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Preliminary Results on the Feeding and Gut Content of *Flaccisagitta enflata* in Coastal Areas of İskenderun Bay (Northeastern Mediterranean Sea)

Tuba TERBIYIK KURT
Çukurova Üniversitesi, Su Ürünleri Fakültesi, Temel Bilimler Bölümü, Adana
✉: tterbiyik@cu.edu.tr

ABSTRACT

In this study, it was aimed to characterize the feeding and diet composition of the most common pelagic chaetognath *Flaccisagitta enflata*. Zooplankton samples were collected using a WP-2 zooplankton net (200 µm) at three stations in the İskenderun Bay in October 2016, December 2016 and March 2017. *F. enflata* was the most abundant chaetognath in all samples and its proportion varied from 42 to 94%. Younger stages (I and II) dominated the population of *F. enflata.* In total, 1663 specimens were examined, but only 185 contained prey in their guts. The total food-containing ratio and the number of prey items for this chaetognath species were 11% and 0.1, respectively. These values varied for different maturity stages. Most food items were unidentified due to digestion. Copepods were the main food resource (36.8%) for the species. Cannibalism was also observed.
This study is the first to describe *F. enflata* feeding behaviour in the coastal area of İskenderun Bay. The preliminary results show that the feeding ratios were within the ranges reported for other regions in the eastern Mediterranean Sea.

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Research Article

İskenderun Körfezi (Kuzeydoğu Akdeniz) Kıyısal Sularında *Flaccisagitta enflata* (Grassi, 1881)'nın Beslenmesi ve Bağırsak İçeriği Üzerine İlk Gözlemler

ÖZET

Mevcut çalışmada, en yaygın pelajik ketognat olan *Flaccisagitta enflata*'nın beslenmesi ve besin kompozisyonu karakterize edilmeye çalışılmıştır. Zooplankton örnekleri, İskenderun Körfezi'nde Ekim ve Aralık 2016, Mart, 2017 periyotlarında 3 istasyonda WP-2 zooplankton kepçesi (200 µm) ile toplanmıştır. Ketognatlar içinde, *F. enflata,* tüm periyotlarda baskın tür olarak gözlenmiş olup, oranı %42–94 arasında değişim göstermiştir. Erken olgunluk aşamaları (I ve II) *F. enflata* populasyonunda baskın olarak gözlenmiştir. Toplam 1663 birey incelenmiş olup, bunlardan sadece 185 bireyin bağırsağında besine rastlanmıştır. Bu tür için toplam besin içerme oranı (FCR) ve ketognat başına düşen besin miktarı (NPC) sırasıyla %11 ve 0.1 olarak bulunmuştur. Bu değerler olgunluk aşamalarına göre farklılık göstermiştir. Çoğu besin sindirilmiş olduğundan dolayı tanımlanamamıştır. Tanımlanan besin canlılar arasında kopepodlar ana besin kaynağını oluşturmuştur (%36.8). Bununla birlikte kannibalizm'de gözlenmiştir.
Bu çalışmada ilk kez İskenderun Körfezi'nin kıyısal alanında *F. enflata*'nın beslenmesi ile ilgili bilgiler elde edilmiş ve ilk gözlemler beslenme oranlarının Doğu Akdeniz'in diğer alanlarından elde edilen sonuçlar ile benzer olduğunu göstermiştir.

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INTRODUCTION

Chaetognaths are carnivorous organisms living in all marine and ocean habitats (Bone et al., 1991). Taking into consideration of their biomass and global distribution, this organism tends to be one of the most important groups in their ecosystems. The chaetognath biomass can be as high as 30% of the total biomass of copepods in all world oceans (Reeve, 1970).

