on many factors, such as the nychthemeral period (diurnal and/or nocturnal captures), size of sample, technique and depth of sampling, hydrological conditions, water temperature and biological and physiological status of fish (state of gonad maturity or spawning period, digestion state of preys, everted and regurgitated stomach rate). The digestive vacuity of this study remains low (between 1.6 and 8.4% for the total population) and seasonal variations are not statistically significant with a higher value in winter (%V= 8.4). Similar values were observed in the Gulf of Valancia (Spain), an average vacuity of 7.8% reaching a maximum of 11.92% in winter (Morte et al., 2002). Also, during spawning time fish need more energy input in order to meet the reproduction requirements (Froese and Pauly, 2000). This finding agrees with the present results where the highest percentage of vacuity index was recorded during spawning season, which may be due to the need of energy for spawning as mentioned by Matarrese et al. (1998) in winter. The low values of the recorded vacuity index reflect the high trophic activity of *P. blennoides* along the Algerian coast which feeds continuously throughout the year, with a slight slowdown due to the reproductive process. These significant variations in vacuity during the breeding season are observed in many teleost fishes on the east coast of Algeria: Sparidae (Chaoui et al., 2005, Benchalel et al., 2010), Moronidae (Kara and Derbal, 1996) and Serranidae (Zaidi et al., 2017). Concerning the fish size, we did not perceive any significant variation of the vacuity (%V) of *P. blennoides* but it varies with sex. Females seems more affected by the decrease of feeding activity than males, because they prepare themselves for the reproductive process which needs a lot of energy reserves to produce eggs and reach the maturity later than males (Rotllant et al., 2002). Everted stomachs caused by swim bladder expansion during rapid decompression (DeMartini et al., 1996) are a common characteristic in phisoclistous fishes, particularly gadiforms (Bowman, 1986). In this study, 20.29% of everted stomach were noted due to the difference of absolute pressure in the environment (depth and shallower) during the fishing. Similar value was observed by Morte et al. (2002) in the Gulf of Valencia (%V=25.2%). This phenomenon is also observed in various marine and freshwater families, *e.g.* Esocidae (Treasurer, 1988), Lutjanidae (DeMartini et al., 1996; Justine et al., 2012), Moronidae (Sutton et al., 2004), Sparidae (Smrzlićet al., 2012; Pekmezci et al., 2014), Scombridae (Casti et al., 2017) and Serranidae (Dierking and Meyer, 2009; Justine et al., 2010a; Kouassi et al., 2010; Rachedi et al., 2018). From the numerical and biomass values, *P. blennoides* of the Algerian coast ingests a large quantity of voluminous prey in summer, however, Morte et al. (2002) observed voluminous preys during both summer and autumn. According to sex, males of the greater forkbeard are more voracious. They ingest a larger amount of voluminous prey conversely to females. Concerning fish size, a decrease in the number of prey with fish size was observed, then an increase of their mass with an increased fish size. However, Morte et al. (2002) also found that larger individuals than TL > 17.5 cm ingested more voluminous prey. Similar situation was observed in the Bay of Biscay, where the frequency, numerical and volumetric importance of preferential prey (natantia crustaceans, teleosts) increased with the growth of individuals (Sorbe, 1977). Consumption of conspecific individuals in teleosts is a common and widespread phenomenon in marine and freshwater ecosystems (Preciado et al., 2015). In this study, cannibalism has been confirmed, especially in individuals which exceed 20 cm in TL. This phenomenon is even more relevant in females and during winter. This behavior was reported accidentally in other Mediterranean populations (Macpherson, 1978; Morte et al., 2002) and can be considered as a population survival mechanism when resources are scarce in the environment (van den Bosch et al., 1988); it also serves as an important recruitment control factor (Uzars and Plikshs 2000; Claessen et al., 2004). This conspecific predation is considered to be a regulating factor in the density of natural populations (Fox, 1975; Uzars and Plikshs, 2000) and cultured populations (Hecht and Pienaar, 1993; Baras and Jobling, 2002; Puvanendran et al., 2008; Pereira et al., 2017). There is a lack of information on mechanisms that constrain this adaptive phenomenon (Preciado et al., 2015). In some cases, filial cannibalism has been related to an adaptive strategy in which parents consume some offspring to increase their future reproductive success (Klug, 2009). In this study, the rare landings of *P. blennoides* can be explained by this intraspecific predation which occured because of the low availability of food and unfavourable life conditions. The nematodes found in the stomach contents of *P. blennoides* were in larval stage. On the west coast of Algeria, Hassani and Kerfouf (2014) identified 8 species (*Anisakis simplex*, *A. physeteris*, *Hysterothylacium aduncum*, *H. manu*, *H.* sp., *Ascarophis collaris*, *Cucullanus cirratus* and *Capillaria gracilis*), while on the eastern Mediterranean coast of Tunisia, the same nematodes species were found in addition to *Hysterothylacium fabri* (Farjallah et al., 2006). These Nematodes have been reported in many commercial fish species with different prevalence (Justine et al., 2010a, b, 2012; Khlifa et al., 2013; Moravec and Justine, 2015; Shamsi et al., 2015; Casti et al., 2017). Most likely, nematodes of our study were not targeted directly by this predator but accidentally ingested with parasitized prey. These larvae are morphologically similar to Anisakidae and did not exceed 42 mm TL (average length = 20 mm). In the study area, *P. blennoides* occupies an important role as a top predator in the trophodynamics of the fish community. It has a carnivorous character regarding the high value of the trophic level. Similar feeding habits have been reported in the Mediterranean basin as well as around the Balearic Islands (TROPH = 3.77 ± 0.63) (Macpherson 1978; 1981). Further studies are needed to create a better understanding of the digestion process and nutrient absorption of *P. blennoides.* Additional information on its growth, sexuality in addition to the health status could identify the possible cause of its rare landings. Moreover, the exploitation rate would also be needed for a better management of natural stocks of *P. blennoides* along the Algerian coast. The diet analysis reveals the existence of similar habitats using associations between ecological and environmental factors and their resource (Bjornsson et al., 2011). Using data of many years, the feeding habits of the greater forkbeard during the spawning could have implications for abundance surveys, multispecies approaches, considerations about gear efficiency and bioenergetic models of cannibalism using prey size preference, and could improve the scientific basis for management of the complex mixed fishery of the greater forkbeard in the Algerian area.

