THE DIET OF CONGER CONGER (L. 1758) IN THE DEEP-WATERS OF EASTERN MEDITERRANEAN SEA

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Abstract

The diet of European conger eel *Conger conger* was investigated for the first time in the Eastern Ionian Sea from specimens collected during experimental bottom long line fishing. Sampling was carried out of Cephalonia Island in deep waters ranging from 300 to 855 m depth in summer and autumn 2010. European conger eel diet was dominated by Fish. Natantia and Brachyura Crustacea were identified as secondary preys, while Cephalopoda, Sipunculida and Isopoda represented accidental preys. *C. conger* exhibits a benthopelagic feeding behavior as it preys upon both demersal and mesopelagic taxa. The high values of Vacuity index and the low stomach and intestine fullness indicated that the feeding intensity of *C. conger* in the deep-water of Eastern Ionian Sea was quite low. Larger individuals showed more intense feeding activity and consume larger preys than smaller ones. However, no statistically significant differences were detected in the diet composition and feeding intensity of the species between seasons or size groups.

Keywords: European conger eel, stomach analysis, intestine analysis, feeding, Ionian Sea.

Η ΔΙΑΤΡΟΦΗ ΤΟΥ CONGER CONGER (L. 1758) ΣΤΑ ΒΑΘΙΑ ΝΕΡΑ ΤΗΣ ΑΝΑΤΟΛΙΚΗΣ ΜΕΣΟΓΕΙΟΥ ΘΑΛΑΣΣΑΣ

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Περίληψη

Η διατροφή του μουγγριού *Conger conger* μελετήθηκε πρώτη φορά στο Α. Ιόνιο πέλαγος σε δείγματα που συλλέχτηκαν κατά τη διάρκεια πειραματικής αλιείας με παραγάδια. Η δειγματοληψία έλαβε χώρα ανοιχτά της Κεφαλλονιάς σε βαθιά νερά που κυμαίνονταν από 300-855 m βάθος, το καλοκαίρι και το φθινόπωρο του 2010. Στη δίαιτα του μουγγριού επικράτησαν τα ψάρια. Οι γαρίδες, τα Βραγχύουρα, και τα καρκινοειδή αποτέλεσαν δευτερεύουσα λεία, ενώ τα κεφαλόποδα, τα ισόποδα και τα Sipunculida, ευκαιριακή λεία. Το *C. conger* παρουσιάζει μια βενθοπελαγική διατροφική συμπεριφορά καθώς θηρεύει τόσο βενθοπελαγικές όσο και μεσοπελαγικές λείες. Οι υψηλές τιμές του δείκτη κενότητας καθώς και χαμηλή πληρότητα του στομάχου και του εντέρου που παρατηρήθηκε, υποδεικνύουν ότι η ένταση διατροφής του στα βαθιά νερά του Ιονίου πελάγους, είναι χαμηλή. Τα μεγαλύτερα άτομα έδειξαν πιο έντονη ένταση διατροφής και κατανάλωναν μεγαλύτερες σε μέγεθος λείες απ' ότι τα μικρότερα. Ωστόσω, καμία στατιστικά σημαντική διαφορά δεν εντοπίστηκε στη σύνθεση και την ένταση διατροφής σε σχέση με την εποχή ή το μέγεθος.

Λέξεις κλειδιά: μουγγρί, ανάλυση στομάχου, ανάλυση εντέρου, διατροφή, Ιόνιο πέλαγος.