The feeding is the main route for transferring energy and matter between communities from lower to higher trophic levels (Bamstedt et al., 2000). Chaetognaths are dominant zooplanktonic predators and generally affect the population of their food organisms in environmental conditions with low organic production (Kimmerer, 1984; Oresland, 1990), such as the Eastern Mediterranean Sea. They feed mainly on copepods (Oresland, 1987), however, they can occasionally can consume a wide variety of other zooplankters (Feigenbaum, 1991). This group may cause problems in fish breeding regions due to consuming fish larvae and eggs as food. Another factor that makes these organisms important is that they contribute significantly to the matter and energy cycle by creating an important link between larger-sized predators, including commercial fish species, and smaller-sized animal organisms (Reeve, 1970; Nagasawa and Marumo, 1981).

Various studies on the distribution of chaetognath species have been conducted in world oceans (Itoh et al., 2006; Kosobokova and Hopcroft, 2010; Coston-Clements et al., 2009; Pierrot-Bults and Nair, 2010; Noblezada and Campos, 2008), especially in the Mediterranean Sea (Andreu, 1992; Kehayias et al. 1994, 1996; Duro and Saiz, 2000; Kehayias 2003, 2004; Batistic et al., 2003; Terbıyık et al., 2007; Kehayias and Ntakou, 2008; Kehayias and Kourouvakalis, 2010). Besides studies on chaetognath distribution, the feeding and predation impact of chaetognaths on their prey has been the subject of several inadequate studies in the Mediterranean Sea (Kehayias et al., 1996; Duro and Saiz, 2000; Batistic et al., 2003; Kehayias, 2003; Kehayias et al., 2005; Kehayias and Kourouvakalis, 2010). These studies were conducted in the Western Mediterranean, Aegean and Adriatic Seas. However, there is no study on the feeding behaviour and diet content of chaetognaths in the Levantine Sea. Additionally, studies on chaetognaths in the Mediterranean coasts of Turkey are rare. Available studies explored the distribution (Terbıyık et al., 2007, Terbıyık and Sarıhan, 2008), ontogenetic stages (İşmen et al., 2003) and genetic structure (Hazar, 2006) of chaetognaths, but there are no studies on chaetognath feeding behaviour in the coast of Turkey.

More than twenty one chaetognath species are known to be distributed in the overall Mediterranean Sea (Kehayias et al., 1999b, Terbıyık et al., 2007; Terbıyık and Sarıhan, 2008). Among the chaetognath species, *F. enflata,* which has a global distribution, is one of the most important contributors and is a generally dominant species among chaetognaths in Mediterranean coastal ecosystems (Kehayias et al., 1999b).

The aim of this study was to provide new information about the ecological role of the chaetognath *F. enflata* as secondary consumers in the productive coastal areas of İskenderun Bay (northeastern Levantine Basin) by studying their diet and feeding ratio. Thus, the present study contributes to better understanding of the food web interaction in the pelagic ecosystem in order to provide basic information for future studies in the basin.

MATERIALS and METHODS

Study area

İskenderun Bay located in the north-eastern region of the eastern Mediterranean Sea covers approximately 2275 km^2 (Figure 1). The average depth of the Bay is around 70 m (Avşar, 1999) and it is known to have the largest continental shelf area after the Nile Delta in the eastern Mediterranean Sea. The Bay is affected by deep currents and wind movements because it has a wide opening connecting to open sea waters (İyiduvar, 1986). The largest stream that flows into the Iskenderun Bay is the Ceyhan River with an average flow rate of 180 m^3/ sec. There is clear seasonal cycling in the İskenderun coastal area. The temperature drops to approximately 17.5 °C in the winter-spring periods, and begins to rise after spring, reaching the highest levels in the summer (29.23 °C). Moreover, the salinity values fluctuate between 36.96 and 41.12‰ due to fresh water and terrestrial inputs (Terbıyık Kurt and Polat, 2015).