ACKNOWLEDGEMENTS

This research is a part of a Thesis study, which is being carried out at the Department of Ecology, in Fisheries laboratory at the University of Science and Technology Houari Boumediene. The authors would like to thank Billel Boufekane and Sidiali Redha for allowing us to collect biological material, Rym Bachetarzi and Myriam Benali for their valuable help in identifying the polychaeta in the stomach contents.

SAŽETAK

SASTAV ISHRANE I TROFIČKA RAZINA TABINJE BJELICE *Phycis blennoides* (GADIFORM: PHYCIDAE) NA ALŽIRSKOJ OBALI

U razdoblju od prosinca 2013. do lipnja 2015. istraživan je sastav ishrane tabinje bjelice *Phycis blennoides* (Brünnich, 1768) na obali Alžira pružajući informaciju o ekologiji vrste te pridonoseći boljem razumijevanju strategije njenog hranjenja. Analizirano je ukupno 956 primjeraka čija je totalna dužina (TL) varirala između 9,7 i 54,5 cm i mase (W) između 2,80 i 1334,11 g. Za obilježavanje relativne važnosti različitih taksona u progutanoj hrani, korišten je indeks relativne važnosti (%IRI) kombinirajući tri glavna deskriptora prisustva različitog progutanog plijena. Kvalitativne i kvantitativne varijacije u ishrani proučavane su prema spolu, veličini i godišnjim dobima. Prosječni godišnji indeks praznine crijeva (% V) je bio 5,51. Nije varirao između sezona (x^2_{cal} = 5,43, x^2_{th} = 7,82, α = 5%) i veličine (x^2_{cal} = 2.08, x^2_{th} = 5,99, α = 5%), ali je bio različit između mužjaka (%V = 4,94) i ženki (%V= 12,78). Kvalitativna analiza sadržaja želudca otkriva prilično raznolik raspon predacije s izbrojana 1342 plijena ukupne mase 462,84 g što odgovara prosječnom broju (AN) i masi (AW) od 3,03 odnosno 1,04 g. Ova vrsta se hrani bentoskim plijenom, uglavnom sastavljenim od rakova plivača (natantia) (% IRI = 44,84) i riba košunjača (% IRI = 2,61) te s intraspecifičnim plijenom (% IRI = 6,15). Ova pojava kanibalizma je česta kod primjeraka s TL koja premašuje 20 cm a još je češća kod ženki u zimskom periodu. Značajne razlike u prehrambenim navikama *P. blennoides* javljaju se prema spolu, veličini ribe i godišnjim dobima. Trofička razina (TROPH) bila je visoka (3.66 <TROPH <3.97), što odgovara karnivornom karakteru vrste.