1. Introduction

The European conger eel *Conger conger* L. 1758 is distributed in the northeast Atlantic from Norway to Senegal, in the Mediterranean and the western Black Seas (Bauchot and Saldanha, 1986, www.fishbase.org). It is a benthic fish found on rocky and sandy bottoms (Whithead et al., 1986; Fischer et al., 1986) living in a wide depth range (www.fishbase.org; Mytilineou et al., 2005). It stays near the coast when young and moves towards deeper waters when reaching adulthood (www.fishbase.org). Despite being a geographically widespread species and a relatively commercial resource (Tregenza et al., 1997; Relini et al., 1999; Morato et al., 1999; Machado et al., 2004), the number of studies on the feeding and even on the biology of European conger eel is very limited (Correia et al., 2002; O'Sullivan et al., 2003; Sbaihi et al., 2005; Correia et al., 2006a; Correia et al., 2006b; Correia et al, 2009; Correia et al., 2011, Abi-ayad et al., 2011). Information on the diet of this species has been reported from the north-eastern Atlantic Ocean (Olaso et al., 1995: Cantabrian Sea; Morato et al., 1999: Azores Islands; O'Sullivan et al., 2004: Irish waters; Xavier et al., 2010: south Portuguese waters), the Western Mediterranean (Abi-ayad et al., 2011: western Algerian waters) and the Central Mediterranean Sea (Cau and Manconi, 1984: Sardinian waters; Vallisneri et al., 2007: northern Adriatic Sea).

The present study is the first work for *C. conger* in the Ionian Sea. It aims to provide qualitative and quantitative information on the diet of the species from specimens caught by experimental long line fishing in the deep waters off Cephalonia Island. Seasonal and size related variations in diet were also studied.

2. Materials and methods

In total, 64 specimens of *C. conger* were collected during experimental bottom long line fishing conducted by HCMR in the Eastern Ionian Sea (Greek waters) within the framework of CORALFISH project (Fig.1). Sampling was carried out with a hired commercial boat in two sub-areas, a Coral (CA) and a non-Coral area (NCA) off Cephalonia Island, in deep waters from 300 to 855m depths during two seasons (summer and autumn 2010).

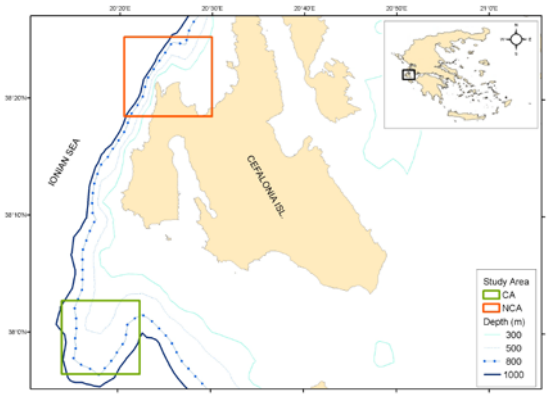

Fig. 1. Map of the study area off Cephalonia Island (Greek Ionian Sea) showing the two sampling sub-areas (CA: coral & NCA: non-coral areas).

The samples were iced immediately after capture and transported back to the laboratory where total length (TL), total weight (TW), net weight (NW), sex, maturity stage, stomach content weight (Wst) and intestine content weight (Wint) were recorded. From the collected European conger eels, 44 specimens were used for the diet study; their size ranging between 472-1480 mm TL. Stomach fullness was recorded using an empirical index of five-step scale, with 0 as empty and 5 as full stomach/intestine and their content weighted and analysed. Prey items were identified to the lowest possible taxonomic level counted and weighted (precision 0.001 g) in both stomachs and intestines. Fish otoliths and Cephalopod beaks were used for the identification of Fish and Cephalopod species respectively.

Feeding intensity was described by the following indices: (i) vacuity index VI [(number of empty stomachs/number of stomachs examined) x100], (ii) stomach/intestine fullness, estimated in two different ways: (iia) percentage of empirical fullness index and (iib) using the repletion index RI= (Wst or Wint/NW) * 100 (Morato et al., 2000). Four indices were used to describe diet composition by prey: (i) frequency of occurrence (F%); (ii) relative abundance (N%) (Hyslop, 1980); (iii) weight percentage (W%) and (iv) alimentary coefficient (Q%: F% x W%) (Hureau, 1970). The importance of various prey items was estimated using two different methods: (i) based on Q% considering preys as favorite for Q>200, secondary for 20<Q<200 and accidental for Q<20 (Hureau, 1970) and (ii) by the Index of relative importance (IRI) of Pinkas et al. (1971) as modified by Hacunda (1981) [IRI= (N% + W%) x %F] and expressed as percentage (IRI%).