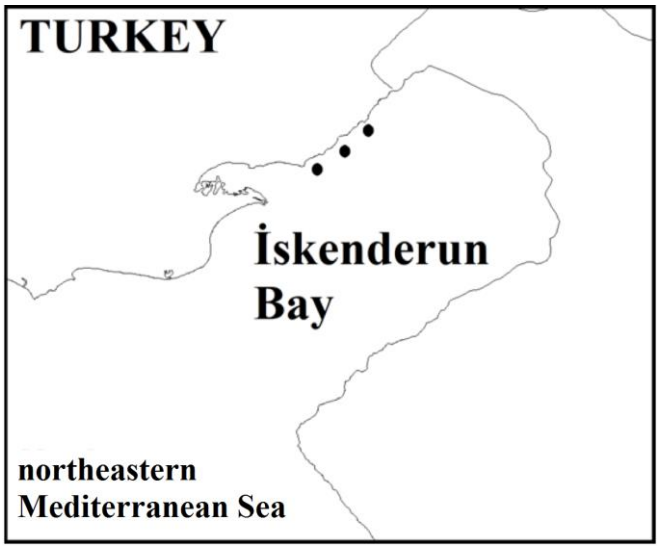

Figure 1. Study area and sampling stations

Samplings

Zooplankton samplings were performed at three stations in October 2016, December 2016 and March 2017 in the western coastal waters of İskenderun Bay. Zooplankton samples were collected vertically with WP-2 zooplankton nets (200 µm mesh size) (Figure 1).

After sampling, the collected material was transferred into a bottle (200 ml) and fixed with sea water-formalin solution (4%). The examination and counting were performed under the SZX 16 Olympus Stereomicroscope.

In the laboratory, all specimens of *F. enflata* were shorted from zooplankton. Abundance values were calculated as individuals per meter cube (ind. m^{-3}). The volume of the filtered water was calculated with the following formula (formula 1) using the haul depth and the radius of the frame of the net:

The volume of the filtered water = $\pi . r^2.h$ (Formula 1)

r: radius of frame of the net

h: haul depth

First, all specimens were classified according to the maturity stage (Table 1) as described by Kehayias et al. (1999a). Afterward, the specimens that contained food organisms in their guts were dissected and the food organisms were identified at the species or group level as much as possible. The food items in their guts were classified into three main categories of unidentified digested food, identified digested food and identified undigested food as described by Oresland (1987).

The food containing ratio (FCR), and the number of prey items per chaetognath (NPC) were calculated according to the method used by Batistic *et al.* (2003) for all maturity stages (Formula 2 and Formula 3, respectively)

FCR: (Number of chaetognaths containing food/total number of chaetognaths)x100 (Formula 2)

NPC: total number of prey items/total number of chaetognaths (Formula 3).

Table 1. Primary characteristics for classifying the maturity stages of chaetognath species.

Maturity stages	Characteristic features
Stage 1	Small individuals without eggs
Stage 2	Small seminal vesicle is absent
Stage 3	Ovaries and seminal vesicles are visible, but small
Stage 4	Seminal vesicle is full, ovaries are big

RESULTS

During the study period, six chaetognath species were observed in the study area: *Mesosagitta minima, F. enflata, Ferosagitta galerita, Serratosagitta serratodentata, Pseudosagitta lyra* and *Sagitta* sp. Among the chaetognaths, *F. enflata* was the most abundant species in all sampling periods (60 ± 33%), and the proportion varied from 42–94% (Figure 2).