Ključne riječi: hranjenje, *Phycis blennoides*, kanibalizam, trofička razina, alžirska obala

REFERENCES

Abdellaoui, S., Masski, H., Tai, I., Labriyaj, K., Hassan, E. H. (2014): Feeding habits of *Merluccius merluccius* L. and its variability factors in the Moroccan Atlantic Sea. Journal of Biology and Earth Sciences, 4, 105-112.

Abdul-Malak, D., Livingstone, R. S., Pollard, D., Polidoro, A. B., Cuttelod, A., Bariche, M., Bilecenoglu, M., Carpenter, E. K., Collette, B.B., Francour, P., Goren, M., Kara, M. H., Massuti, E., Papaconstantinou, C., Tunes, L. (2011): Overview of the conservation status of the marine fishes of the Mediterranean Sea. Gland Switzerland and Malaga, Spain, IUCN, 61.

Alvarez, Z. R., Crustàceos, R. (1968): Decàpodos Ibéricos. Investigacion pesquera. BarcelonaTomo 32, agosto, Deposito legal M. 865-1958, 510.

Baras, E., Jobling, M. (2002): Dynamics of intra cohort cannibalism in cultured fish. Aquaculture Research, 33, 7, 461-479.

Benchalel, W., Derbal, F., Kara, M. H. (2010): Régime alimentaire du sar commun *Diplodus sargus sargus* (Sparidae) des côtes de l'est algérien. Cybium, 34, 3, 231-242.

Benghali, S. M., Mouffok, S., Kherraz, A., Zitouni, B. (2014a): Reproductive biology and growth of greater forkbeard *Phycis blennoides* (Brünnich, 1768) in Western Algerian coasts (Osteichthyes, Gadidae). Journal of Biodiversity and Environmental Sciences, 4, 6, 389-398.

Benghali, S. M., Mouffok, S., Kherraz, A., Zitouni, B. (2014b): Some aspect on the reproductive biology of greater forkbeard *Phycis blennoides* (Brünnich, 1768) in Western Algerian coasts (Osteichthyes, Gadidae). International Journal of Recent Research and Applied Studies, 19, 3, 199-206.

Bjornsson, B., Reynisson, P., Solmundsson, J., Valdimarsson, H. (2011): Seasonal changes in migratory and predatory activity of two species of gadoid preying on inshore northern shrimp *Pandalus borealis.* Journal of Fish Biology, 78, 4, 1110-1131.

Bowman, R.E. (1986): Effect of regurgitation on stomach content data of marine fishes. Environmental Biology of Fishes, 16, 1-3, 171-181.

Carpentieri, P., Colloca, F., Cardinale, M., Belluscio, A., Ardizzone, G.D. (2005): Feeding habits of European hake (*Merluccius merluccius*) in the central Mediterranean Sea. Fishery Bulletin, 103, 2, 411-416.

Casti, D., Scarano, C., Piras, M. C., Merella, P., Muglia, S., Piras, F., Garippa, G., Spanu, C., Luigi De Santis, E.P. (2017): Occurrence of Nematodes of the Genus *Anisakis* in Mediterranean and Atlantic Fish Marketed in Sardinia. Italian Journal of Food Safety, 6, 1, 6185.

Chaoui, L., Derbal, F., Kara, M. H., Quignard, J. P. (2005): Alimentation et condition de la dorade *Sparus aurata* (Telestoei: Sparidae) dans la lagune du Mellah (Algérie Nord Est). Cahier de Biologie Marine, 46, 221-225.

Christensen, V., Pauly, D. (1992a): A guide to the ECOPATH II software system (version 2.1). ICLARM Software 6, 72.

Christensen, V., Pauly, D. (1992b): The ECOPATH II – a software for balancing steady-state ecosystem models and calculating network characteristics. Ecological Modelling, 61, 169-185.

Claessen, D., De Roos, A. M., Persson, L. (2004): Population dynamic theory of size-dependent cannibalism. Proceedings. Biological Sciences, 271, 1537, 333-340.