All diet analyses were performed for two seasons (summer and autumn) and two size groups (TL<1000mm, TL>1000mm). Analysis of variance was applied for differences in RI of stomachs/intestines between seasons and size groups. Statistical differences in IRI values for all prey categories between seasons were established by applying the Spearman's rank correlation coefficient (r_s) (Zar, 1996).

3. Results

3.1. FEEDING INTENSITY

The vacuity index VI of *C. conger* by season and size group indicated generally high values (Fig. 2a, b). VI values were similar between seasons (~35%) (Fig. 2a). Different VI values were obvious between smaller (45%) and larger individuals (8%) (Fig. 2b). RI values were generally low (Fig. 2c, d) and did not presented statistically significant differences between seasons and size groups ($p>0.05$), although RIst was higher in summer than autumn and RIst of larger individuals was higher than that of smaller ones (Fig. 2d).

The fullness index analysis revealed mainly higher percentages for the three first stages of fullness (0-2) of the scale and lower percentages for the remaining ones (Table 2). Less full stomachs were observed than intestines. The intestines were in most cases in a medium fullness condition. Larger individuals showed higher stomach and intestine fullness indices compared to the smaller ones supporting the results of VI and RI analyses. Both stomach and intestine fullness indices indicated generally higher percentages in summer than in autumn (Table 2).

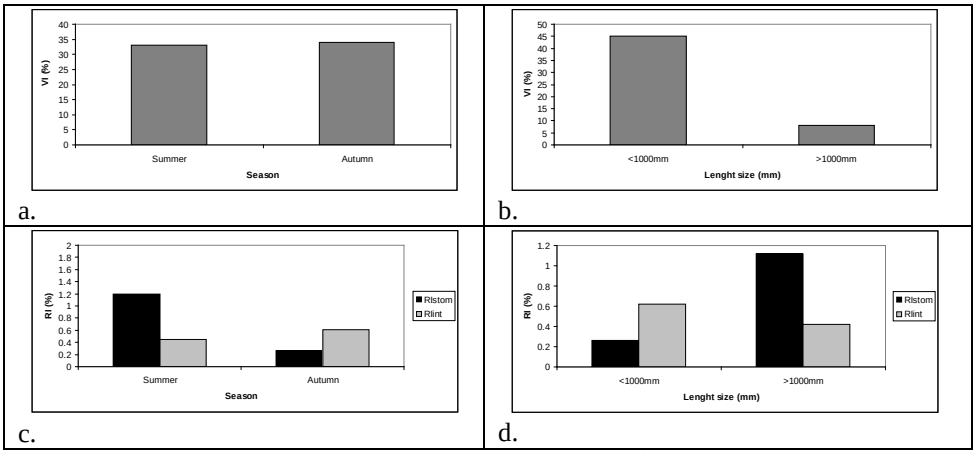

Fig. 2. Variation in the vacuity (VI) (a,b) and repletion (RI) (c,d) indices of *Conger conger* in the Eastern Ionian Sea by (i) season (summer and autumn) and (ii) size group (<1000 mm and >1000mm).

Table 2. Stomach and Intestine fullness index (%) of *Conger conger* per size group (<1000mm and >1000mm) and season (summer and autumn).

SCALE	<1000mm	>1000mm	<1000 mm	>1000mm	Summer	Autumn	Summer	Autumn
	Stomachs		Intestines		Stomachs		Intestines	
0	45	8	0	0	34	33	0	0
1	29	46	17	0	28	50	7	21
2	19	23	40	14	25	8	27	43
3	3	8	23	57	6	0	33	36
4	3	0	17	7	3	0	20	0
5	0	15	3	21	3	8	13	0
N	**31**	**13**	**30**	**14**	**32**	**12**	**30**	**14**