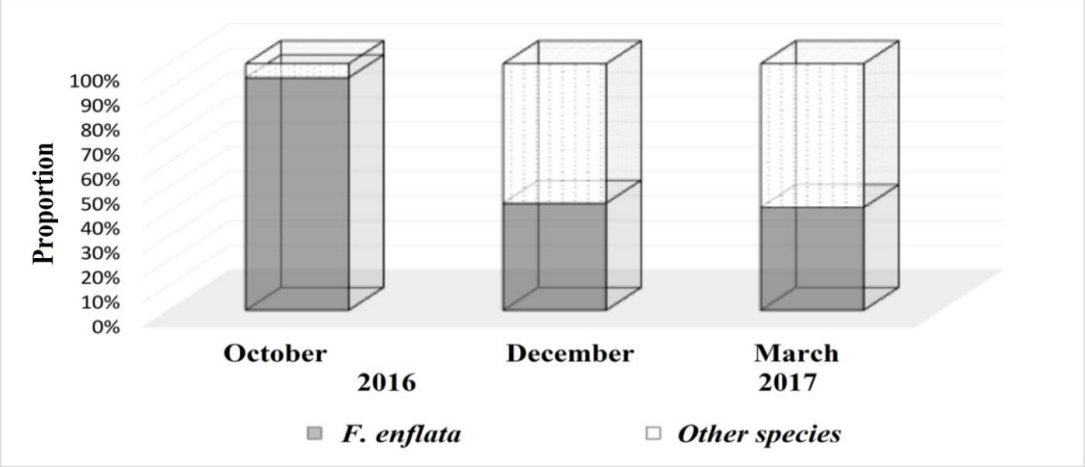

Figure 2. The proportion of *F. enflata* among the total chaetognath population

The mean abundance of chaetognaths was 92 ± 133 ind. m^{-3} and varied during the sampling periods (Figure 3). Younger stages (I and II) dominated the population of *F. enflata* (Figure 4).

In total, 1663 specimens were examined, but only 185 contained prey in their guts. The FCR and NPC for this species were 11% and 0.1, respectively. These values varied between sampling periods and maturity stages, and the highest FCR (Figure 5) and NPC (Figure 6) values were observed in immature specimens.

Most food items were unidentified due to digestion. The proportion of identifiable food organisms within digested and undigested foods was about 39.5%. copepods were the main food resource (36.8%) for this species, including the genera *Oithona, Microsetella, Centropages, Oncaea, Euterpina, Paracalanus,*

copepodits, and nauplii. Cannibalism was also observed (Table 2).

DISCUSSION and CONCLUSION

In the present study, the feeding ratio and diet composition of different maturity stages of *F. enflata* were investigated in the coastal waters of İskenderun Bay and importantly, information to help predict the impact of chaetognath feeding behaviour on the ecosystem was obtained.

Chaetognath species observed in the study area were evenly distributed in the Mediterranean Sea (Kehayias *et al.* 1994, 1996; Batistic *et al.*, 2003; Duro and Saiz, 2000; Kehayias, 2003, 2004; Kehayias *et al.*, 2005; Kehayias and Ntakou, 2008; Kehayias and Kourouvakalis, 2010) and also in the İskenderun Bay (Terbıyık and Sarıhan, 2008; İşmen et al., 2003; Hazar, 2006; Terbıyık Kurt and Polat, 2013).

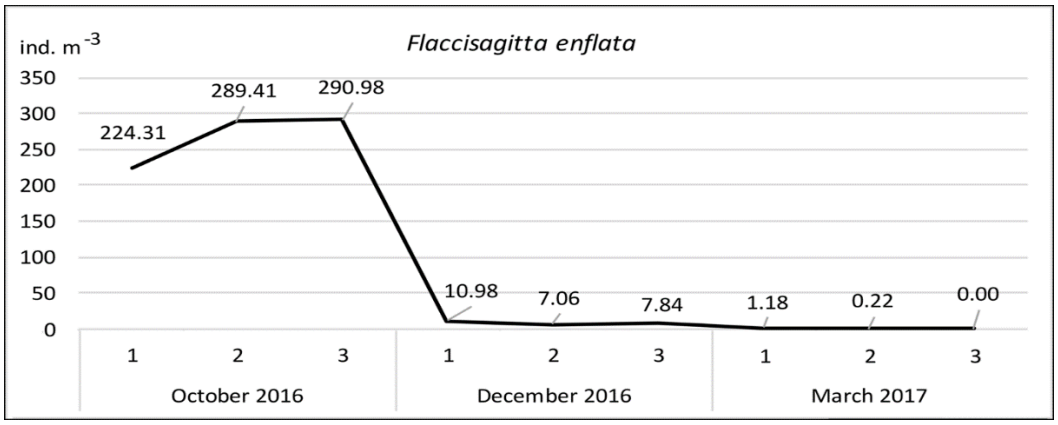

Figure 3. Changes in *F. enflata* abundance in sampling stations and periods (ind., individuals)