Clarke, M. W. (2005): A life history approach to the assessment of deep-water fisheries in the northeast Atlantic. [cited 2018 May 18]. Available from http://www.fao.org/docrep/009/a0210e/a0210e0c.htm

Cohen, D. M., Inada, T., Iwamoto, T., Scialabba, N. (1990): FAO species catalogue: Gadiform fishes of the world. FAO Fisheries Synopsis, 125, 10, 442.

Cortes, E. (1998): Methods of studying fish feeding: Reply. Canadian Journal of Fisheries and Aquatic Science, 55, 2708.

D'onghia, G., Lloris, D., Politou, C. Y., Sion, L., Dokos, J. (2004): New records of deep-water teleost fishes in the Balearic Sea and Ionian Sea (Mediterranean Sea). Scientia Marina*,* 68, 3, 171-183.

Dagnelie, P. (1975): Analyse statistique à plusieurs variables. Presses agronomiques de Gembloux, 362.

DeMartini, E. E., Parrish, F. A., Ellis, D. M. (1996): Barotrauma associated regurgitation of food: implications for diet studies of Hawaiian pink snapper; *Pristipomoides filamentosus* (family Lutjanidae). Fishery Bulletin, 942, 250-256.

Dierking, J., Meyer, A. L. (2009): Prey regurgitation in the grouper *Cephalopholis argus*. Journal of Applied Ichthyology, 25, 5, 600-602.

Falciai, L. Minervini, R. (1992): *Guida dei crostacei decapodi d'Europa.* Prima edizione: giugno (Eds), 282.

Farjallah, S., Ben Slimane, B., Blel, H., Amor, N., Said, K. (2006): Anisakid parasites of two forkbeards (*Phycis blennoides* and *Phycis phycis*) from the eastern Mediterranean coasts Tunisia. Parasitology Research, 100, 1, 11-17.

Fernandez-Arcaya, U., Rotllant, G., Ramirez-Llodra, E., Recasens, L., Aguzzi, J., Flexas, M.M., Sanchez-Vidal, A., Lopez-Fernandez, P., Garcia, J. A., Company, J. B. (2013): Reproductive biology and recruitment of the deep-sea fish community from the NW Mediterranean Continental margin. Progress in Oceanography, 118, 222-234.

Fox, L. R. (1975): Cannibalism in natural populations. Annual Review of Ecology and Systematics, 6, 87-106.

Fritz, E. S. (1974): Total diet comparison fishes by Spearman rank correlation coefficient. Copeia*,* 1, 210-215.

Froese, R., Pauly, D. (2000): Concepts, design and data sources ICLARM, Los Banos Laguna, 344.

Garcia, S. (2015): *Phycis blennoides*. The IUCN Red List of Threatened Species 2015. [cited 2018 May 2]. Available from: http://www.iucnredlist.org/details/198603/1

Hassani, M. M., Kerfouf, A. (2014): Diversity of Nematodes from the greater forkbeard *Phycis blennoides* (Teleostei: Gadidae) in the Western Mediterranean Sea. International Journal of Sciences: Basic and Applied Research, 18, 97-103.

Hecht, T., Pienaar, A. G. (1993): A review of cannibalism and its implications in fish larviculture. Journal of the World Aquaculture Society. 24, 2, 246-261.

Justine, J. L., Beveridge, I., Boxshall, G. A., Bray, R. A., Miller, T. L., Moravec, F., Trilles, J. P., Whittington, I. D. (2012): An annotated list of fish parasites (Isopoda, Copepoda, Monogenea, Digenea, Cestoda, Nematoda) collected from Snappers and Bream (Lutjanidae, Nemipteridae, Caesionidae) in New Caledonia confirms high parasite biodiversity on coral reef fish. Aquatic Biosystem, 8, 1, 22.

Justine, J. L., Beveridge, I., Boxshall, G. A., Bray, R. A., Moravec, F., Whittington, I. D. (2010a): An annotated list of fish parasites (Copepoda, Monogenea, Digenea, Cestoda and Nematoda) collected from Emperors and Emperor Bream (Lethrinidae) in New Caledonia further highlights parasite biodiversity estimates on coral reef fish. Zootaxa*,* 2691, 1- 40.