3.2. DIET COMPOSITION

The diet composition of the 44 examined *C. conger* specimens included 23 prey taxa in both stomach and intestines (Table 3, 4). Among examined individuals, only one had reverted stomach. Fish (Osteichthyes) were the dominant and most favorite prey (Q>200; IRIst: 93.4%; IRIint: 59.01%) ingested by this species. Crustaceans, particularly Natantia and Brachyura were the secondary preys (20<Q<200) found mainly in intestines (Table 4). Cephalopoda followed by Sipunculida and Isopoda were accidentally consumed (Q<20). Additionally, a significant number of parasites and especially nematodes, as well as a number of Turbellaria (Platyhelminthes) parasites were frequently found in the stomachs and intestines of the species (results not shown here). Some stones were included in the stomachs of a few individuals sporadically. Among the fish prey items, *Mora moro, Phycis blennoides* and Myctophidae remains were identified. In most cases, a higher taxonomic level of Osteichthyes could not be detectable from the presence of vertebrae and flesh remains. The cephalopod remains identified belonged to the families Histiotheuthidae (*Histiotheuthis bonnellii*), Enoploteuthidae (*Abralia veranyi*) and Sepiolidae (*Rossia macrosoma, Neorossia caroli, Heteroteuthis dispar*). Some cephalopod preys (*A. veranyi*, *R. macrosoma*) indices were not estimated, when prey weight was not available (Table 4).

Table 3. Stomach dietary composition and trophic indices of *Conger conger*. F%: by frequency of occurrence; N%: relative abundance; W%: weight percentage; Q: alimentary coefficient; IRI: index of relative importance.

TAXA	**F%**	**N%**	**W%**	**Q**	**IRI%**
NATANTIA	9.09	9.09	1.05	9.58	1.93
CEPHALOPODA	9.09	9.09	0.56	5.13	1.84
Histioteuthidae	4.55	4.55	1.62	7.35	0.59
Histioteuthis bonnellii	4.55	4.55	0.39	1.80	0.47
OSTEICHTHYES	59.09	59.09	9.44	557.63	84.74
Moridae					
Mora moro	4.55	4.55	86.92	395.09	8.70
STONES	9.09	9.09	0.01	0.1	1.7
Number of stomachs			29		
Number of prey			22		

Table 4. Intestine dietary composition and trophic indices of *Conger conger*. F%: by frequency of occurrence; N%: relative abundance; W%: weight percentage; Q: alimentary coefficient; IRI: index of relative importance.

TAXA	**F%**	**N%**	**W%**	**Q**	**IRI%**
BRACHYURA	8.57	7.69	24.48	188.28	11.21
Xanthidae	2.86	2.56	4.15	10.65	0.78
NATANTIA	14.00	17.94	22.22	398.63	21.31
ISOPODA	2.86	2.56	0.02	0.05	0.30
CEPHALOPODA	8.57	10.26	2.39	24.51	5.01
Enoploteuthidae					
Abralia veranyi	2.86	2.56			
Sepiolidae					
Rossia macrosoma	2.86	2.56			
Neorossia caroli	2.86	2.56	0.45	1.15	0.35
Heteroteuthis dispar	11.43	10.26	0.31	3.21	4.91
OSTEICHTHYES	25.71	23.08	31.92	736.57	57.49
Myctophidae	2.86	2.56	0.27	0.70	0.33
Phycidae					
Phycis blennoides	2.86	2.56	7.66	19.63	1.19
SIPUNCULIDA	5.71	5.13	0.22	1.17	1.24
UNIDENTIFIED	2.86	2.56	5.89	15.11	0.98
STONES	2.86	5.13	0.01	0.07	0.60
Number of stomachs			44		
Number of prey			35		

The diet analysis by season (results not shown here) indicated that IRI did not differ significantly between seasons according to Spearman Rank Correlation test. Fish was the dominant and most favorite prey category for both seasons (Q>>200; summer: IRI 89%; autumn: IRI 98%). In summer, Natantia was a secondary favorite prey (Q>200), followed by Brachyura and Cephalopoda which were identified as secondary preys (20<Q<200). In autumn, Natantia and Cephalopoda were found as secondary preys (20<Q<200).

Regarding the analysis by size (results not shown here), Fish was found the most favorite prey category in both groups (Q>>200). Among the identified fish prey taxa, *M. moro* and *P. phycis* were found only in the diet of the larger individuals, whereas the small sized Myctophids were mostly consumed by the smaller specimens. In the diet of larger specimens (TL> 1000mm) Natantia Crustacea, Cephalopoda and Sipunculida were shown to be accidental preys (Q<20). Individuals belonging to the small size group (TL<1000mm) consumed Natantia as a second favorite prey (Q>>200), whereas Brachyura and Cephalopoda as secondary preys. Among the latter, the small sized sepiolid *H.* dispar was the most frequent.