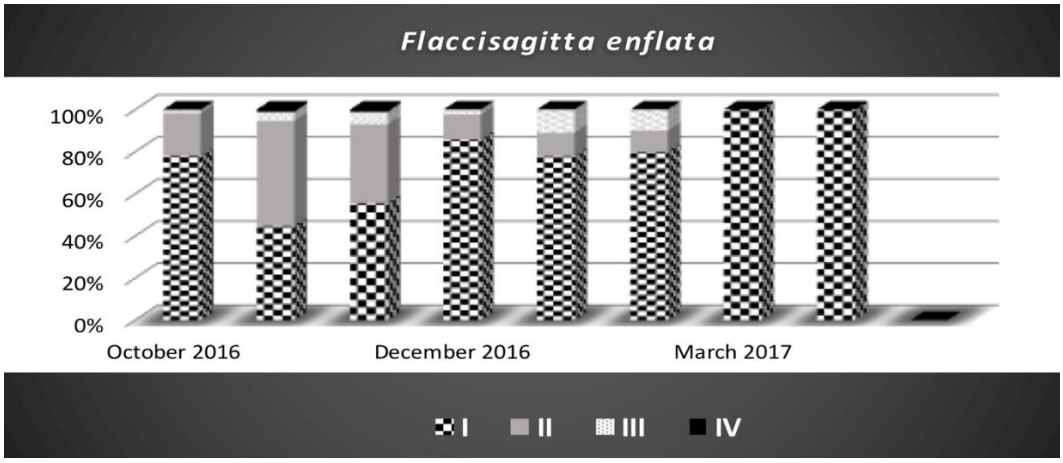

Figure 4. Graph of proportional distribution of different maturity stages of *F. enflata*

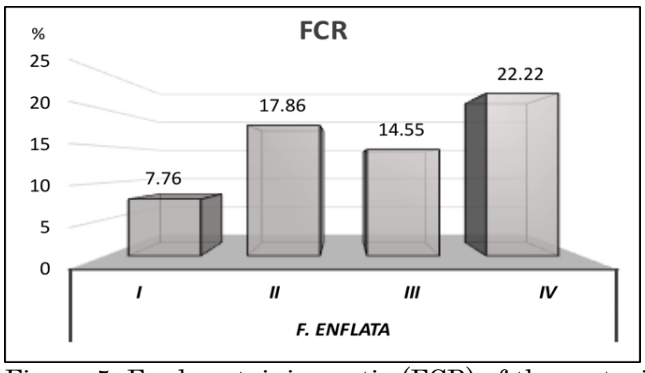

Figure 5. Food containing ratio (FCR) of the maturity stages of *F. enflata*

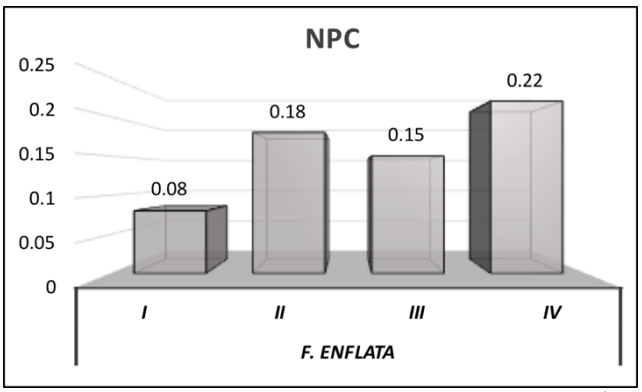

Figure 6. Number of foods per chaetognath (NPC) according to the maturity stages of *F. enflata*