Justine, J. L., Beveridge, I., Boxshall, G. A., Bray, R. A., Moravec, F., Trilles, J. P., Whittington, I. D. (2010b): An annotated list of parasites (Isopoda, Copepoda, Monogenea, Digenea, Cestoda and Nematoda) collected in groupers (Serranidae, Epinephelinae) in New Caledonia emphasizes parasite biodiversity in coral reef fish. Folia Parasitologica, 57, 4, 237-262.

Kara, M. H., Derbal, F. (1996): Régime alimentaire du loup *Dicentrarchus labrax* (Poisson Moronidé) du golfe d'Annaba, Algérie. Annales de l'Institut océanographique 72, 185-194.

Khlifa, S., Faliex, E., Sasal, P., Galzin, E., (2013): Étude de l'infestation par des larves d'Anisakidés de trois espčces de poissons d'intérêt économique en Mauritanie. Cybium, 37, 1-2, 39-48.

Klug, H. (2009): Relationship between filial cannibalism, egg energetic content and parental condition in the flagfish. Animal Behaviour, 77, 1313–1319.

Kouassi, K. D., N'da, K., Diaha, N. C. (2010): Régime alimentaire du mérou blanc *Epinephelus aeneus* (Serranidae) de la pêche artisanale en Côte d'Ivoire. Cybium 34, 3, 263-268.

Krumsick, K. J., Rose, G. A. (2012): Atlantic cod (*Gadus morhua*) feed during spawning off Newfoundland and Labrador. ICES Journal of Marine Science, 69, 10, 1701-1709.

Liao, H., Pierce, C. L., Larsche, G. J. (2001): Empirical Assessment of Indices of Prey Importance in the diets of predacious fish. Transactions of the American Fisheries Society, 130, 583-591.

Macpherson, E. (1978): Regimen alimentario de *Phycis blennoides* Brünnich y Antonogadus megalok ynodon Kolom batovic Pisces: Gadidae en el Mediterraneo occidental. Investigacion Pesquera, 42, 2, 455-466.

Macpherson, E. (1981): Resource partitioning in a Mediterranean demersal fish community. Marine Ecology Progress Series, 4, 2, 183-193.

Magnussen, E. (2011): Food and feeding habits of cod (*Gadus morhua*) on the Faroe Bank. ICES Journal of Marine Science, 68, 9, 1909-1917.

Massuti, E., Morales-Nin, B. Lloris, D. (1996): Bathymetric distribution and recruitment patterns of *Phycis blennoides* (Pisces: Gadidae) from the slope of the northwestern Mediterranean. Scientia Marina, 60, 4, 481-488.

Matarrese, A., D'Onghia, G., Basanisi, M., Mastrototaro, F. (1998): Spawning and recruitment of *Phycis blennoides* (Phycidae) from the northwestern Ionian Sea (middle-eastern Mediterranean). Italian Journal of Zoology, 65, 203-209.

Morato, T., Solà E., Grós, M. P., Menezez, G. (1999): Diets of forkbeard (*Phycis phycis*) and conger eel (*Conger conger*) off the Azores during spring of 1996 and 1997. Arquipélago. 17A, 51-64.

Moravec, F., Justine, J. L. (2015): Anisakid nematodes (Nematoda: Anisakidae) from the marine fishes *Plectropomus laevis* Lacépčde (Serranidae) and *Sphyraena qenie* Klunzinger (Sphyraenidae) off New Caledonia, including two new species of *Hysterothylacium* Ward & Magath, 1917. Systematic Parasitology, 92, 3, 181-195.

Morte, M. S., Redon, M.J., Sanz, B.A. (2002): Diet of *Phycis blennoides* in relation to fish size and season in the western Mediterranean. Marine Ecology, 23, 2, 141-155.

Pauly, D., Froese, R., Sa-A, P., Palomares, M. L., Christensen, V., Rius, J. (2000): TrophLab Manual. Manila: ICLARM.

Pekmezci, G. Z., Onuk, E. E., Bolukbas, C. S., Umur, S. (2014): Molecular identification of Anisakis species (Nematoda: Anisakidae) from marine fishes collected in Turkish waters. Veterinary Parasitolpgy, 201, 1-2, 82-94.

Pereira, L. S., Agostinho, A. A., Winemiller, K. O. (2017): Revisiting cannibalism in fishes. Review in Fish Biology and Fisheries, 27, 3, 499-513.

Philips, A. E. (2012): Feeding behavior of the European hake *Merluccius merluccius* Linnaeus, 1758 (Family: Gadidae) from Egyptian Mediterranean waters off Alexandria. Egyptian Journal of Aquatic Research, 38, 1, 39-44.