4. Discussion

The stomach and intestine content analysis of *C. conger* showed that the vacuity index presented relatively high values while the repletion and fullness indices relatively low values. This let us suggest that the feeding intensity of the species was quite low, particularly if we take into account that the digestion rate is supposed to be slow in the deep Mediterranean waters (Cartes and Abello, 1992). These results could be related to the following reasons: a) longline fishing is a passive method, which might select fish that are not satiated and which show a great response to eat the bait, b) sampling time may not coincide with the feeding time of the species, which has been reported as a nocturnal predator (Göthel, 1992) and c) the oligotrophic character of deep waters, suggested also by Gore (1984) for the family Polychelidae. The feeding intensity, according to the results of repletion index (RI) did not differ statistically between seasons and size groups, although it was found higher in summer than autumn and in larger than smaller size group.

The diet of *C. conger* in the deep waters of Eastern Ionian Sea was found to be based mainly on Osteichthyes. This prey group, which represents more than 50% of IRI and Q>200, can be classified as the main and favorite prey. Natantia and Brachyura Crustacea, were the prey of secondary importance. Cephalopoda, Sipunculida and Isopoda were of minor importance and probably represent accidental food. The results of the present study generally agree with the findings of other authors concerning the importance of Fish as favorite prey in the diet of *C. conger*. Regarding crustaceans, Cau and Manconi (1984), Morato et al. (1999), O'Sallivan et al. (2004) and Xavier et al. (2010) classified them as accidental preys in Sardinian, Irish, Azorean and South Portuguese waters respectively, whereas Abi-ayad et al. (2011) as favorite prey off western Algerian coasts. These differences may be attributed to geographical differences in prey availability.

According to our results, the diet of *C. conger* includes demersal fish (*M. moro* and *P. blennoides*), supra-benthic and bathy-benthic cephalopods (*A.* verany,i *R. macrosoma* and *N. caroli)*, benthic Brachyura, meso-pelagic Myctophids, meso-pelagic squids (*H. bonnelii*) and meso-pelagic *sepiolids* (*H. dispar*). Thus, it could be suggested that *C. conger* forages both in the near bottom layer and the water column. This is in accordance with the existing results for European conger eels from different geographic areas (Morato et al., 1999, O' Sullivan et al., 2004, Xavier et al., 2010).

The diet composition of *C. conger* in our study area indicated no seasonal variability. The observed seasonal changes in the index of relative importance IRI of the different prey taxa probably reflect fluctuations of the available prey in the environment. As a result, the increased Natantia consumption during summer could be related to the high densities of new recruits of decapod species that period (Robertson, 1984). Abi-ayad et al. (2011) reported also that diet of *C. conger* was homogeneous among seasons.

Considering the role of size, the larger European conger eels in the eastern Ionian Sea fed almost exclusively on fish, while the smaller ones consumed more Natantia as well as Cephalopoda and Brachyura. The increasing consumption of Natantia by the smaller individuals is in agreement with the findings of Olaso & Rodrígues-Marín (1995). According to these authors, the relative importance of decapod crustaceans appeared to be greater in the diet of European conger eel smaller than 35cm (TL). Moreover, Abi-ayad et al., (2011) found crustaceans as the most important prey in conger eels ranging from 220-940mm. Although, the smallest specimen caught in the present work was 472 mm, our findings might indicate a similar trend. The presence of larger (*M. moro* and *P. blennoides*) and smaller (Myctophidae) fish in the diet of larger and smaller European conger eels, respectively, reinforces the findings of Xavier et al. (2010), which mentioned a positive relationship between the *C. conger* body mass and the standard length of fish prey and fish prey mass.

The present study is the first work for *C. conger* in the Eastern Mediterranean Sea, focusing on its diet. Thus, it highlights our knowledge on a basic aspect of the species poor known life history in the area.

5. Aknowledgements

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