Table 2. Gut content of *F. enflata*

Taxas		Proportion (%)
Digested unidentified foods		60.5
Copepoda	Adult	14.2
	Copepodite	2.7
	Nauplii	4.2
	Eggs	0.5
	Calanoida	4.2
	Centropages furcatus	1.6
	Paracalanus sp.	0.5
	Oithona sp.	0.5
	Oithona oculata	2.1
	Oithona plumifera	0.5
	Oncaea spp.	3.2
	Corycaeus sp.	0.5
	Harpacticoida	0.5
	Euterpina acutifrons	0.5
	Microsetella sp.	1.1
Chaetognatha	*F. enflata*	1.1
Appendicularia		1.6

F. enflata was similarly reported as a dominant species among chaetognaths in previous studies conducted in Iskenderun Bay (Terbıyık et al., 2007; Terbıyık and Sarıhan, 2008; Terbıyık Kurt and Polat, 2013). There are few studies on chaetognath feeding behaviour in the Mediterranean Sea and most of these studies reported data from the Aegean Sea (Kehayias et al., 2005; Kehayias and Kourouvakalis, 2010), Adriatic Sea (Batistic et al., 2003) and Western Mediterranean Sea (Duro and Saiz, 2000). The feeding ratios (FCR, NPC) determined in the present study are in agreement with the data reported from other regions of the Mediterranean Sea (Table 3). The FCR and NPC values, which were considered to be quite low, are indicative of low abundance values of fodder zooplankton (Stuart and Verheye, 1991). Indeed, the reported values of zooplankton abundance and biomass in similar seasons in the previous studies were lower than in other seasons (Terbıyık Kurt and Polat, 2013; Terbıyık Kurt and Polat, 2015).

It has previously been reported that copepods are the main food organisms for chaetognaths (Reeve, 1970; Pearre, 1974; Øresland, 1987; Duro and Saiz, 2000). Additionally, the taxonomic diversity of food organisms in this study was much lower than in other studies. The lower diversity of food organisms could be related to their low availability or abundance (Kuhlmann, 1977).

In conclusion, the data obtained in this study is similar to the results from other studies conducted in different regions of the Mediterranean Sea. The values related to feeding activity were considered low, and therefore, their effect on population of food organisms is rather limited. In this study, we obtained information for the first time regarding chaetognath feeding behaviour in the coastal waters of İskenderun Bay. The information could help researchers better understand the function and structure of the marine ecosystem. This data will also serve as a source for upcoming related studies.

Conducting similar studies in different species and different areas and revealing the temporal and spatial changes in relation to environmental variables will help researchers better understand the importance and conditions in the pelagic ecosystem.

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Table 3. Reported FCR and NPC values for *F. enflat*a in other regions of Mediterranean Sea

	Batistic et al. (2003) Adriatic Sea	Kehayias (2003) South Aegean Sea	Kehayias et al. (2005) North Aegean Sea	Duro and Saiz (2000) Catalan Sea	Present study
FCR	0-13.4%	10% (in total)	14% (in total)	2-10%	11%
NPC	0-0.17	0.1 (in total)	0.1 (in total)	0.4-0.6	0.1

REFERENCES

Andréu P 1992. Vertical migration of three coastal species of chaetognaths in the western Mediterranean Sea. Scientia Marina, 54(4): 367-372.

Avşar D 1999. Physico-Chemical Characteristics of the Eastern Mediterranean in Relation to Distribution of the New Scyphomedusae (*Rhopilema nomadica*). Turkish Journal of Zoology, 23(2): 605-616.