Pinkas, L. M., Oliphant, S., Iverson, L. K. (1971): Food habits of albacore, bluefin tuna and bonito in Californian waters. Fish Bulletin, 152, 1-105.

Preciado, I., Punzón, A. Velasco, F. (2015): Spatio-temporal variability in the cannibalistic behaviour of European hake *Merluccius merluccius*: the influence of recruit abundance and prey availability. Journal of Fish Biology, 86, 1319-1334.

Puvanendran, V., Laurel, V. B., Joseph, A., Brown, J. A. (2008): Cannibalism of Atlantic cod *Gadus morhua* larvae and juveniles on first-week larvae. Aquatic Biology, 2, 113-118.

Rachedi, M., Derbal, F., Kara, M. H. (2018): Feeding habits of the comber *Serranus cabrilla* (Linnaeus, 1758) (Teleostei, Serranidae) from the gulf of Annaba (Eastern coast of Algeria), Cahier de Biology Marine, 59, 149-158.

Rosecchi, E., Nouaze, Y. (1987): Comparaison de cinq indices alimentaires utilisés dans l'analyse des contenus stomacaux.Revue des Travaux de l'Institut de Pêches Maritime, 49, 3-4, 111-123.

Ross, S. D., Gislanon, H., Andersen, N. G., Nielsen, J. R. (2016): The diet of whiting *Merlangius merlangus* in the western Baltic Sea. Journal of Fish Biology, 88, 5, 1965-1988.

Rotllant, G., Moranta, J., Massuti, E., Morales-Nin, B. (2002): Reproductive biology of three gadiform fish species through the Mediterranean deep-sea range (147-1850 m). Scientia Marina, 66, 2, 157-166.

Sartor, P. (1995): Regime alimentare di osteitti Gadiformi nel mar Tireeno settentrionale. Atti della Società Toscana de Scienze Naturali di Pisa, 102, 59-67.

Shamsi, S., Poupa, A., Justine, J. L. (2015): Characterisation of ascaridoid larvae from marine fish off New Caledonia, with description of new Hysterothylacium larval types XIII and XIV. Parasitology International, 64, 396-404.

Shannon, C. E., Weaver, W. (1969): The mathematical theory of communication. University of Illinois Press, Urbana, 125.

Smrzlić, I. V., Valić, D., Kapetanović, D., Kurtović, B. Teskeredžić, E. (2012): Molecular Characterisation of Anisakidae Larvae from Fish in Adriatic Sea. Parasitology Research, 111, 2385-2391.

Sorbe, J.C. (1977): Régime alimentaire de *Phycis blennoides* (Brünnich, 1768) dans le sud du Golfe de Gascogne. Revue des Travaux de l'Institut de Pêches Maritime, 41, 3, 271-281.

Stagioni, M., Montanini, S., Vallisneri, M. (2011): Feeding Habits of European Hake, *Merluccius merluccius* (Actinopterygii: Gadiformes: Merlucciidae), from the Northeastern Mediterranean Sea. Acta Ichthyologica et Piscatoria, 41, 4, 277-284.

Stergiou, K. I., Karpouzi, V. S. (2002): Feeding habits and trophic levels of Mediterranean fish. Review in Fish Biology and Fisheries, 11, 217-254.

Sutton, T. M., Cyterski, M. J., Ney, J. J., Duval, M. C. (2004): Determination of factors influencing stomach content retention by striped bass captured using gillnets. Journal of Fish Biology, 64, 903-910.

Treasurer, J. W. (1988): Measurement of regurgitation in feeding studies of predatory fishes. Journal of Fish Biology, 33, 2, 267-271.

Uzars, D., Plikshs, M. (2000): Cod (*Gadus morhua* L.) cannibalism in the Central Baltic: Interannual variability and influence of recruit abundance and distribution. ICES Journal of Marine Science, 57, 2, 324-329.

van den Bosch, F., de Roos, A. M., Gabriel, W. (1988): Cannibalism as a life boat mechanism. Journal of Mathematical Biology, 26, 6, 619-633.

Zaidi, R., Derbal, F., Kara, M. H. (2017): Temporal and ontogenic variations of diet of the goldblotch grouper *Epinephelus costae* (Serranidae) in the eastern coast of Algeria. Journal of the Marine Biological Association of the United Kingdom 97, 259-267.