Bamstedt U, Gifford D J, Irigoien X, Atkinson A, Roman M 2000. Feeding. (ICES Zooplankton Methodology Manual, Academic Press, CaliforniaUSA: Eds. Harris R, Wiebe P, Lenz J, Skjoldal HR, Huntley M) 297-400.

Batistic M, Mikuš J, Njire, J 2003. Chaetognaths in the South Adriatic: vertical distribution and feeding. Journal of the Marine Biological Association of the United Kingdom, 83(6): 1301-1306.

Bone Q Happ H, Pierrot-Bults AC 1991. Introduction and relationships of the group. (The Biology of Chaetognaths,. Oxford University Press, OxfordUSA: Eds. Bone Q, Kapp H, Pierrot-Bults AC) 137-147.

Coston-Clements L, Waggett RJ, Tester PA 2009. Chaetognaths of the United States South Atlantic Bight: Distribution, abundance and potential interactions with newly spawned larval fish. Journal of Experimental Marine Biology and Ecology, 373(2): 111-123.

Duró A, Saiz E 2000. Distribution and trophic ecology of chaetognaths in the western Mediterranean in relation to an inshore–offshore gradient. Journal of Plankton Research, 22(2): 339-361.

Feigenbaum D 1991. Food and feeding behavior. (The Biology of Chaetognaths. Oxford University Press, USA: Eds. Bone Q, Kapp H, Pierrot-Bults AC) 45-54.

Hazar D 2006. İskenderun Körfezi'nde bulunan ketognat (sagittidae) türlerinin taksonomisi ve genetik analizi. MKÜ, Fen Bil. Ens., Su Ürünleri ABD, Yüksek Lisans Tezi, 60 s.

Itoh H, Ono Y, Kubota T 2006. Vertical distribution of large-size chaetognaths in Suruga Bay, central Japan. Journal of the School of Marine Science and Technology-Tokai University, 4(1): 1–13.

İşmen P, İşmen A, Başusta N 2003. Species composition, distribution and breeding of chaetognata in İskenderun Bay (The Eastern Mediterranean). (International Symposium of Fisheries and Zoology Proceeding Book, Turkey: Oray IK, Çelikkale; MS Özdemir G) 89-102.

İyiduvar O 1986. Hydrographic Characteristics of Iskenderun Bay. METU, Institute of Marine Sciences, The department of Physical Oceanography, Masters Thesis, 157 p.

Kehayias G 2003. Quantitative Aspects of Feeding of Chaetognaths in the Eastern Mediterranean Pelagic Waters. Journal of the Marine Biological Association of the United Kingdom, 83(3):559-569.

Kehayias G 2004. Spatial and temporal abundance distribution of chaetognaths in eastern Mediterranean pelagic waters. Bulletin of Marine Science, 74(2): 253-270.

Kehayias G, Fragopoulu N, Lykakis J 1994. Vertical community structure and ontogenic distribution of chaetognaths in upper pelagic waters of the Eastern Mediterranean. Marine Biology, 119: 647–653.

Kehayias G, Fragopoulu N, Lykakis, J. 1999a. An Identification Key for The Chaetognath Species of The Mediterranean Sea. Biologia Gallo-Hellenica, 25: 105-124.

Kehayias G, Kourouvakalis D 2010. Diel vertical migration and feeding of chaetognaths in Coastal Waters of The Eastern Mediterranean. Biologia, 65(2): 301-—308.

Kehayias G, Koutsikopoulos C, Fragopoulou N, Lykakis J 1999b. A Single Maturity Classification Key for Five Common Mediterranean Chaetognath Species. Journal of the Marine Biological Association of the United Kingdom, 79: 1137-1138.

Kehayias G, Lykakis J, Fragopoulu N, 1996. The diets of the chaetognaths *Sagitta enflata, S. serratodentata atlantica* and *S. bipunctata* at different seasons in Eastern Mediterranean coastal waters. ICES Journal of Marine Sciences, 53: 837-–846.

Kehayias G, Michaloudi E, Koutrakis E, 2005. Feeding and predation impact of chaetognaths in the north Aegean Sea (Strymonikos and Ierissos Gulfs). Journal of the Marine Biological Association of the United Kingdom, 85(6): 1525-1532.

Kehayias G, Ntakou E 2008. Abundance, vertical distribution and feeding of chaetognaths in the upper 50 m layer of the eastern Aegean Sea. Journal of Natural History, 42(5-8): 633-648.

Kimmerer, WJ 1984. *Sagitta enflata* (Chaetognatha). Marine Ecology Progress Series, 15: 55-62.

Kosobokova KN, Hopcroft RR 2010. Diversity and vertical distribution of mesozooplankton in the Arctic's Canada Basin. Deep Sea Research Part II: Topical Studies in Oceanography, 57(1): 96-110.

Kuhlmann D 1977. Laboratory studies on the feeding behaviour of the chaetognaths *Sagitta setosa* J. Milller and S. elegans Verrill with special reference to fish eggs and larvae as food organisms. Berichte der Deutschen Wissenschaftlichen Kommission für Meeresforschung, 25: 163-171.

Nagasawa S Marumo R 1981. Chaetognaths as food of demersal fishes in the East China Sea. Bulletin of the Seikai National Fisheries Research Institute, 56: 1-13.

Noblezada MMP, Campos WL 2008. Spatial distribution of chaetognaths off the northern Bicol Shelf, Philippines (Pacific coast). ICES Journal of Marine Science: Journal du Conseil, 65(3): 484-494.

Oresland V 1990. Feeding and predation impact of the chaetognath Eukrohnia hamata in Gerlache Strait, Antarctic Peninsula. Marine Ecology Progress Series, 63(2): 201-209.

Oresland V 1987. Life cycle and feeding of the chaetognaths *Sagitta setosa* and *S. elegans* in European shelf waters. University of Stockholm, Department of Zoology, PhD thesis, 85 p.

Pearre SJr 1974. Ecological studies of three west-Mediterranean chaetognaths. Investigacion Pesquera, 38: 325-369.

Pierrot-Bults AC, Nair VR 2010. Horizontal and vertical distribution of Chaetognatha in the upper 1000m of the western Sargasso Sea and the Central and South-east Atlantic. Deep Sea Research Part II: Topical Studies in Oceanography, 57(24): 2189-2198.

Reeve MR 1970. The biology of Chaetognatha I. Quantitative aspects of growth and egg production in *Sagitta hispida*. (Marine food chains, Oliver and Boyd, UK: Ed. Steele JH) 168-189.

Stuart V, Verheye HM 1991. Diel migration and feeding patterns of the chaetognath, *Sagitta friderici*, off the west coast of South Africa. Journal of Marine Research, 49: 493-515.

Terbıyık T, Çevik C, Toklu-Alıçlı B, Sarıhan E 2007. First record of *Ferosagitta galerita* (Dallot, 1971) [Chaetognatha] in the Mediterranean Sea. Journal of Plankton Research, 29(8): 721-726.

Terbıyık Kurt T, Polat S 2013. Seasonal distribution of

coastal mesozooplankton community in relation to the environmental factors in Iskenderun Bay (north-east Levantine, Mediterranean Sea). Journal of the Marine Biological Association of the United Kingdom, 93: 1163-1174.

Terbıyık Kurt T, Polat S, 2015. Zooplankton abundance, biomass, and size structure in the coastal waters of the northeastern Mediterranean Sea. Turkish Journal of Zoology, 39: 378-387.

Terbıyık T, Sarıhan E, 2008.Seasonal distribution of species composition and abundance of chaetognaths in the Yumurtalik Inlet (Adana) Çukurova Üniversitesi Fen ve Mühendislik Bilimleri Dergisi, 17(8): 90–95.